Employment Creation in Small Technological and Design Innovators in the U.K. during the 1980s

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ABSTRACT. This paper provides rare empirical evidence on employment creation by innovative small firms in the U.K. over the eleven years between 1980 and 1991. Drawing on a database of firms which were recognised as having introduced important innovations, the paper examines the extent of employment growth in these companies and compares their growth with that discovered by other studies of small firms in the U.K. This shows that the innovative firms have grown at a significantly faster average rate than small firms generally. Some of the factors associated with employment change in small firms are assessed. This shows that the initial size, age, sector of activity and type of innovation introduced by the firms were all associated with differences in their average rate of growth. The employment created was, however, highly concentrated in a few firms, but even the fastest growing of these companies (directly) created hundreds rather than thousands of new jobs over the period of analysis.

Introduction

Over the last twenty years, small firms have been seen as an increasingly important source of economic regeneration through technological innovation (Pavitt et al., 1987; Acs and Audretsch, 1990) and the creation of new employment (Birch, 1979). In the United Kingdom in particular, the Thatcher and Major governments (1979–1997) placed a strong emphasis on the ability of new and small firms, especially those that were innovative or technology-based, to rejuvenate the economy and to provide new large enterprises. For example, responding to the report on "The Enterprise Challenge: Overcoming the Barriers to Growth in Small Firms" by the Advisory Council on Science and Technology (ACOST, 1990), the government stated:

> SMEs have a crucial role to play in bringing about a dynamic and competitive economy. They have a significant role in innovation, and are a major source of new competition and new employment opportunities. . . . While most SMEs are likely to remain small the minority which do grow rapidly have a particularly important role to play; amongst other things they have the potential to become the new large firms of tomorrow.
>
> Extract from the U.K. Government's Response to the ACOST Report (1990)

There can be little doubt that innovative or technology-based firms were expected to provide a sizeable proportion of the minority which grow rapidly.

More recently, the Bank of England has entered the debate, reporting on "The Financing of Technology Based Small Firms" (Bank of England, 1996). The involvement of the Bank of England is indicative of both the perceived importance of this type of firm (to the development of the U.K. economy) and the perception that the U.K. has failed to realise its potential in terms of their development.

Oakey (1991, 1993) has criticised the stance of the Conservative governments of the 1980s. He claims that, on the basis of some highly questionable assumptions about the employment growth potential of innovative and technology-based new and small firms, such firms mistakenly became a "virtual panacea" for long-standing structural economic problems, and that these

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governments' preoccupation with the perceived potential of these firms led to their indifference to the fates of existing large firms in other sectors, such as motor vehicles and aerospace.

But despite their perceived importance, little research has been conducted in the U.K. at the micro-level on the actual extent of employment growth amongst innovative small firms. Such research would provide an objective assessment of their true contribution to employment growth and economic regeneration. The purpose of this paper is to provide some evidence on employment growth amongst innovative small firms in the U.K. during the 1980s.

The structure of this paper

This paper provides evidence on the individual and collective growth of a set of 149 innovative small firms in the U.K. over the period 1980 to 1991. Although other studies have tracked the growth of "high technology" small firms in the U.K., these have typically assessed companies over relatively short time periods (of up to six years). Here employment creation within firms is monitored over an eleven-year period.[1] Furthermore, the analysis tracks firms which are known to have been innovative, having introduced a product or technology which was judged by independent experts to be outstanding according to established criteria.

After the discussion of the data-set, the analysis is divided into four sections. The first examines the aggregate amount of employment directly created by the innovative small firms in the data-set. This section also attempts to provide an objective assessment of their employment growth performance by comparing their average rate of (direct) employment creation with that achieved by small firms in other studies based in the U.K. during the 1980s.

The second analytical section investigates, through univariate analysis, some of the factors associated with employment change in the firms. These factors include the initial size of the firms, their age, sector of activity and the type of innovation they introduced. This section thereby monitors some of the factors which might systematically affect the rate of employment creation in the firms.

The third section investigates the variation in the rate of employment change within the sample of the firms, thus providing an assessment of the extent to which growth is peculiar to individual firms. It reveals the extent to which employment creation is concentrated in a few firms, and provides an indication of the extent of direct employment creation achieved by the fastest growing of these innovative small firms over the eleven-year period.

The fourth section, which concludes the analysis, employs multivariate analysis to draw together the evidence presented in the second and third sections. Lastly, some conclusions are provided.

The data-set

The firms examined in this paper are described as "innovative" because each produced a product or technology which was recognised as outstanding through winning either the Queen's Award for Technological Achievement or the British Design Award between 1980 and 1990.

Both of these award schemes are state-run and are therefore independent of commercial interests; both rely on panels of independent experts to judge the excellence of innovations which companies seeking to win the awards submit for assessment. Both schemes claim to grant their awards solely on the merit of the technologies or designs assessed, and in both cases less than 10% of the applicants receive the award (Tether, 1996).

For each year between 1980 and 1990, both award schemes provided a list of the award winning innovations and the firms responsible for their introduction. These lists provided the sampling frame to which further information was added with respect to the size (in terms of employment) and ownership (independent or subsidiary) of the innovating firms in 1980, 1986 and 1991. The year of each firm's establishment was also collected, as was information on its sector of activity.

Although both schemes were open to companies of all sizes, this paper concerns only those that were SMEs[2] at the start of the period of analysis (1980), or which were established as SMEs during the 1980s, and which survived until 1991.

Whilst the use of the two award schemes offers advantages in terms of the independent recognition of innovative outputs (rather than relying on firms to identify themselves as innovative), their use also imposes some important limitations which should be noted. The first is that the awards recognise mainly product innovations from manufacturing firms. Although twelve computer software innovations (and therefore software firms) are included, the product innovation and manufacturing bias, which is common to most data-sets of innovations, means that process and service sector innovations are largely absent from the analysis. A second limitation is that the paper only considers employment change within the firms studied. Because an assessment of indirect employment change is extremely difficult to undertake, the analysis does not account for the employment lost from the firms' competitors as a result of their development, nor does it account for the employment created within the firms' supply chains. The paper therefore assesses direct employment creation within small innovative producer firms in the U.K. during the 1980s, and not the employment implications of innovative small firms more generally.

