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Entry, Exit and Establishment Survival in UK Manufacturing

by

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Abstract

Despite the profusion of theoretical IO literature on the exit and entry of firms, there are few empirical studies. This paper provides evidence on entry, exit and survival for UK manufacturing establishments from 1974 to 1991 using the ARD database, a newly released dataset containing the universe of such establishments since 1972. We examine patterns of entry and exit across industries and over time. The paper utilises an augmented Cox proportional hazard to examine the survival of new plants in the UK in the 1980s. The results indicate a secular fall in cohort survival probabilities over time, and complex interactions between survival, age of firm and the size of the firm over time.

Outline

1 Introduction

There has been a profusion of theoretical work in the Industrial Organisation literature on entry and exit of firms (see e.g. Scherer and Ross (1990) for a textbook treatment). Relative to the large weight of theory however, there is comparatively little empirical work in the area. Such work as exists is broadly of two sorts. First, there are some case studies; for example documenting certain industries over a particular period.[1] Second, there is a small set of more general studies based on longitudinal firm-specific data.[2]

The purpose of this paper is to augment the empirical literature by providing evidence on entry and exit for the United Kingdom (UK) using a new data set that has just been selectively released by the UK statistical authorities. The data used is the Annual Business Inquiry Respondents Database (or ARD) which starts from 1972 and ends in 1992 (when the sampling base was changed which complicates updating). This is the microdata set corresponding to the UK Census of Production, and is therefore analogous to the micro Census data used in entry/exit studies for Canada (Baldwin, 1995), Germany (Boeri and Bellman, 1995), Portugal (Mata et al, 1995) and the US (Dunne et al, 1988, Davis, Haltiwanger and Schuh, 1996). All UK manufacturing establishments of over 100 employees, and a sample of smaller establishments are sent an annual questionnaire about employment, investment, industry and ownership, sales, costs, skills etc.. Every establishment has a unique identifier.[3] Thus we can construct a panel of establishments, identify entrants and exitors and trace the fortunes of various cohorts in the data.

In using these data we hope to make a number of contributions. First, we document the patterns of entry and exit across UK manufacturing industries 1974-91. As far as we are aware, the only other related UK evidence are tabulations of average industry entry and exit data for 1974-79 reported in Geroski (1991, table 2.1). Second, we distinguish between entry by new establishments and entry through the expansion of existing establishments. No study has looked at this for the UK before. Third, we estimate the determinants of exit by looking at the effect on hazard rates of cohort, industry and establishment characteristics. There are only two related studies for the UK. Ganguly (1985) tabulates

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[1] See, for example, Leiberman (1987) on US chemicals, Ghemawat (1984) on titanium dioxide, and Baden-Fuller (1989) on UK steel castings.

[2] Surveyed by Caves (1998). For example, Baldwin (1995), Evans (1987), Hall (1987), Dunne, Roberts and Samuelson (1988) and the papers on the Post Entry Performance of Firms in the Special Issue of the *IJIO* (1995).

cohort survival rates (using different data) for the cohorts entering in each year 1974-1982 and Geroski (1991, table 2.11 and 2.12) reports some averages over one and five years of experience for cohorts entering in 1975-78 and 1980-82. Neither author analyses the determinants of the cohort hazard rates (neither had access to data to do so) and as we show below our data are more appropriate than Ganguly's.

Our findings and their implications fall into two broad areas. First, calculations on the raw data show a number of interesting features about entry and exit, many of which have been shown for other countries but not for the UK. We show, for example; that there are high rates of entry and exit in the UK and that rates of entry and exit correlate strongly across time and within industries; that entrants and exitors average about 11 employees, while stayers average about 44 employees; and that about half of entry and exit employment is due to entry/exit from new establishments set up by existing enterprise groups. Second, estimating hazard functions shows that initial size, current size, growth, ownership and demand are all important after we condition on industry and date of establishment. But the effect of these variables critically depends on the age of the firm: the beneficial effects of large initial size for example reduce with age. Furthermore, firms born in later cohorts over the 1980s showed increasing hazard rates, even conditioning on other factors. The non-linearity in the relationship between the hazard and the covariates, and the presence of significant cohort effects, appear to be novel research findings even in the context of the existing international literature on these issues.

The plan of the rest of this paper is as follows. In the next section, we describe the data and the considerable complications involved in making it amenable to analysis. Section 3 describes the industry patterns of entry and exit and entry type. Section 4 outlines the analysis of cohorts of establishments and section 5 concludes.

2 Data

Details of the ARD data can be found in Oulton (1997), Haskel and Heden (1999) and in Heden and Haskel (1998). Here we briefly set out the main features of the data, and then concentrate on the problems involved in constructing a consistent record of entry and exit.

[3] The ARD sampling procedure set out below covers more than establishments, but we use establishments here for convenience.

The ARD (*A*nnual Census of Production (ACOP) – now the *A*nnual Business Inquiry *R*espondents *D*atabase) is the micro-level data used to construct the industry-level tables published as the *UK Census of Production*. The micro data is formed by a register of businesses. We can think of a record on the register as an address, called a "local unit". Some addresses/local units might be a plant. Some might be a head office responsible for a number of plants. Some might be deemed too small to provide reliable information on the full Census questionnaire. Therefore is it convenient to define the following categories. An "establishment" is the smallest entity which possesses the data necessary to answer the questions on the Census form. Thus the simplest case is a "single", which is a local unit that is an establishment. A local unit too small to return a Census form is a "child" of a "parent", the latter being a local unit that reports on other local units under its control as well as on itself. Finally, an "enterprise group" is one or more establishments under common ownership or control.