1. Employment change in context

This first analytical section provides evidence on the aggregate amount of employment created by the set of innovative small firms in the U.K. The section begins by presenting the aggregate number of jobs directly created by the firms, but its purpose is to provide an objective assessment of the average employment creation performance of these firms. This is done by comparing their median rate of employment creation with those discovered by other studies of small firms, including "high technology" small firms, in the U.K. during the 1980s.

With regard to the aggregate number of jobs directly created by the firms, the 119 firms which existed in 1980 provided almost ten thousand more jobs in 1991 than they had provided in 1980, and through this growth they more than doubled their aggregate employment over the period of analysis. Furthermore, by 1991, 1,788 people were employed by the 30 firms established after 1980.

Whether this performance is regarded as successful, or disappointing, will depend on the (subjective) expectations of the reviewer, but a comparison with the results of other longitudinal studies of small firms in the U.K. provides an objective benchmark by which the employment growth performance of the firms can be assessed.

1.1. *A comparison with other studies of small firms*

Direct comparisons of the employment growth "performance" of different sets of firms are difficult due to a raft of influential factors (Storey, 1994), but the employment created by the award winning firms can, nevertheless, be compared with three other longitudinal studies of small firms in Britain: North et al.'s (1994) study of small manufacturing firms located in three areas of the U.K.; a study of a representative sample of small firms (including service sector firms) in Britain by Jones (1991); and a study, by Westhead and Cowling (1995), of high-technology (manufacturing and service) small firms located on and off science parks in the U.K.

North et al.'s (1994) study relates to employment creation within surviving small manufacturing firms over the whole of the 1980s (actually 1979–1990) and includes only firms that had fewer than 100 employees in 1979. To compare the employment created by North et al.'s "not known to be innovative" firms with that created by the award winning innovators, only those award winners which had fewer than 100 employees in 1980 are used in the comparison. Despite this restriction, the award winning small firms included had, in 1980, a mean of 28 employees, eight more than the 1979 mean in North et al.'s study. Therefore, at the start of the period of analysis, the mean size of the North et al. firms was only about three-quarters of that of the innovative small firms included in the comparison.

Unlike the North et al. study, the Jones (1991) and Westhead and Cowling (1995) studies both relate to employment creation by small firms in the latter part of the 1980s. In making a comparison with these studies, the analysis will assess the employment created by the innovative small firms over the 1986 to 1991 period. For this comparison the analysis of the award winners was restricted to the smallest category of firms – those with

fewer than 50 employees in 1986 – because the mean sizes of the firms in the other studies were much smaller than that of all of the innovative SMEs. But again, despite this restriction, the mean size of the award winning firms included was (in 1986) more than twice that of the firms from the general population in the Jones study (in 1985). However, the mean employment of the award winners was similar to that of the "high technology" small firms in the Westhead and Cowling study (in 1986).

Employment change can be measured in two ways: absolute or relative growth. For data-sets that include very small companies, relative changes in employment (i.e. percentage changes over time) can be misleading because a very small absolute change in the number of jobs can result in a large percentage change in employment. Because of this, the examination of employment change in this paper uses an absolute measure of employment change. To provide a standardised measure of the absolute employment created within the surviving firms over time, the mean "mean annual (employment) change" (MAC) was calculated. For individual firms, this is given by:

$$\mathrm{MAC}_i = \frac{E_{i,t_1} - E_{i,t_0}}{t_1 - t_0}$$

Where E_i is employment in firm i, t_0 is the start of the period of analysis and t_1 is the end of the period of analysis. Averages can then be derived to compare the "performance" of different samples. However, in any sample of firms, employment creation tends to be concentrated in a small proportion of the firms (Storey, 1994, and section 3 below), so while the sample's mean MAC provides a standardised measure of employment growth per firm, its median MAC provides a truer indication of the employment change in the "average" firm within the sample. We stress, however, that even the median does not provide a wholly robust comparison, as influential factors, such as sample composition[3] and the period of study, will influence the results. What the median does provide is an illustrative comparison of the average number of jobs created annually by the "average" firm in each study.

Table I provides both the mean and median rates of employment creation amongst these sets of firms,[4] but we focus on the medians rather than the means. The table shows that between 1979 and 1990 the median "not known to be innovative" small manufacturing firms in the North et al. (1994) study created 0.1 new jobs a year. In comparison, between 1980 and 1991, the median annual rate of employment creation amongst the surviving award winners with fewer than 100

TABLE I
A comparison of employment creation in surviving firms

Study	Number of firms assessed	Mean employment at t_0	Mean employment at t_1	Employment change $t_1 - t_0$	Mean MAC $t_1 - t_0$	Median MAC $t_1 - t_0$
North et al.'s Study	302	20.9	24.7	+1,159	0.4	0.1
Award Winners I	89	28.5	121.5	+8,273	8.3	3.9
Jones' Study	130	7.7	8.8	+149	0.2	0.0
W & C Study: SP	31	11.3	26.8	+508	2.6	1.2
W. & C. Study: OP	46	21.4	37.8	+713	2.7	0.5
Award Winners II	64	16.7	32.6	+1,017	3.2	1.1

MAC – Mean annual (employment) change between t_0 and t_1

North et al.'s study	North et al.'s (1994) study of manufacturing SMEs	t_0: 1979	t_1: 1990
Award Winners I	Award winners with less than 100 employees in 1980	t_0: 1980	t_1: 1991
Jones' study	Jones (1991) general population of SMEs	t_0: 1985	t_1: 1991
W & C Study: SP	Westhead and Cowling (1995) "Science Park" firms	t_0: 1986	t_1: 1992
WW. & C. Study: OP	Westhead and Cowling (1995) high tech. small firms not located in science parks ["Off-Park" firms]	t_0: 1986	t_1: 1992
Award Winners II	Award winners with fewer than 50 employees in 1986	t_0: 1986	t_1: 1991

employees in 1980 was 3.9 new jobs a year. The average rate of employment creation amongst the innovative small firms was therefore considerably greater than that found for North et al.'s sample of small manufacturing firms from the general population.

Table I also shows that, in the second half of the 1980s, the median firm in Jones' (1991) study did not create any new employment. By contrast, the median Science Park firm in the Westhead and Cowling (1995) study created a mean of 1.2 new jobs a year, whilst its "Off-Park" counterpart created a mean of 0.5 new jobs per year. The median award winner with fewer than 50 employees in 1986 created a mean of 1.1 new jobs per year,[5] a median growth rate very similar to Westhead and Cowling's Science Park firms.

From their analysis, Westhead and Cowling (1995) conclude that the average absolute rate of employment growth amongst technology-based small firms is markedly higher than that in more "conventional" firms (i.e., Jones, 1991). This contrasts with the recent study by Cosh et al. (1996) who found the median rate of employment change amongst "innovative" small firms (between 1990 and 1995) was the same as that achieved by non-innovative firms.[6] From the evidence presented here, it would appear that, like Westhead and Cowling's technology-based firms, the innovative firms in this study of award winners have "out-performed" firms from the general population in terms of employment creation.

2. Factors associated with employment change in the SMEs

The analysis in Section 1 showed that the innovative small firms examined in this paper have, as a group, grown rapidly relative to small firms in the general population. Furthermore, they have matched the superior growth performance demonstrated by the high technology small firms examined in Westhead and Cowling's (1995) study. The next obvious question to arise is: "what factors are associated with the employment growth performance of these firms?"

Although this question is interesting, it has dangers. By assessing "the factors which affect growth", such investigations imply that growth was a desired outcome. This may be the case from a policy perspective, but employment growth for its own sake was unlikely to have been a common objective of these businesses. Moreover, most small businesses do not strive for rapid growth, preferring instead modest expansion or to remain stable in size (Hakim, 1989; Cambridge Small Business Research Centre, 1992). It is therefore important to appreciate that the failure to create employment is not a business failure.

But the question "what factors affect the employment growth performance of companies?" is often asked and a raft of factors have been associated with employment growth in firms. Through a review of the evidence, Storey (1994) argues that it is a coincidence of attributes relating to three dimensions which distinguishes rapidly growing firms from those that remain stable in size or decline. These three dimensions are:

1. the starting resources of the entrepreneur(s)[7]
2. the (characteristics of the) firm[8]
3. the strategy[9] (followed once the business has started)

In assessing the factors associated with the growth of firms, researchers have been hampered by both a lack of consensus with regard to the theory of firm growth (such a theory would provide a strong indication of the variables required for empirical analysis), and by the difficulties of gathering the data to assess the impact of the factors suggested by the literature.

Overwhelmingly, studies of employment change in small firms have focused on the variables that are easy to collect, but these are not necessarily those with the greatest bearing on employment growth within firms. Consequently, the variables assessed differ (according to their availability) from study to study, but even those studies which assess a large number of factors, such as that by Westhead and Cowling (1995), cannot claim to have examined an exhaustive list of those which might affect employment change in small firms. All multivariate analyses based on these data-sets therefore face the possibility of model miss-specification errors which can lead to erroneous interpretations of the data. We stress that our own multivariate analysis in Section 4 is not immune to this criticism. A further point to note is that as employment growth and loss are highly concentrated in a few firms (see Section 3

below), the characteristics of the firms at the extremities can dramatically affect the "performance" of the categories to which they belong. For these reasons it is useful to present simple and descriptive univariate assessments of the factors available before attempting to assess their interaction in multivariate analysis.

The analysis which follows does not claim to investigate all of the factors which influenced employment change in the award winning small firms, especially because there are no data to examine the characteristics of the entrepreneurs or the strategies of the firms (Storey, 1994). Instead, only a few characteristics will be assessed: the firms' initial size; their age; sector of activity; and the type of award they won. These factors are very limited and the patterns discovered by the analyses may conceal the true factors which systematically influenced the change in employment within these firms. On the other hand, the patterns discovered are consistent with plausible theoretical arguments and/or the patterns found by previous empirical studies.

2.1. *Employment change by the initial size of the firms*

Previous studies have found employment growth to be both positively and negatively related to the initial size of the firms assessed (Storey, 1994), although more studies have found a negative relationship, with the rate of employment growth declining with increasing initial firm size (Evans 1987a, Evans 1987b).

Table II shows this was the case for the innovative small firms assessed in this paper. Amongst the smallest firm in 1980 (those with fewer than 50 employees), the median firm increased its employment by a mean of 3.7 new jobs a year over the eleven year period to 1991. This was a higher mean rate of employment creation than that achieved by the median firms in the other categories of larger small firms (50–199 employees in 1980 – median MAC = 3.0) and medium-sized firms (200–499 employees in 1980 – median MAC = 1.4).

2.2. *Employment change by the age of the firms*

With regard to the age of the firms, previous studies have shown that, of all small firms, it is the youngest that are the most volatile; they are both the most likely to close and the most likely to grow (Evans, 1987b).

Table III shows that, with regard to growth, this was broadly the case for the award winning small firms, although it was not the youngest firms (those established in the 1980s) which grew at the most rapid rate, but those established in the second half of the 1970s. These firms, which formed 19% of the sample, were responsible for 32% of the employment created by the full sample of firms. Amongst these, the median firm increased its employment by a mean rate of 5.3 new jobs a year. By contrast, the slowest growing group were those established in the 1960s; the median firm amongst which created a mean of just 1.7 new jobs a year.