Figure 1

Structure of the ARD data

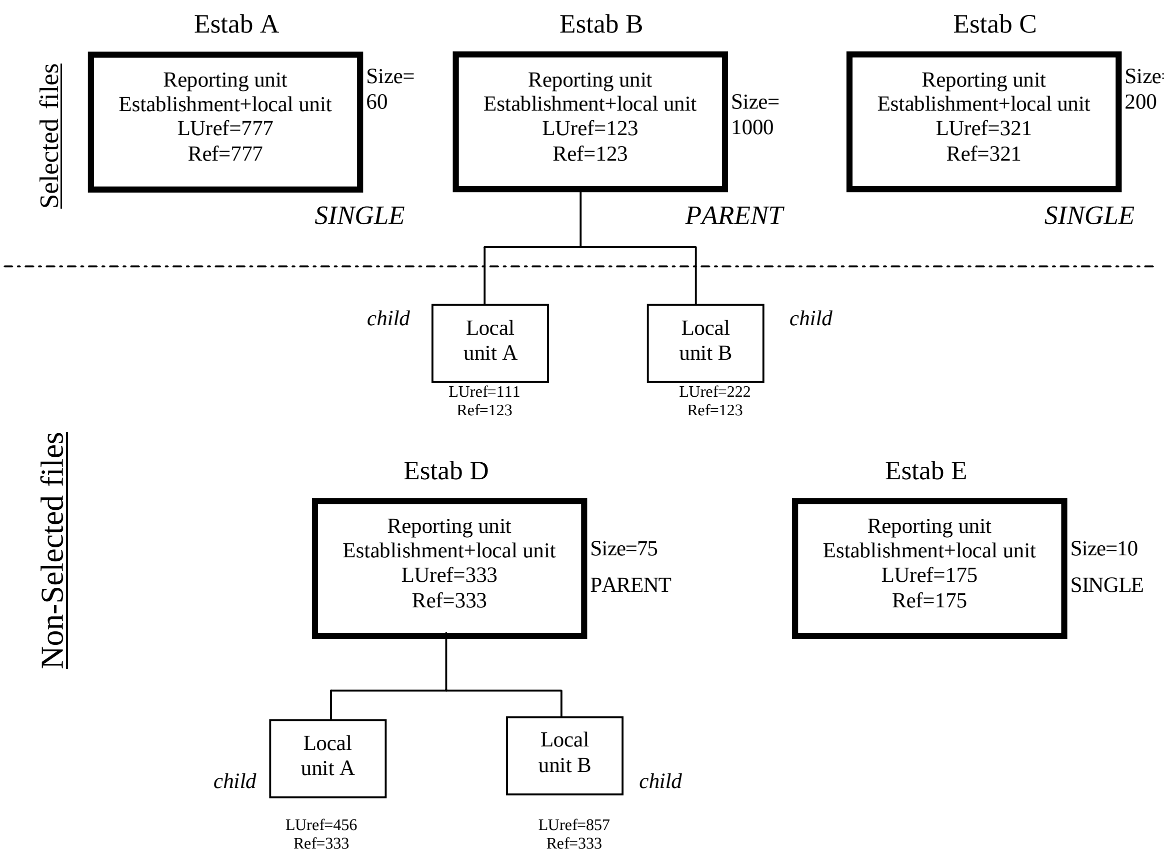

Figure 1 will help with an example. Ignore the selected/non-selected distinction for the moment to consider three establishments, A, B and C. Establishments A and C are singles with 60 and 100 employees. Establishment B has 1000 employees but is a parent to local units A and B; it reports on itself and two local units.

Crucially for this study, each local unit, establishment and enterprise group has a unique identification number. This number enables us to measure stayers, entrants and exitors and to identify if an entrant is owned by an existing firm, or independent. In our example then, establishment A has as reference number (ref=777), and a local unit reference number (LUref=777)[4]. Establishment B and its children have separate LUrefs but the same "ref" since the children are allied to the establishment.[5] Data on the establishments in the register is gathered as follows. All establishments with employment over a certain size (generally 100 employees) have to complete a full Census form. Smaller establishments are sampled with the sampling rules changing every so often (Oulton, 1997).[6] Sampled establishments report full census information on themselves if sufficiently large, and in addition must give information on employment and investment at local unit level if reporting for "children". The sampling method means that for each year there are two data files: selected and non-selected. The selected file holds data on establishments that were sent a Census form. The non-selected file holds data on the rest of the establishments (and their children if they exist[7]) giving their industrial classification, postcode and imputed employment data based on register information such as turnover[8].

To return to Figure 1, establishments B and C are over 100 employees and are therefore sent a full Census form. Establishment A, with 60 employees we assume has been sampled and completes a full form. Hence establishments A, B and C are all held in the selected files. Establishment D, size 75, could potentially be sampled with the full form, but in this example is not: hence its records, and those of its children, are only on industrial classification, postcode and imputed employment data. These records are held in the non-selected files. Finally, establishment E, being of size 10, is too small to be sent a full Census form and hence is held on the non-selected files.

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[4] It also has an enterprise group number (not shown). If for example establishments A and B were owned by the same firm they would have the same enterprise group number. In the event of a merger with establishment C all establishments would have a common enterprise group reference number.

[5] We must of course be careful not to double count local units reported on by their parents.

[6] For example, in 1986 and 1988, all units with employment over 100 were sent a form, while half of the businesses with employment between 50-100 and a quarter of those with employment between 20-50 were sampled.

[7] As figure 1 shows, the children of any selected establishments are held in the non-selected files.

The total number of establishments on the data set, selected and non-selected files, 1973-1992 is 2,389,031. With such large numbers there are clearly a number of issues we must deal with in cleaning the data. First, we were worried that entry/exit would be biased if establishments changed their reference numbers owing to data error. We therefore dropped any establishment which disappeared for one or more periods and then reappeared with the same reference number.[9]

Second, to calculate entry and exit correctly we have to use both the selected and non-selected data, since entry and exit onto the selected data might be due to "true" entry and exit but also due to firms being sampled or not. However, the data on employment and investment for the non-selected sample are missing from the computer files for the 1970s. So we can calculate the numbers of entrants/exits for this period but not their employment and investment. We note that none of the other users of the ARD data so far have used the non-selected sample (except Harris, 1999).

Third, changes to the construction of the register are important. As mentioned above, the basis for ACOP is a register of businesses which, before 1984, was based on VAT (tax) payments, evidence from other government databases and previous returns. In 1984 a new business register based on the VAT register was adopted as the basis for the Census. This resulted in around 33,000 new (mostly small) establishments being added to the register. From the 1987 Census onwards the system of reporting was again changed. Previously, firms were asked to report on establishments and exclude activities not in the scope of the Census. From 1987 they were asked to report on the company, called the "business" and were no longer asked to exclude non-Census activities.[10] These changes mean that there are apparently huge waves of entry and exit in the changing register years and just after. We deal with these issues below.

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[8] The non-selected firms are overwhelmingly small, about 20 percent of total employment, so although one should be cautious about using imputed employment the vast majority of employment is in firms with non-imputed data.

[9] If a firm exits and then enters again it is allocated a new reference number. Our deletion procedure therefore dropped establishments that seemingly exited one year and re-entered some years later; we assume these are due to incomplete reporting.

[10] This may result in an increase in the number of firms, increase in employment per firm etc. as non-Census activities/entities were supposed to be excluded.

3 Patterns of Entry and Exit

3.1 Whole Manufacturing Averages

In this section we use the ARD data to establish a number of facts for UK manufacturing. For example:

(a) Around three in 10 establishments in any one year are current entrants or will exit next period.

(b) Entrants and exitors are small: average establishment size (over the 1980s) was about 33 employees, stayers were about a third bigger, whilst entrants and exitors were about two thirds smaller.

(c) Entry and exit rates show no particular cyclical pattern aside from 1981 when exit rates fell sharply.

(d) About 10 percent of firm entry/exit is due to entry/exit from new establishments set up by existing enterprise groups, although this is about half of entry and exit employment.

In what follows, it is useful to divide establishments into the categories set out in Table 1:[11]

Table 1
Definitions

Establishment type	Definition
Entrant:	Present in t not present in t-1.
Exitor:	Present in t will not be present in t+1.
One-year-only:	Present in t not present in t-1, will not be present in t+1.[12]
Stayer:	Neither an entrant, exitor nor one-year only.

Table 2 presents some raw data. We begin in 1974 since that is the earliest year we can calculate entry and exit. In all, there were just over 100,000 establishments in UK manufacturing in the early part of the period.

[11] We trace entry and exit on the basis of establishment reference number. Merger merely changes a firm's enterprise group number (see footnote 4) and so does not show up as an entry/exit. If an establishment were to physically move all its plant to another location it would get a new local unit reference number and so shows up as an exit and entry. We could in principle measure entry and exit on basis of appearance and disappearance of local unit reference numbers. However, since we have very limited data at the local unit level we chose to identify entrants/exitors at the establishment level.

[12] The one-year-only group are entrants who immediately exit. As we shall see, defining them in a separate group is convenient for adding-up purposes and to understand the changes in sampling base.