TABLE II
Employment creation by the initial size of the firms which were established by 1980

Firm size in 1980	Number of firms	Total employment in 1980	Total employment in 1991	Employment change 1980–1991	Mean MAC [s.d.]	Median MAC
1–49 employees	66	911	7,230	+6,319	8.7 [14.5]	3.7
50–199 employees	39	3,869	6,353	+2,484	5.8 [11.7]	3.0
200–499 employees	14	4,562	5,498	+936	6.1 [20.5]	1.4
All firms	119	9,342	19,081	+9,739	7.4 [14.5]	3.6

MAC – Mean annual (employment) change. [s.d.] – standard deviation.
To assess whether the average growth rate differed significantly between the categories, Mann-Whitney tests were conducted which compared the firms in each of the categories with those in the other categories. Mann-Whitney tests were conducted because the distributions could not be assumed to be normally distributed. No significant difference was found for the two larger categories, whilst the smallest firms differed from the larger firms at the 11% level.

TABLE III
Employment creation by the age of the firms

Year established	Number of firms	Total employment in 1980	Total employment in 1991	Employment change 1980–1991	Mean MAC [s.d.]	Median MAC
Before 1961	28	5,242	7,137	+1,895	6.2 [15.4]	3.3
1961–1970	34	2,282	3,757	+1,475	3.9 [8.9]	1.7
1971–1975	29	1,304	3,986	+2,682	8.4 [14.0]	3.6
1976 –1980	28	514	4,201	+3,687	12.0 [18.2]	5.3
1981–1987	30	0	1,788	+1,788	7.4 [13.1]	3.4
All firms	149	9,342	20,869	+11,527	7.4 [14.1]	3.5

MAC – Mean annual (employment) change. For the firms established after 1980, this is calculated by dividing each firm's employment in 1991 by its age in years in 1991. [s.d.] – standard deviation.
To assess whether the average growth rate differed significantly between the categories, Mann-Whitney tests were conducted which compared the firms in each of the categories with those in the other categories. The firms established in 1961–1970 differed from the others at the 6.3% level, whilst those established in 1976–80 differed from the others at the 11% level. No significant difference was found for any of the other categories.

The median mean annual rate of employment change achieved by the youngest firms, those established between 1981 and 1987, was 3.4 new jobs per year, which was almost identical to the median rate achieved by the firms already established by 1980.

2.3. *Growth by industry*

Previous studies have shown that the average rate of employment growth in companies can vary by the sector of activity (Audretsch, 1995; North et al., 1984). Table IV shows there were differences between sectors in the average rates of employment change amongst the award winning firms.

In particular, over the 1980 to 1991 period, the median "instruments" firm grew fastest, at a mean rate of 5.7 new jobs a year. At the other end of the spectrum, the growth achieved by the median "mechanical equipment" and miscellaneous "other manufacturing" firms were comparatively modest, at mean rates of 1.6 and 1.1 new jobs a year respectively. But although the median rates of employment change amongst the "mechanical equipment" and "other manufacturing" firms appear low, it is notable that even in these sectors the median growth rates achieved by the innovative SMEs were high relative to the growth achieved by firms analysed in other studies (Jones, 1991, North et al., 1994 – see Table I above). So although there are sectoral differences in the rates at which the firms have grown, in all the sectors the innovative firms appear to have outperformed firms from the general population.

2.4. *Growth by the type of innovation introduced/type of award won*

Given that innovation has an influence on the employment growth performance of firms, it follows that different types of innovation may have different effects on employment change within firms. The fourth factor which can be examined for its association with the rate of employment change amongst the innovative SMEs is the type of award the companies won: the Queen's Award for Technological Achievement, the British Design Award, or both.

Table V shows there was considerable variation between the sets of award winners and the average rates at which their employment changed between 1980 and 1991. Amongst the small group of companies that won both awards, the median firm increased its employment by a mean rate of 3.0 new jobs a year, whereas the median firm which won only the Queen's Award increased its employment by a mean rate of 5.2 new jobs per year, and the median firm which won only the Design Award increased its employment by a mean rate of 2.3 new jobs a year.

Although these differences may be masking other factors, there are two other explanations for

TABLE IV
Employment change, 1980–1991, by the industry of innovation

Industry of innovation	Number of firms[a]	Mean employment in 1980[b]	Mean employment in 1991	Mean age in 1991	Mean MAC [s.d.]	Median MAC
Chemicals	8 + 1	202.0	280.6	30.0	9.3 [21.2]	3.5
Mechanical	28 + 4	91.1	117.4	29.6	3.6 [9.5]	1.6
Electronics & IT	18 + 9	51.5	182.8	13.5	14.8 [23.8]	4.1
Instruments	33 + 6	65.1	136.4	21.0	7.7 [8.0]	5.7
Medical equipment	14 + 4	84.0	136.7	24.6	6.6 [9.9]	3.3
Other	18 + 6	53.1	78.0	24.7	3.7 [9.5]	1.1
All firms	119 + 30	78.5	140.1	23.1	7.4 [14.1]	3.5

[a] The first figure is the number of firms that existed in 1980, the additional figure is the number of firms established since 1981.
[b] Includes only firms established by 1980.
MAC – Mean annual (employment) change. For the firms established after 1980, this is calculated by dividing each firm's employment in 1991 by its age in years in 1991. [s.d.] – standard deviation.
To assess whether the average growth rate differed significantly between the categories, Mann-Whitney tests were conducted which compared the firms in each of the categories with those in the other categories. The Instruments, Mechanical Equipment and "Other Manufacturing" firms differed from the others at the 1.1%, 2.3% and 5.6% levels respectively. No significant difference was found for any of the other categories (the significance level for the Electronics and IT sector being 15%).

TABLE V
Employment change, 1980–1991, by the type of ward won

Award won	Number of firms[a]	Mean employment in 1980[b]	Mean employment in 1991	Mean age in 1991	Mean MAC [s.d.]	Median MAC
Both awards	8 + 1	98.8	153.9	27.1	6.4 [10.9]	3.0
Queen's award	57 + 10	86.2	191.2	20.9	11.3 [18.5]	5.2
Design award	54 + 19	67.4	91.4	24.5	4.0 [7.4]	2.3
All firms	119 + 30	78.5	140.1	23.1	7.4 [14.1]	3.5

[a] The first figure is the number of firms that existed in 1980, the additional figure is the number of firms established since 1981.
[b] Includes only firms established by 1980.
MAC – Mean annual (employment) change. For the firms established after 1980, this is calculated by dividing each firm's employment in 1991 by its age in years in 1991. [s.d.] – standard deviation.
To assess whether the average growth rate differed significantly between the categories, Mann-Whitney tests were conducted which compared the firms in each of the categories with those in the other categories. Both the Queen's Award winning firms and the Design Award winning firms differed from the other firms at the 2.4% level. The firms which won both awards did not differ significantly.

the discovered differences between the two sets of award winners. The first is that the selection methodology used by the Queen's Award scheme resulted in the *ex ante* identification of more successful *firms* than did the selection methodology for the Design Awards. The second explanation is that the two schemes recognised different types of *innovation* and these had, on average, different consequences for the development of the innovating firms.

With regard to the first explanation, the selection methodologies were, in fact, very similar; both schemes used teams of experts to assess the merit of the applications submitted for the awards and both assessments focused on the innovations rather than the innovating firms (Tether, 1996). Neither assessment required long term information on the dynamic development of the applicant firms. On this basis, it seems unlikely that the methodologies used to select the firms (as opposed to the innovations) were sufficiently different to explain a large proportion of the difference in the

average employment growth rates achieved by the firms recognised by the two schemes.

By contrast, and with regard to second explanation, the selection of the innovations, there were clear differences between the two schemes in terms of the type of innovations they were seeking to recognise. The Queen's Award sought to recognise *technological innovations* which incorporate "a significant advance . . . in the application of technology . . . or the production for sale of goods which incorporate new or advanced technological qualities" (Queen's Awards for Technological Achievement application form). The Design Award, on the other hand, does not specifically recognise technological innovations. Instead, these were "given in recognition of *design innovation*; excellent performance and reliability; ease of use, manufacture and maintenance; outstanding appearance; and value for money" (Design Council, 1991).

These differences resulted in the identification, by the two schemes, of innovations which differed considerably in their nature (Tether, 1996).[10] In general, the Queen's Award recognised innovations which contained significant conceptual and technical advances. We describe these as "*technological innovations*", and the companies which introduced them as "technological innovators". As the Design Award recognised innovations which contained significant conceptual advances but which need not have contained significant technical advances, we refer to these as "*design innovations*", and to the companies which introduced them as "design innovators".

These different types of innovation require different types of knowledge and resources to develop (Tether, 1997). In particular, the production of technological innovations, which embody technical advances, requires technical knowledge which is particularly difficult to acquire. These innovations are, therefore, often difficult for rival producers to imitate, and the innovator is likely to be able to appropriate a greater proportion of the returns to the innovation than would be the case with innovations which are more easily imitated. By contrast, design innovations, especially those which contained conceptual but not technical novelty ("concept-based innovations" – Tether, 1997),[11] are easier for rival producers to imitate. Consequently, the firms which introduce these innovations are less likely to appropriate a high proportion of the returns to their innovations, especially if they have large potential markets which stimulates rapid imitation.

It does, however, appear that both types of innovation may facilitate relatively rapid growth. Although the median growth performance of the Design Award winners (or "design innovators") was poor relative to that of the Queen's Award winners (or "technological innovators"), it was still superior to that achieved by North et al.'s (1994) "not known to be innovative" manufacturing firms from the general population.

3. Internal dynamics within the sample of innovative firms

Section 2 examined, on a univariate basis, some of the generic factors which appear to be associated with differences in the employment growth rates of the firms in the study. This section, by contrast, focuses on the internal variation within the set of firms. Readers may have noticed that the standard deviations reported alongside the mean MACs in Tables I to V were all large, which indicates the substantial variation between the firms within each of the classifications analysed. This section therefore focuses on the individual firms. In particular, it investigates the extent to which employment creation was concentrated in a few firms, and will report the absolute amount of employment created by the fastest growing of these firms.

Table VI shows the "fates", over the 1980–1991 period, of all the firms included in this study. The table shows that only a small proportion of the firms grew dramatically, whilst the majority remained, in 1991, in the same size categorisation to which they belonged in 1980. This reflects the fact that employment creation (and loss) is concentrated in a few firms.

3.1. *The concentration of employment generation*

With regard to the concentration of employment creation, Table VII shows that 17 of the firms (11% of the sample) created more than half of all the new employment generated by the full sample of firms between 1980 and 1991. Five firms (3%

TABLE VI
The size of the innovative firms in 1991 by their initial size in 1980

Employment in 1980	Employment in 1991					All firms
	1–49	50–199	200–499	500–999	1,000+	
0[a]	21 (70.0)	8 (26.7)	1 (3.3)	0 (0.0)	0	30
1–49	29 (43.9)	29 (43.9)	5 (7.6)	3 (4.5)	0	66
50–199	3 (7.7)	23 (59.0)	12 (30.8)	1 (2.6)	0	39
200–499	0 (0.0)	1 (7.1)	10 (71.4)	3 (21.4)	0	14
All firms	53	61	28	7	0	149

[a] Firms established since 1981. The figures in parenthesis relate to the percentage distribution of the firms in each of the 1980 size categories by their 1991 size categorisation.

of the sample) were responsible for a quarter of all the jobs created.

The concentration of employment creation is a recurrent finding from longitudinal studies of employment change in firms: Storey et al. (1987) have argued that "out of every 100 small firms, the four fastest growing firms will create half the jobs in the group over a decade".[12] Amongst the 46 Science Park firms studied by Westhead and Cowling (1995), the 5 fastest growing (11% of the sample, and 14% of the 35 firms which increased their employment) generated 57% of the new employment created by all the firms in their study. North et al.'s (1994) analysis found that the 70 (23%) "high-growth" firms in their sample of 302 firms were responsible for 71% of all the new employment created by the sample between 1979 and 1990 (see also Cosh et al., 1996).