Table 2
The number of establishments stayers, entrants and exitors

Year	All	Stayers	Entrant	Exitors	1-year	Stayers	Entrant	Exitor	1-year
	Number					Fraction of All			
						S/All	N/All	X/All	1y/All
1973	93,161	93,161				100.0			
1974	100,633	83,630	12,542	5,612	1,151	83.1	12.5	5.6	1.1
1975	102,904	91,285	7,865	4,317	563	88.7	7.6	4.2	0.5
1976	105,793	95,614	7,142	3,422	385	90.4	6.8	3.2	0.4
1977	106,602	99,570	4,121	3,139	228	93.4	3.9	2.9	0.2
1978	107,017	100,983	3,829	2,370	165	94.4	3.6	2.2	0.2
1979	106,820	100,929	2,115	3,959	183	94.5	2.0	3.7	0.2
1980	106,675	99,665	3,696	3,606	292	93.4	3.5	3.4	0.3
1981	105,919	93,075	3,237	9,779	172	87.9	3.1	9.2	0.2
1982	100,039	92,537	4,084	3,612	194	92.5	4.1	3.6	0.2
1983	100,018	39,135	2,975	59,538	1,630	39.1	3.0	59.5	1.6
1984	133,515	36,861	93,325	87,254	83,925	27.6	69.9	65.4	62.9
1985	136,735	43,503	90,285	18,691	15,744	31.8	66.0	13.7	11.5
1986	140,920	98,043	24,219	23,620	4,962	69.6	17.2	16.8	3.5
1987	142,070	97,568	24,857	24,516	4,871	68.7	17.5	17.3	3.4
1988	145,084	100,664	27,995	37,146	20,721	69.4	19.3	25.6	14.3
1989	147,930	91,968	39,367	30,116	13,521	62.2	26.6	20.4	9.1
1990	139,484	101,090	21,041	22,205	4,852	72.5	15.1	15.9	3.5
1991	133,063	95,088	15,779	26,573	4,377	71.5	11.9	20.0	3.3
1992	134,649	134,649				100.0			
Total	2,389,031	1,789,018	415,747	374,259	189,993	74.9	17.4	15.7	8.0

Source: Authors' calculation from ARD

Reading across the row for 1974, for example, just over 83,000 establishments (83 percent) were stayers. Over 12,000 (12.5 percent) were entrants and over 5,000 (5.6 percent) were exitors. Finally, around 1,000 were one-year-only. Hence stayers plus entrants plus exitors less one-year-only add up to the total.[13] Looking then at the 1970s data, we see a mild rise in the number of establishments. Roughly nine out of 10 establishments are stayers, and one in 10 establishments will enter or exit.

There are in fact three major changes in the data that will affect entry. The first, not apparent in the table (but will be important in what follows), is that in the 1970s we know whether an establishment is present or not, but have no further data for the non-selected establishments. Since the non-selected establishments are overwhelmingly small, we have no employment data in the 1970s for the smallest establishments. Such data is however available from 1980 onwards. In what follows therefore we mostly analyse the 1980s.

[13] If we defined entrants are those present in t, not present in t-1 but who will be present in t+1 this would allocate the one-year only to exitors which would understate entry.

The second change is apparent in 1983. As explained briefly above, in that year the Office of National Statistics (ONS) changed the sampling base and updated the old register of establishments. The table shows the effect of this change. Consider the 1984 data first. The number of establishments rises suddenly by about 33,000. This is because the new register was more comprehensive and sampled many more (mostly small) establishments. Not surprisingly there was apparently a huge wave of entry in 1984, over 93,000 establishments. But as the table shows, the vast majority of those establishments only stayed for one year, and there appears to be another huge wave of entry in 1985. Inquiries at the ONS revealed that the reason appears to be the statistical authority's problems with linking the firms across the two different registers. This meant that many "entrants" in 1984 were in fact existing (mostly small) firms. This is why there appeared to have been so much exit in 1983. In 1985 there were further adjustments to the register and many of the 1984 new "entrants" exited (showing up as high exit in 1984) and subsequently re-entered, hence the large apparent entry in 1985. By 1986 the register had settled down.

A third change occurred in 1987 when the system of company reporting was changed to business-based. Again, there appears to have been a rise in exit that year, presumably when firms stopped reporting on establishments they had previously reported upon. The following year shows a large rise in entry, presumably due to the new reporting units constituting new firms. In both years there are a large number of one year stayers.

What patterns emerge from Table 2? The changes discussed above make comparisons over time somewhat difficult, with "spikes" from the register changes and the higher fractions of stayers in the 1970s likely due to the undersampling of small firms relative to the 1980s. It therefore seems best to confine attention to the data 1986-91 (and ignore the "spike" in 1988). This shows a fall in the number of establishments. In addition, about seven out of 10 establishments are stayers, whilst three out of 10 enter or exit in each year. [14]

Our entry data are very similar to the UK entry numbers and rates in Geroski (1995, table 2.1, figure 2.1) who uses (unpublished) data on new establishments for 87 three-digit Census industries 1974-79. However, Ganguly (1985, table 19), who relies on

[14] These data are comparable to other countries. In the US, 61.5 percent of entrant firms left in 5 years (Dunne et al, 1989, table 8). In Canada, 10 percent of entrant firms in the 1971 cohort left in the first year (Baldwin, 1995, figure 2-2), and 60 percent left by 1982 (ibid., p.19). In Portugal, averaging over cohorts 1983 to 1990, 25 percent of new entrants die in the first year and 50 percent in five years (Mata et al, 1995, figure 2).

(unpublished) VAT registrations and deregistrations to calculate entry and exit for 1980-82, shows larger numbers of entrants and exitors (about 10,000 for each year) than table 1. This is likely to be due to the use of VAT data however.[15]

Table 3 shows the average size of entrants, stayers and exitors. Consider 1991.[16] The average size of establishment was 32 employees. But the median size was four. This shows how skewed the size distribution of establishments is, as is well known. Stayers are however rather bigger with an average size of 41. Interestingly however, entrants and exitors are on average smaller, with exitors being larger than entrants. One-year-only establishments are smaller still. Overall then, although there are a large number of entrants and exitors, they are overwhelmingly small[17].

Table 3
Mean and median establishment size

	ALL		Stayers		Entrants		Exitors		1-year-only	
Year	**mean**	**Median**	**mean**	**median**	**Mean**	**Median**	**mean**	**median**	**mean**	**median**
1983	49	9	110	25	32	8	9	5	10	5
1984	36	5	111	25	6	3	6	3	4	3
1985	34	4	95	20	5	3	12	3	6	3
1986	33	4	43	5	9	2	13	4	7	2
1987	33	4	43	4	8	2	12	3	6	2
1988	32	4	42	4	7	2	8	2	3	1
1989	32	3	46	5	6	1	9	2	4	1
1990	33	4	41	4	8	2	13	3	6	2
1991	32	4	41	5	10	2	11	2	6	1
1992	31	4			6	2			6	2

Source: Authors' calculation from ARD

Has this story changed over the sample period? The 1983-5 data is contaminated by the sampling change described above. Exitors and entrants are mostly smaller than stayers,

[15] There are two potential differences between VAT and Census data. First, before 1983 the Census register did not use VAT information and so undersampled small firms. Hence VAT data should show more entry and exit during that time. Second, in the ARD data, if an establishment is a 'child' (i.e. part of a larger group), then it has a separate identifier and so if exits this will show up as an exit. VAT numbers however are specific to parents (i.e. the enterprise has one VAT number but may have many establishments). Thus exit by a child establishment, or entry by the setting up of a new establishment by an existing group, will not show up as an entry if one is using the VAT numbers. As we show below such entry and exit is quantitatively important: accounting for around 20 percent of firms and 50 percent of employment. Hence VAT figures should show less entry and exit. Hence the Ganguly data overstates entry and exit relative to the ARD before 1983 (when the register was not VAT-based) but understates entry and exit after 1983 (when the register was VAT based).

[16] Table 3 does not show data from before 1983 since the register was then on a different basis.

[17] We also looked at variations in market shares of entrants and exitors across and within industries. The average entrant had a market share of 3 percent and exitor a market share of 6 percent with 10th and 90th percentiles at 0.6 percent and 6.3 percent and 2 percent and 10 percent.

with exitors larger than entrants, but the relative sizes of stayers, entrants and exitors have stayed rather similar.