In comparison, 23% of the surviving award winning small firms (34 firms) generated 74% of all the new jobs created by the sample of firms between 1980 and 1991 (Table VII), a degree of concentration not markedly different from that in the North et al. study. There was also a close similarity with Westhead and Cowling's Science Park firms result, with 11% of the award winning SMEs (or 14% of those that increased their employment) providing 55% of all the new employment created by the firms (Table VII).[13] Broadly, therefore, the degree to which employment growth was concentrated in a few firms was similar amongst the award winning SMEs to that discovered by other studies of small firms in the U.K.

Beyond this, Table VII is interesting because it reveals the extent of absolute employment growth amongst the fastest growing firms in this study. It can be seen from the table that, over the eleven year period of analysis, even the fastest growing firms amongst this relatively fast growing group of firms individually created hundreds rather than thousands of new jobs.

4. Multivariate regression analysis

This fourth and final analytical section examines, in a multivariate framework, which, if any, of the factors assessed above were associated with statistically significant differences in the average rate at which the firms changed their employment.

The conventional approach to the analysis of employment change in firms over time is:

$$e_{i,t_1} = f(e_{i,t_0}, x_{i,t_0})$$

where e_{i,t_0} and e_{i,t_1} are the log of firm i's employment at time t_0 and t_1 respectively, and x_{i,t_0} is a vector of the other characteristics of the firm at time t_0 (Hart and Oulton, 1996). This amounts to a test of Gibrat's "law of proportional effect", which estimates the relative rather than the absolute change in the employment of firms. But, as stated earlier, the application of such analysis to data-sets which include very small firms is problematic, as, amongst these, small absolute changes in employment can translate into large relative changes which may be misleading. Because of this, and following Westhead and Cowling (1995), the analysis undertaken here uses an absolute measure of employment change, the mean annual change (MAC) in the firms' employment between 1980 and 1991. All the variables used in the analysis are defined in Table VIII.

TABLE VII
The concentration of employment creation amongst the award winning small firms

Employment increase parameter	Number of firms at or above this parameter	As a percentage of all the firms	As a percentage of firms that grew	Cumulative employment change	Cumulative percentage of all "new" employment
700 +	2	1.3	1.7	+1,483	11.6
500 +	5	3.4	4.3	+3,270	25.5
–	6	4.0	5.1	+3,764	29.4
–	13	8.7	11.1	+6,141	47.9
200 +	17	11.4	14.5	+6,990	54.6
–	34	22.8	29.1	+9,540	74.5
100 +	39	26.2	33.3	+10,098	78.8
50 +	58	38.9	49.6	+11,442	89.3
20 +	88	59.1	75.2	+12,523	97.8
1 +	117	78.5	100.0	+12,808	100.0
No growth*	32	21.5	–	–	–
All firms	149	100.0			

* Companies which experienced zero or negative growth.

Using the ordinary least squares (OLS) regression technique, the mean annual employment change (MAC) in the firms might be estimated using Equation 1, which includes both additive and multiplicative dummy variables:

$$\begin{aligned} MAC_i = {} & \beta_0 + \beta_1 e_i + \beta_2 C_i + \beta_3 C_i e_i + \beta_4 O_i \\ & + \beta_5 O_i e_i + \beta_6 Q_i M_i + \beta_7 Q_i M_i e_i \\ & + \beta_k I_{ij} + \beta_l I_{ij} e_i + \beta_m Q_i I_{ij} \\ & + \beta_n Q_i I_{ij} e_i + \beta_t Y_{it} + \varepsilon_i \end{aligned} \quad (1)$$

This specification, which uses the "mechanical equipment design innovators" as the base, permits each sector to have a different firm-size-growth relationship, and also permits different firm-size-growth relationships between the technological and design innovators within the three sectors which had both types of innovator. The "chemicals" and "other (manufacturing)" sectors are identified separately, because these contained only Queen's Award winners (i.e., only "technological innovators") and only Design Award winners (i.e., only "design innovators") respectively. Essentially, the purpose of this specification was to enable the modelling to move from the general to the specific, through the gradual elimination of those factors which were found to have no statistically significant relationship with the MAC.

However, estimation of this equation by OLS resulted in an important difficulty: the distribution of the residuals was not normal, and thus an assumption of the classical linear regression model (CLRM) was violated. The reason for this deviation from normality was a relatively small number of firms with large positive residuals.

These "rogue" observations were the fast growth firms (discussed in Section 3) which were responsible for a large proportion of the total employment created by the sample. One way of satisfying the CLRM assumptions whilst accommodating these firms was to classify the 13 fastest growing firms into two groups, each identified by a new dummy variable: $S_i = 1$ for the six most spectacular growth companies ($S_i = 0$ otherwise); and $R_i = 1$ for the seven next most rapidly growing companies ($R_i = 0$ otherwise). The revised model took to form:

$$\begin{aligned} MAC_i = {} & \beta_0 + \beta_1 e_i + \beta_2 C_i + \beta_3 C_i e_i + \beta_4 O_i \\ & + \beta_5 O_i e_i + \beta_6 Q_i M_i + \beta_7 Q_i M_i e_i \\ & + \beta_k I_{ij} + \beta_l I_{ij} e_i + \beta_m Q_i I_{ij} + \beta_n Q_i I_{ij} e_i \\ & + \beta_r R_i + \beta_s S_i + \beta_t Y_{it} + \varepsilon_i \end{aligned} \quad (2)$$

The use of dummy variables to identify the fastest growing companies amounts to an admission that we were unable to "explain", *ex ante*, the exceptional performance of these firms using the independent variables in the regression alone. On the other hand, the fact that the residuals in the original regression were not normal indicates that these firms were exceptional, so their separate identification was justified.[14]

TABLE VIII
The variables used in the regression analysis

MAC_i	Mean annual employment change in firm *i*: $MAC_i = \frac{E_{i,t_1} - E_{i,t_0}}{t_1 - t_0}$
i	Firms, 1 to 149 (1 to 136 in the versions of models 2 and 2a which exclude the 13 fastest growing firms).
$E_{i,\,t_0}$	Firm *I*'s employment in 1980. Set to zero for firms established after 1980.
$E_{i,\,t_1}$	Firm *I*'s employment in 1991.
t_{0i}	1980, except if firm i was established after 1980, in which case it is the year of establishment.
e_i	$\mathrm{Ln}(E_{i,\,t_0})$. Set to zero for firms established after 1980.
C_i	Chemicals sector dummy: $C_i = 1$ for "Chemicals" firms; otherwise $C_i = 0$.
I_{ij}	Industry dummies, for $j = 1, 2, 3$, where $j = 1$ is the Electronics and IT sector; $j = 2$ is the Instruments sector; $j = 3$ is the Medical equipment sector.
$I_{i,\,x23}$	Dummy identifying all the firms which were not in the Instruments ($I_{i,\,2}$) or Medical Equipment ($I_{i,\,3}$) sectors ($I_{i,\,x23} = 0$ if $I_{i,\,2} = 1$ or $I_{i,\,3} = 1$; otherwise $I_{i,\,x23} = 1$).
M_i	Mechanical sector dummy: $M_i = 1$ for "Mechanical" firms; otherwise $M_i = 0$.
O_i	"Other (manufacturing)" sector dummy: $O_i = 1$ for "Other" firms; otherwise $O_i = 0$.
Q_i	Dummy identifying the Queen's Award winning firms – $Q_i = 1$; otherwise $Q_i = 0$.
R_i	Dummy identifying the seven rapid growth companies – $R_i = 1$; otherwise $R_i = 0$.
S_i	Dummy identifying the six spectacular growth companies – $S_i = 1$; otherwise $S_i = 0$.
Y_{it}	Period of establishment dummies, for $t = 1, 2, 3$, where $t = 1$ is for the years 1975 to 1980; $t = 2$ is for the years 1981–1984; $t = 3$ is for the years 1985 to 1987.

"Robust" regression estimation techniques, which reduce the weight of any outlying observations in the derivation of the estimated coefficients by giving each observation a weight between 0 and 1, offer an alternative way of accommodating these "rouge" observations.

We shall report the results which arose from using both techniques to accommodate the "rouge" observations. The use of the two dummies is easier to understand, whilst "robust" regression provides a more sophisticated solution to the problem. Interestingly, and as we shall see, the two approaches provided similar results.

The estimation of the OLS model with the two additional dummy variables is displayed, after the elimination of the insignificant variables, as Model 2 in Table IX. The "robust" estimation of Model 1 is also shown, as Model 1R in Table IX, after the elimination of the insignificant factors. Both of these models could, however, be simplified further, by the introduction of a new variable, $I_{i,x23}e_i$, to estimate the relationship between initial firm size and the average absolute growth of all the firms other than those in the "instruments" and "medical equipment" sectors, whilst the firms in each of those sectors were allowed to have a different firm-size-growth relationship.

For the "robust" estimation, the revised model (Model 1a-R) model took the form:

$$MAC_i = \beta_0 + \beta_1 I_{i,x23} e_i + \beta_2 Q_i I_{i,1} + \beta_3 I_{i,2} e_i + \beta_4 I_{i,3} e_i + \beta_5 Y_{3,i} + \varepsilon_i \qquad (1a\text{-}R)$$

Whereas the revised version of the OLS model with the additional dummies (Model 2a) was:

$$MAC_i = \beta_0 + \beta_1 I_{i,x23} e_i + \beta_2 Q_i I_{i,\,1} + \beta_3 I_{i,2} e_i + \beta_4 I_{i,3} e_i + \beta_5 R_i + \beta_6 S_i + \beta_7 Y_{3,i} + \varepsilon_i \qquad (2a)$$

As, for both the techniques, the estimated coefficients for both $I_2 e_i$ and $I_3 e_i$ were found to be insignificantly different from zero, both these variables were deleted. Model 1a-R and Model 2a in Table IX provide the "robust" and OLS estimations of these models.

In considering these estimations, we will first discuss the characteristics of the 13 fast growth companies identified by the two additional dummy variables (S_i and R_i) in Models 2 and 2a, and which were given low or zero weightings in the "robust" regressions (Models 1-R and 1a-R).[16] Following

TABLE IX
The estimated models

Independent variables:	Dependent variable: Model:	MAC 1-R	MAC 2	MAC 1a-R	MAC 2a
Intercept		5.38 (0.99***)	6.54 (0.92***)	5.55 (0.70***)	6.06 (0.65***)
e – All firms: Log of employment in 1980		–1.37 (0.31***)	–1.37 (0.29***)	N/A	N/A
$I_{x23}e$ – All firms except instruments and medical equipment. firms: Log of employment in 1980		N/A	N/A	–1.41 (0.27***)	–1.62 (0.24***)
Q_{I1} – Dummy identifying Queen's Award winning electronics and information technology firms		7.06 (1.88***)	6.92 (1.80***)	7.04 (1.85***)	7.12 (1.77***)
I_2e – Instruments firms: Log of employment in 1980		1.63 (0.38***)	1.64 (0.33***)	–	–
I_3e – Medical equipment firms: Log of employment in 1980		1.14 (0.48**)	1.10 (0.43**)	–	–
R – Dummy identifying the seven rapid growth firms		N/A	27.8 (2.26***)	N/A	27.3 (2.23***)
S – Dummy identifying the six spectacular growth firms		N/A	55.4 (2.62***)	N/A	55.4 (2.62***)
Y_3 – Dummy identifying firms established between 1985 and 1987		–	–4.92 (2.72*)	–	–4.44 (2.64*)
N [*N-other* – observations for which $S_i = R_i = 0$]		149	149 [136]	149	149 [136]
F-Statistic [F-Statistic for regressions on the *N-other* sub-sample]		9.28***	108.38*** [8.80***]	18.23***	151.40*** [14.31 ***]
$\overline{R}^2$ [$\overline{R}^2$ for regressions on the *N-other* sub-sample		N/A	0.835 [0.224]	N/A	0.836 [0.228]

Standard errors in round parenthesis.
*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level.

this, we discuss the results that apply to the 136 remaining firms (i.e. 91% of the sample).