We turn now to the entry and exit rates. For compatibility within a year, we choose to define the rates with respect to the current year's stock of establishments.[18] Define:

$$entry\ rate_t = \frac{\#\,establishments\ enter\ \ from\ t\ to\ t+1}{\#\,establishments_t} \tag{1}$$

and

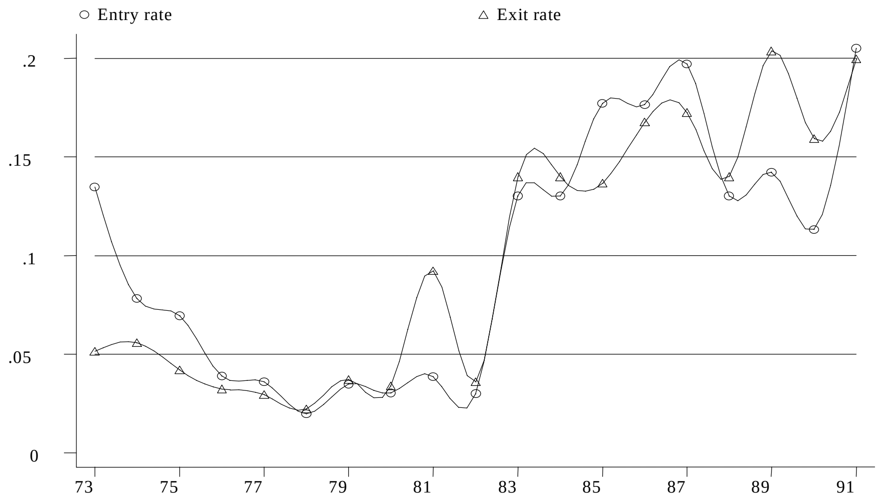
$$entry\ rate_t = \frac{\#\,establishments\ exit\ between\ t\ and\ t+1}{\#\,establishments_t} \tag{2}$$

Figure 1 shows the resulting rates, adjusted for the register changes.[19] A number of points are worth noting. First, both rates move closely together over the cycle. This may suggest a sorting hypothesis whereby high entry periods might mean the entry of lower quality establishments at the margin, which are therefore more likely to exit more rapidly. Second, there is no obvious cyclical pattern aside from 1981 when exit rates rose very sharply. Third, although it would appear that the 1980s were more "turbulent" than the 1970s, the lower entry and exit rates in the 1970s may be due to the "old" business register's lack of information on small establishments' existence.

[18] Note the timing of these rates. The way we calculate the data is as follows. An exitor in t is present for the last time in t. Hence they exit at some time between surveys in t and t+1. An entrant in t is observed for the first time in t. Hence they must have entered between surveys in t-1 and t. Thus to compare entry and exit between the same sample interval, one must compare exit in t and entry in t+1. The construction of entry and exit rates from table 1 is therefore as follows. Consider 1975. The number of entrants, 7,865 are those appearing for the first time in 1975. Hence the entry rate in 1974 is calculated as 7,865/100,633 i.e. the stock number is that from the previous year. The number of exitors, 4,317 are those appearing for the last time in 1975 i.e. they do not appear in 1976. Hence the exit rate in 1975 is calculated as 4,317/102,904 i.e. the stock number is that from the previous year.

[19] As mentioned above the exit is disrupted by a number of changes in the data available and the register. To smooth out the 1983, 1984 and 1988 "spikes" we regressed the industry exit and entry rate on a set of industry dummies and interacted industry and time dummies for those years. For those three years we generated the exit and entry rates as the actual rate less the coefficient on the interacted industry/time dummy. The other exit and entry rates are as in the raw data.

Figure 1
Entry and Exit rates in UK Manufacturing



Note: the figure shows average entry and exit rates by two digit industries, with register effects smoothed out as shown in the text. Note that the sampling change post 1983 raises both rates.
Source: Table 1.

Finally, Table 4 shows entry and exit by establishment type since 1984. With our data we are able to distinguish between entry due to an independent enterprise (a "single") and due to a new establishment owned by an existing enterprise group (an "enterprise group"). As first column in each panel show, the bulk of entry and exit, in terms of *numbers*, is by singles. But as the other columns show, these establishments are overwhelmingly small, and so most entry/exit in terms of employment is due to enterprise groups. Note in addition that the market share of singles in exit and entry appears to fall over time.

Table 4
Entry and exit by type

	Fraction of entrants and Exitors that are 'singles'		Market share of entrants and exitors that are 'singles' of total entry and exit	
Year	**Entrants**	**Exitors**	**Entrants**	**Exitors**
1984	0.92	0.92	0.74	0.65
1985	0.93	0.87	0.77	0.45
1986	0.92	0.79	0.57	0.36
1987	0.93	0.89	0.56	0.42
1988	0.93	0.91	0.57	0.42
1989	0.95	0.87	0.60	0.40
1990	0.90	0.83	0.55	0.34
1991	0.88	0.89	0.40	0.35

Source: ARD calculations.

3.2 Differences across Industries

In this section we undertake cross-industry comparisons that suggest the following:

(a) there is wide variation in entry and exit rates both within and across industries.

(b) high exit rates in industries are accompanied by high entry rates.

(c) above average entry appears to be followed by below average exit rates, which is inconsistent with a sorting hypothesis.

Table 5 shows entry and exit rates across industries, averaged over the 1980s. The first columns of 'entry' and 'exit' give the two-digit industry averages, while 'p10' and 'p90' refer to the rates at the three-digit level within each two-digit industry at, respectively, the 10th and 90th percentile.

Table 5
Entry and exit rates across industries

SIC80	Industry Class	Entry Rates			Exit Rates		
		mean	**p10**	**p90**	**Mean**	**p10**	**p90**
21	Extraction and preparation of metalliferous ores	0.199	0.000	0.500	0.279	0.061	0.692
22	Metal manufacturing	0.090	0.035	0.146	0.108	0.048	0.171
23	Extraction of minerals nes	0.076	0.000	0.202	0.110	0.000	0.272
24	Non-metallic mineral products	0.119	0.019	0.207	0.130	0.042	0.217
25	Chemical industry	0.115	0.037	0.183	0.132	0.033	0.200
26	Man-made fibers	0.095	0.042	0.160	0.085	0.040	0.172
31	Metal goods nes	0.091	0.016	0.151	0.104	0.030	0.150
32	Mechanical engineering	0.106	0.021	0.176	0.122	0.033	0.181
33	Office machinery and computers	0.243	0.133	0.376	0.187	0.050	0.279
34	Electrical/electronic engineering	0.153	0.038	0.235	0.146	0.037	0.222
35	Motor vehicles and parts thereof	0.113	0.030	0.166	0.123	0.048	0.173
36	Other transport equipment	0.131	0.030	0.212	0.139	0.039	0.233
37	Instrumental engineering	0.121	0.023	0.214	0.131	0.030	0.217
41/42	Food, drink and tobacco	0.094	0.013	0.183	0.124	0.029	0.195
		0.095	0.015	0.184	0.134	0.031	0.213
43	Textile industry	0.100	0.024	0.194	0.128	0.053	0.194
44	Leather and leather goods	0.104	0.014	0.216	0.160	0.030	0.264
45	Footwear and clothing industries	0.130	0.018	0.223	0.182	0.040	0.298
46	Timber and wooden furniture	0.109	0.026	0.205	0.124	0.025	0.192
47	Paper and paper products; printing and publishing	0.116	0.036	0.204	0.119	0.031	0.167
48	Processing of rubber and plastics	0.110	0.027	0.183	0.111	0.031	0.166
49	Other manufacturing industries	0.152	0.024	0.292	0.148	0.034	0.238
2-4	**ALL**	**0.113**	**0.023**	**0.204**	**0.131**	**0.032**	**0.209**

Notes: Each rate is a mean for each two digit industry calculated across 108 three-digit industries across 1980 to 1992. "p10" shows the mean rate at the 10th percentile of the within-two digit industry distribution of industries and "p90" the mean at the 90th percentile.
Source: Authors' calculations using selected and non-selected files from ARD data.

As the first column shows, entry rates vary considerably across industries. Looking at the means of broad groups of industries, industries with the highest entry rates are extraction

(SIC 21)[20] and computers (SIC 33) where on average, more than one in five (20 percent and 24 percent) of establishments are new since last year. The lowest are in metals (SIC 22 and SIC 23) at nine percent and eight percent respectively. The second panel of table 5 shows exit rates and again shows a wide variation. Extraction (SIC 21) which has the highest entry rate also has the highest exit rate, with almost one in three establishments exiting. The second highest exit rate is in computers (SIC 33), which has the second highest entry rate, where one in five establishments exit. The lowest exit rate is man-made fibres (SIC 26), where only one in 10 exit.

Within industries, that is, looking at industries disaggregated to the three digit level there is also considerable variation. Within "computers", for example, where the average entry rate is 24 percent, the 1st decile of entry rates has an average entry rate of 13 percent, whereas the 9th decile an average rate of 38 percent. Likewise, there is considerable within industry variation in exit rates, with computers having the 9th and 1st deciles varying between 28 percent and five percent. An analysis of variance reveals that for both entry and exit rates, 90 percent of the variance is within two digit industries is and 10 percent across industries (confirming stylised fact 2 in Geroski, 1995).[21]

Table 5 suggests that industry entry and exit rates are correlated i.e. that an industry with a high entry rate will also have a high exit rate over time. Dunne et al (1988) find broadly similar results for the US and Geroski notes this too (1995, stylised fact 3). Table 6 examines this and a number of possible hypotheses more formally. The left panel shows simple correlations of entry and exit rates across industries over discrete time intervals. Cell 1 (top-left cell), for example, shows the correlation of the proportion of firms in industry *I* in 1980 who were new since 1973 (NR) with the proportion of exitors in industry *I* between 1973 and 1980 (XR) where *I* is one of 16 two-digit industries. There are strong correlations along the diagonals which we interpret as likely to be largely industry fixed effects, such as technological conditions, which cause high entrant industries also to be high exit industries. The off diagonal elements vary in sign showing no consistent pattern of intertemporal correlation.

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[20] This is a very small industry with an average size of 40 with only about 15 establishments and so the entry rate appears large owing to the entry in 1990 of seven establishments.

[21] We have also looked at variations in market shares of entrants and exitors across and within industries. The average entrant had a market share of 3 percent and the exitor a share of 6 percent, with 10th and 90th percentiles at 0.6 percent and 6.3 percent, and 2 percent and 10 percent respectively.

Table 6
Correlations between entry and exit rates

Ordinary correlations of entry and exit rates				Correlation of entry and exit rates controlling for industry fixed effects			
	NR73-80	**NR80-85**	**NR85-91**		**NR73-80**	**NR80-85**	**NR85-91**
XR73-80	**0.40**	-0.57	-0.41	**XR73-80**	**0.60**	-0.65	-0.20
XR80-85	0.10	**0.66**	0.45	**XR80-85**	-0.44	**0.77**	-0.26
XR85-91	-0.02	-0.18	**0.65**	**XR85-91**	-0.34	-0.13	**0.66**

Note: Calculation on basis of four cross sections only, 1973, 80, 85 and 91. An entrant in 1985 is a firm present in the 1985 cross section but not in the 1980 cross section. Likewise an exitor would be a firm present in 1980 but not in 1985.
Source: Authors' calculations from ARD.

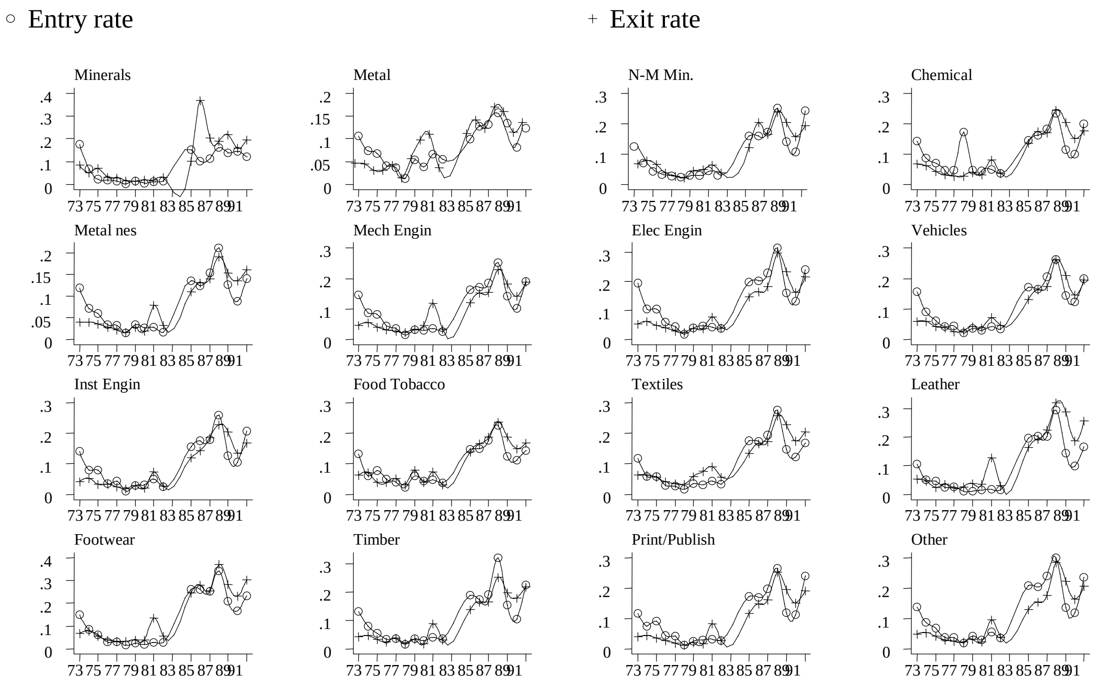
There is also the related issue of whether periods of above (below) average entry are associated with above (below) average exit. If sorting were important, high entry in a period means the below average firms would be expected to raise exit shortly after (since the marginal entrant is of worse quality in periods of above average entry). To examine this we adopt a simple fixed effects approach and calculate:

$$corr(N_I*, X_I*) = corr(N_{It} - \overline{N}_i, X_{It} - \overline{X}_i) \quad (3)$$

where N_{it} is the entry rate of industry *I* at time *t* and *X* is the equivalent exit rate. The results from calculating this are shown in the right panel of Table 6. The diagonal elements of the panel confirm that periods of above average entry and above average exit are correlated. Interestingly, this is the opposite result to the US where periods of above average entry are periods of below average exit (Dunne et al, 1988). However there is little evidence of further sorting effects. Consider the lower triangle elements of the bottom panel. If entry and exit were affected by sorting, then industries with higher than average entry would be expected to have higher than average exit in subsequent periods. The table does not support this: rather it suggests that periods of above average entry are followed by periods of below average exit. Figure 2 shows the time series variation in entry and exit rates across industries.[22] There is little cross-industry variation in the time series behaviour of these rates, reinforcing the impression given by the series for manufacturing industry as a whole (Figure 1).

[22] We have again smoothed out the spikes in 1983, 1984 and 1988.

Figure 2
Entry and exit rates across two digit industries



Source: author's calculations using selected and non-selected data from the ARD.

4 Modelling the Survival of Cohorts of Establishments

Studies of entry and exit rates at a point in time are useful in examining the turnover of establishments. But to understand establishment survival we can exploit the longitudinal aspect of the data. In this section we therefore estimate how the hazard rate of exit depends on establishment, business cycle and cohort variables.[23]

There are a number of theories of firm survival that have been addressed in the empirical literature. Audretsch (1995) argue that firms enter at a small initial size relative to minimum efficient scale and so will exit unless they can grow. Hence hazard rates should depend on initial size and growth. Jovanovic (1982) and Ericson and Pakes (1992) argue that a firm's success depends on its learning about its ability; survivors are those who have good ability and so become large. Hence hazard rates should depend on current size. Our

[23] Other studies that study exit rates are Mata et al (1995), on a similar data set for Portugal and Audretsch and Mahmood (1995) using a cohort of US firms started in 1976. Boeri and Bellmann (1995) estimate the log odds ratio of the hazard rate on German data and Doms et al (1995) estimate a binary probit for whether a

investigations are also motivated by a number of other questions. Do, for example, establishments 'born' in different cohorts have different chances of survival? How is survival affected by the business cycle? Are establishments of a particular age particularly at risk of failure over the business cycle?

To investigate this we estimate a Cox proportional hazard model on all cohorts of establishments born between 1980 and 1990.[24] 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). Then we write

$$\lambda_{it} = \lambda_0(t)\exp(Z(t)\beta) \tag{4}$$

where $\lambda_0(t)$ is the baseline hazard and **Z** is a vector of variables. Three questions that arise are therefore (i) modelling the baseline hazard (ii) the proportional hazard assumption and (iii) choice of variables in Z.[25] As for the baseline hazard, a parametric specification of the baseline may lead to misspecification. We therefore adopted the Cox (1972) specification, which being non-parametric specifies the baseline hazard very flexibly (Mata et al, 1995, and Audretsch and Mahmood, 1995, also use the Cox model). As discussed above we have a number of sampling changes which we shall deal with by dummies[26] but the advantage of the non-parametric baseline is that it will also pick up any other sampling effects in the event that time dummies are too crude.

Turning to the proportional hazard assumption, this implies that the impact of, say, initial employment on the hazard is the same irrespective of whether the firm is one year old or 10 years old. Since this seems to be excessively restrictive, we interacted all our basic variables with *AGE*. Thus we can test the effect on the hazard of, for example, being a large firm but of younger or older age. Given the stress in the theoretical work on learning,

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plant failed or not between 1988 and 1991. For a justification and illustration of using conditional rather than unconditional probability distributions, see Kiefer (1988).

[24] See Lancaster (1990) for a discussion of duration models.

[25] A separate question is how to admit unobserved heterogeneity to the model. The difficulty here is that this substantially complicates the estimation procedure. With over a million observations the computations incorporating unobserved heterogeneity took too long to be practical.

[26] We used a simple 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.

this seems important. We have not seen this done in other hazard studies, but as we show, the interaction terms are important.[27]

Our choice of Z variables was influenced by other studies, though of course limited by data available on particular variables in our data set. Previous work has typically included size, initial size, demand and whether the firm is part of a larger group. We therefore include log of employment (*size*) to investigate whether size helps or hurts exit chances.[28] Unlike other studies, we also included $size^2$ since it seems reasonable to allow size to have a non-linear effect. We also included initial size and its square (*isize* and $isize^2$). We experimented with whether a firm is a single establishment, as opposed to being part of an establishment group (*SINGLE*).[29] To deal with the possible influence of the cycle we entered real manufacturing output growth (σ). Finally, we entered a vector of cohort and industry dummies as well as the time dummies set out in note 26 above (*DUM*). Thus our Z variables can be written

$$Z_{it} = \beta_1 size_{it} + \beta_2 size_{it}^{\ 2} + \beta_3 isize_i + \beta_4 isize_i^{\ 2} + \beta_5 \sigma_t + \beta_6 SINGLE_{it} + \beta_7 DUM_t \quad (5)$$

and entering the Z variables and their interaction with *AGE* gives the specification of the hazard as

$$\lambda(t, x, \beta) = \lambda_0(t) \exp\{\alpha_1 Z + \alpha_2 Z * AGE\} \quad (6)$$

The results of estimating (6) are set out in Table 7. Column 1 enters the basic regressors linearly and shows similar results to those obtained elsewhere; *size* has a negative effect, suggesting that increases in size lower the probability of exit and *isize* a positive effect, which seems to suggest that high initial size raises exit rates. We remark on this below. Demand, σ has a poorly defined positive effect, but suggests that increases in demand raise the hazard rate[30] and *SINGLE* is negative, suggesting that single firms have less chance of

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[27] With the Cox specification we cannot enter age directly since it is collinear with the baseline hazard. We could enter age directly if we adopted a parametric specification for the baseline, but we would then be relying on identification of the age effect from the assumed functional form. Studies such as Boeri and Bellman (1995) whose dependent variable is the log odds hazard ratio can enter age directly.

[28] Strictly speaking, since size also depends on elements of the Z vector, we should either instrument size or estimate size and survival simultaneously. We leave this to later work.

[29] We did not include initial single status, which was considered by Dunne, Roberts and Samuelson, (1989) and Mata (1995) since it was highly collinear with single itself. Results replacing single with its initial value were very similar.

[30] Different studies find different effects of "demand" variables on hazards. Audretsch and Mahmood (1995) find that low unemployment and high industry growth lower hazard rates, but that high interest rates also

exit. This latter effect might be seen as counter-intuitive since multiplant firms might be expected to benefit from economies of scope and cross-subsidisation, but has also been found by Mata et al (1995) for Portugal.[31] We return to this finding below.

Table 7
Hazard estimates (numbers are the αs in equation 6)

	1		2		3	
Covariates	coeff	t-stat	Coeff	t-stat	Coeff	t-stat
size	-0.234	26.41	-0.261	18.63	-0.162	4.44
size^2	-	-	0.015	3.21	0.055	4.88
isize	0.069	7.74	0.193	13.13	0.048	1.30
isize^2	-	-	-0.048	9.56	-0.083	7.33
σ	0.002	1.32	0.002	1.36	0.037	10.39
SINGLE	-0.117	16.08	-0.141	19.52	0.284	20.21
*size*AGE*	-	-	-	-	-0.011	1.33
size^2**AGE*	-	-	-	-	-0.012	5.33
*isize*AGE*	-	-	-	-	0.045	5.45
isize^2**AGE*	-	-	-	-	0.006	2.65
σ**AGE*	-	-	-	-	-0.012	11.36
*SINGLE*AGE*	-	-	-	-	-0.187	35.20
cohort 80	-0.154	6.57	-0.123	5.27	-0.120	4.89
cohort 81	-0.317	12.36	-0.291	11.35	-0.280	10.69
cohort 82	-0.408	14.70	-0.381	13.63	-0.364	13.05
cohort 83	-0.312	10.28	-0.281	9.18	-0.222	7.33
cohort 84	0.136	7.60	0.154	8.57	0.101	5.46
cohort 85	-	-	-	-	-	-
cohort 86	0.191	17.23	0.210	18.87	0.190	16.87
cohort 87	0.196	17.56	0.215	19.21	0.155	12.62
cohort 88	0.013	0.50	0.021	0.81	-0.075	2.83
cohort 89	0.315	29.91	0.336	31.57	0.299	28.13
cohort 90	0.185	12.12	0.206	13.40	0.245	15.27
Log likelihood	-1,440,654.4		-1,440,517.9		-1,439,822.5	

Notes: Estimates are coefficients from Cox proportional hazard estimates. Cohort (cohort 1985 omitted) and two digit industry dummies (the latter not reported) included along with register change dummies. Absolute robust t-statistics reported. Number of obs:= 475,402, a 50 percent random sample of the full sample of to ease computation time.

Column 2 adds the polynomial terms. Both are significant and a likelihood ratio test of column 1 versus column 2 rejects the restricted version in column 1 ($\chi^2_{(2)}$=273, critical level at 99 percent is 9.21). Note that the quadratic terms suggest that the relationship is more complicated than a linear specification. Since *size* is in logs, following Mata et. al.,

lower them. Mata et al (1995) find that high industry growth lowers hazard rates, but that industries with high growth and high entry have raised hazard rates (they also include time dummies in their regression but these are not reported).

[31] The negative effect of single is rationalised in Baden-Fuller (1989) by assuming that multi-plant firms are more efficient in reassigning labour although this does not explain why such firms would not be more efficient overall. Reynolds (1988) reasons that remaining plants in a multi-plant firm are more likely to benefit from a reduction in the number of suppliers than a single plant.

(1995) we can rearrange the terms to write the equation in terms of *isize*, growth and higher order terms obtaining:

$$\theta = -0.068 isize - 0.033 isize^2 + (size - isize) - 0.261 + 0.030 \frac{(size + isize)}{2} \qquad (7)$$

which has the following interpretation. Initial size has a non-linear effect on the hazard; larger initial firms have declining hazards but at a diminishing rate. The second term shows the effect on the hazard of growth from initial entry size and shows that the effect depends on the average size of the firm. Consider firms declining from their initial size. They have a rising chance of exit, but if their average size is over 6,000, declines in size lower their chance of exiting. Conversely, consider firms growing from their initial size. They have a declining hazard, but if their average size reaches 6,000 their hazard of exit rises.

Column 3 interacts these terms with *AGE*. All terms vary with age and once again the likelihood indicates that the additional variables are jointly significant. This suggests that this way of relaxing the proportional hazard model is statistically desirable. Note too that the effect of σ becomes much better defined. Rewriting gives that

$$\begin{aligned} \theta = &-0.148 isize - 0.022 isize^2 + (size - isize) - 0.074 + 0.124 \frac{(size + isize)}{2} \\ &+ 0.034 isize - 0.006 isize^2 + (size - isize) - 0.023 - 0.024 \frac{(size + isize)}{2} * age \\ &+ 0.025\sigma - 0.012\sigma * age + 0.097 SINGLE - 0.187 SINGLE * age \end{aligned} \qquad (8)$$

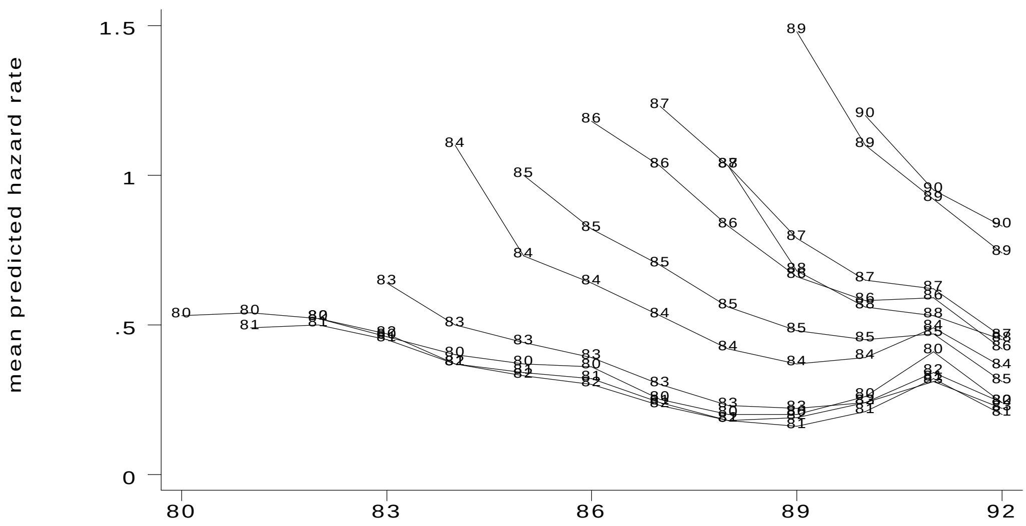
where in (8) *age* is measured as (*AGE*-1) so that *age* means that in the first year of an establishment existence its age is set to zero.

Thus the basic message of (8) is that the effects of the Z regressors depend on age. Consider *isize*. As in (7), a larger initial size reduces the hazard, but at a diminishing rate. But as (8) shows, the effect of *isize* wears off as a company gets older: this seems intuitive. For the average size of the entrant (3.46 employees=1.24 in logs), the beneficial effect of *isize* goes to zero after one year. As for the effects of growth, firm growth reduces the hazard of exit, as in (7). In addition, (8) shows that this marginal impact is increased with age, and the effect of average size is to lower the marginal effect of growth as the company gets older. Turning to the effects of σ, an increase in demand appears to raise hazard rates. This is true however only for young firms; after two years an increase in demand lowers hazard rates. Likewise, single firms are more likely to survive initially but after a year are less likely to do so. Hence the interaction with *AGE* shows the perhaps counter-intuitive negative effects of *SINGLE* and positive effect of σ on the hazard are due to the failure to interact with *AGE*.

These results therefore suggest an element of truth in both Audretsch (1995) on the one hand and Jovanovic (1982) and Ericson and Pakes (1992) on the other. Both initial size and the subsequent growth of the establishment are important. But the relationship is non-linear: the 'benefits' (in terms of survival) of initial size wear off quickly. The impact of growth also varies with age. Crucially, too, age of establishment is an important determinant of the impact of demand conditions and of single status of the establishment.

Another striking feature of the data is the pattern of cohort dummies. All the specifications in Table 7 show a consistent pattern: namely an increase in the average hazard rate over successive cohorts. This is in contrast to other work on the issue which either ignores cohort effects or finds no significant trend. The omitted cohort dummy is 1985. Cohorts before 1983 are significantly less than this, and the signs on the coefficients after 1985 (bar 1988) show a significant rise. All this suggests that over the period each successive cohort had a rising probability of exit compared with earlier cohorts. This phenomenon is illustrated in Figure 3.

Figure 3
Mean predicted conditional hazard rates by cohort



Note: the figure shows the predicted hazard rates, by cohort and year using predicted values from the equation estimated in table 7, column 3, removing the effects of the register dummies.

What may have caused these 'cohort effects'? There are at least three possible explanations. One possibility is the change in register sampling which, with its increased sampling of small firms, may give the appearance of increased hazards after 1984. Recall that the omitted year in Table 7 is 1985. We observe significant positive coefficients in all but one of the years after 1985, suggesting a continued upward trend in the hazard even after the change in the register. An alternative way of making the same point is to examine the impact of the average cohort effect over time. To do this we tested, for each cohort, if the average of following cohorts is significantly different from that of the preceding cohorts.[32] In all but a comparison of 1980 with the average cohort effect 1981-90, the difference between the average cohort effect after and before each year indicates a rise in the average hazard, and this rise is significant in all but two years (1981 and 1982). Thus we do not simply believe that this increasing hazard over time is a register effect. A second possibility is that the cohort dummies are picking up time variation in the economic environment, particularly demand conditions at the time of establishment set-up. Thus, for example, the years 1989-90 were recession years, and there is also the possibility of relationships between cycles and, say, initial entry characteristics, notably size. It is apparent from Table 7 however that a specification including age interactions, including an interaction with demand, σ, although significant, does not affect the significance of the individual cohort dummies. Further specifications[33] which include interactions of all the variables with initial size, for example, do not eliminate these cohort effects either.

A third possibility is that the firms which entered as the decade wore on had different characteristics to those in earlier periods. In particular, they may be from different industries. For example, Table 5 suggested much higher rates of entry and exit in the computer industry (SIC 33) than in the textile industry (SIC 43). Suppose, for example, that over time SIC 43 declined in importance and SIC 33 increased its share of establishments. Then we might expect to find rising exit (and entry) over time. A natural experiment is to see whether cohort effects are present when we examine individual two-digit industries. We provide sample regressions for a number of different industries in Table 8 and plot some predicted hazard rates by cohort in Figure 4.

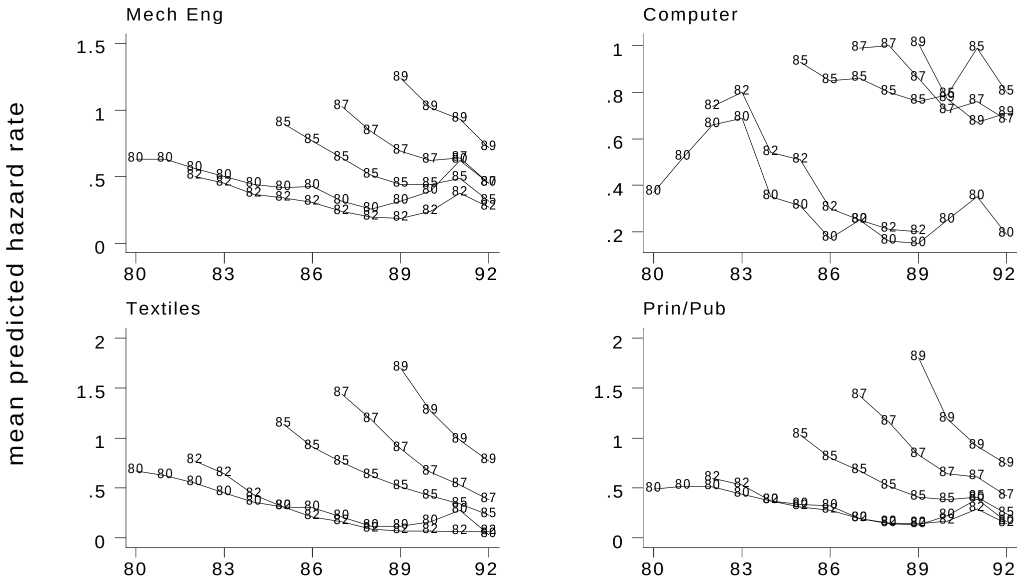
Table 8
Hazard estimates (numbers are the αs in equation 6) for selected two-digit industries

Covariates	**Mechanical engineering**		**Computers & office equipment**		**Textiles**		**Printing & Publishing**	
	coeff	t-stat	Coeff	t-stat	Coeff	t-stat	Coeff	t-stat
size	-0.163	1.65	-0.580	2.32	0.356	1.87	-0.232	2.22
$size^2$	0.084	2.57	0.059	0.85	-0.045	0.83	0.055	1.74
isize	0.014	0.14	0.387	1.50	-0.342	1.79	0.050	0.47
$isize^2$	-0.107	3.14	-0.058	0.76	0.005	0.10	-0.058	1.76
σ	0.015	1.65	0.078	2.34	0.023	1.22	0.063	6.38
SINGLE	0.208	5.70	-0.061	0.51	0.419	6.33	0.294	8.73
*size*AGE*	-0.008	0.36	0.075	1.30	-0.096	2.26	-0.020	0.87
$size^2$**AGE*	-0.015	2.36	-0.011	0.90	-0.005	0.48	-0.004	0.66
*isize*AGE*	0.054	2.39	-0.010	0.16	0.086	2.04	0.058	2.40
$isize^2$**AGE*	0.007	0.98	-0.007	0.37	0.004	0.36	-0.008	1.15
σ**AGE*	-0.010	3.76	-0.017	1.70	-0.005	0.96	-0.017	6.19
*SINGLE*AGE*	-0.182	12.39	-0.019	0.39	-0.217	9.24	-0.219	16.86
cohort 80	0.000	0.00	0.046	0.20	-0.187	1.52	-0.117	1.55
cohort 81	-0.179	2.51	-0.144	0.68	-0.538	3.61	-0.269	3.54
cohort 82	-0.329	4.60	0.124	0.56	-0.208	1.60	-0.273	3.26
cohort 83	-0.091	1.18	0.132	0.68	-0.391	2.57	-0.158	1.83
cohort 84	0.186	3.69	0.196	1.31	0.009	0.09	0.181	3.54
cohort 85	-	-	-	-	-	-	-	-
cohort 86	0.216	7.14	0.077	0.84	0.139	2.23	0.248	8.03
cohort 87	0.129	3.97	-0.028	0.29	0.189	2.94	0.237	7.15
cohort 88	0.043	0.63	-0.066	0.31	-0.123	0.86	0.065	0.99
cohort 89	0.269	9.22	-0.047	0.50	0.318	5.53	0.425	15.10
cohort 90	0.201	4.77	0.032	0.22	0.321	3.92	0.456	10.35
Number of observations	79,418		4,279		14,799		74,914	

Notes: Estimates are coefficients from Cox proportional hazard estimates. Cohort (cohort 1985 omitted) and two digit industry dummies (the latter not reported) included along with register change dummies. Absolute robust t-statistics reported. Number of observations are a 50 percent random sample of the full sample.

[32] For example in 1984 we tested if the average cohort effect 1985-90 was different from the average 1980-84.
[33] Further specifications available on request from the authors.

Figure 4
Mean predicted conditional hazard rates by cohort for selected industries



Note: the figure shows the predicted hazard rates, by cohort and year using predicted values from the equation estimated in table 8, columns 1-4, removing the effects of the register dummies. To avoid clutter not all predicted hazards for all cohorts shown.

Again the results suggest a pattern of rising hazard rates by cohort, with the exception of the 'computing and office equipment' industry, where there is no clear cut evidence of a rising hazard. These illustrations cast doubt on any explanation of the rising cohort hazard in terms of industrial composition, not least because one of the industries with high exit and entry rates which we might expect to have become of growing importance over time (computers and office equipment) is in fact the one industry illustrated for which there is no distinct rising hazard by cohort over time.

If these three explanations for the cohort effects (register changes, demand conditions and industrial composition) are rejected, we are left with the default explanation that the 1980s saw an increase in the competitive environment in the UK, which both increased the number of new establishments but which also made existing establishments more vulnerable to exit. Further work, perhaps examining individual industries and examining cohort effects explicitly in comparative studies across countries, might shed further light on this issue.

5 Conclusions

This paper has provided new evidence on entry, exit and survival of establishments, using a newly released UK database. We have examined patterns of entry and exit, and the data exhibit similar features to studies in North America and Europe. We have also, in common with a small set of studies in other countries, estimated hazards of exit for manufacturing industry as a whole and for individual industries. Some of our findings provide support for hypotheses tested elsewhere (although not, to our knowledge, in the UK). However two new findings concern the complexity of the relationship between initial size, subsequent growth of employment and age, and also the importance of cohort effects, and therefore the apparent secular increase in the hazard of establishment exit over the 1980s. Finally, we suggest that there are clearly a number of additional hypotheses left to explore, such as the joint determination of employment growth and hazard rates. But we believe that even this preliminary exploration of this rich data set has uncovered some important facts and raised interesting questions.

Data Appendix

Definitions to covariates in Table 7 and Table 8.

size	the natural log of the number of employees per establishment
size2	the square of *size*
isize	the natural log of the number of employees per establishment when it appeared in the data set for the first time
isize2	the square of *isize*
σ	the first difference of log real manufacturing output
SINGLE	a dummy variable that equals one if an establishment is not part of an enterprise group
*size*AGE*	*size* interacted with age of the establishment
*size2*AGE*	the square of *size* interacted with age of the establishment
*isize*AGE*	*isize* interacted with age of the establishment
*isize2*AGE*	the square of *isize* interacted with age of the establishment
σ**AGE*	σ interacted with age of the establishment
*SINGLE*AGE*	*SINGLE* interacted with age of the establishment

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