4.2. *The thirteen exceptionally fast growing companies*

The thirteen fast growing companies which were separately identified by the dummy variables S_i and R_i in the OLS models constituted just 9% of all the firms, but accounted for nearly half (48%) the new employment created by the full sample of firms (Table VII).

These firms were divided into two groups: the six "spectacular growth" companies ($S_i = 1$), which accounted for 29% of all the new employment created, and the seven "rapid growth" companies ($R_i = 1$) which accounted for a further 18.5% of the new employment created. All of the "spectacular growth" firms increased their employment by a mean of at least 45 new jobs a year, and for two firms the mean annual increase exceeded 70. In U.K. terms at least, the growth of these firms was spectacular.[17] But whilst these firms were exceptional by U.K. standards, their growth is modest compared with that achieved by some firms established in the U.S. over the last 25 to 30 years (Simonetti, 1996).[18]

Given that the OLS regression analysis was unable to accommodate these firms without the inclusion of a dummy variable to identify them, the question arises: "what were the characteristics of these firms?" In relation to this, these firms are notable because:

- All six "spectacular growth" companies were Queen's Award winners (and thus "technologically innovative"); none were Design Award winners (or "design innovators").
- Four of the six, and the three fastest growing, were active in the "electronics and IT sector". The other two were in the "chemicals" and "mechanical equipment" sectors.
- With regard to their age and initial (1980) size, three of the "electronics and IT firms" were established in the 1970s (and all of these had fewer than 50 employees in 1980), whilst the fourth was established in 1984. But the "chemicals" and "mechanical equipment" firms were both much older, both having been formed in the 1950s (both of these were medium sized firms, with between 200 and 499 employees, in 1980).

In contrast to the "spectacular growth" group of companies, the seven "rapid growth" companies, each of which created a mean of between 21 and 34 new jobs a year over the period of analysis, were much more diverse. Five were Queen's Award winners, and thus "technologically innovative",[19] whilst two were "design innovators", having won only the Design Award. The five Queen's Award winners operated in a variety of sectors, but both the "design innovators" were in the miscellaneous "other manufacturing" sector. As a group, these seven firms were also diverse with regard to their age and initial (1980) size.[20]

The achievement of exceptionally rapid growth is likely to be a reflection of characteristics that are unique to the individual fast growing firms. However, some of these firms shared common characteristics. In particular, it is notable that a much larger proportion (11 of the 13) were Queen's Award winners ("technological innovators") than the share of "technological innovators" in the sample as a whole (Table X). This suggests that while the ability to innovate technologically is neither a necessary nor sufficient condition for rapid growth, such a capability does increase the probability of rapid growth.

The second commonality is that there is a much larger share of "electronics and IT sector" firms than that which could be expected from the share of firms in this sector in the sample as a whole. As the period of analysis coincides with the emergence of the information technology "techno-economic paradigm" (Freeman and Perez, 1986; Simonetti, 1996)[21] this is not surprising. But it is notable that all the fast growing firms from this sector were "technological innovators" (i.e., Queen's Award winners) despite the fact that these accounted for less than half the firms in the sample which were active in this sector. Perhaps this reflects the fact that in a rapidly emerging sector the most successful firms must be at the forefront of technological developments and have the capacity to innovate technologically.

TABLE X
A comparison of the characteristics of the thirteen fast growth companies with those of the full sample of award winning SMEs

1980 employment	Fast growth N. 13	All firms N. 149	Industrial sector	Fast growth N. 13	All firms N. 149
0	1 (8%)	30 (20%)	Chemicals	2 (15%)	9 (6%)
1–49	5 (38%)	66 (44%)	Mechanical	1 (8%)	32 (21%)
50–199	5 (38%)	39 (26%)	Electronics and IT	5 (38%)	27 (18%)
200–500	2 (15%)	14 (9%)	Instruments	1 (8%)	39 (26%)
			Medical	2 (15%)	18 (12%)
Year established			Other	2 (15%)	24 (16%)
Before 1960	3 (23%)	28 (19%)	Award won/Type of innovation		
1961–1970	2 (15%)	34 (23%)			
1971–1975	3 (23%)	29 (19%)	Both awards	1 (8%)	9 (6%)
1976–1980	4 (30%)	28 (19%)	Queen's award	10 (77%)	67 (45%)
1981–1987	1 (8%)	30 (20%)	Design award	2 (15%)	73 (49%)

For each of the four characteristics of the firms, the percentage distributions of the 13 fast growing firms and the full sample of 149 firms are given in parentheses.

4.3. *The 136 "other" firms*

We now discuss the regression results as they apply to the 136 "other" companies not separately identified as "fast growing" by the dummy variables S_i and R_i. Model 1 was estimated for the 136 observations that were not identified by the dummy variables S_i and R_i (i.e., the observations for which $S_i = R_i = 0$), and the estimated coefficients were insignificantly different from those reported in Table IX for Model 2.[22] However, with the removal of the 13 exceptionally fast growth firms, the adjusted R^2 for the regression fell dramatically to 0.22, which implies the regression could "explain" 22% of the variation in the data, a proportion not dissimilar to that "explained" by other analyses (e.g. Westhead and Cowling, 1995).

In detail, both the OLS (Model 2a) and "robust" regression (Model 1a-R) estimations found that, in all sectors other than "instruments" and "medical equipment", the mean number of jobs created annually declined with initial (1980) firm size and, on average, firms which had more than 50 employees in 1980 had, by 1991, reduced their employment. In the "instruments" and "medical equipment" sectors, by contrast, there was no relationship between the average growth rate and the initial size of the firms.

Beyond this it is notable that, in general, there was no general difference between the mean annual employment change achieved by the technological and the design innovators. Instead, this difference was only significant amongst the firms in the "electronics and IT sector", with the average technological innovators growing significantly more rapidly. Interestingly, the design innovators in the "electronics and IT sector" did not exhibit a significant growth premium over the firms in other sectors. As the period of analysis coincides with the emergence of the information technology "techno-economic paradigm" (Freeman and Perez, 1986) such a growth premium might have been expected.

The other notable feature of the models is that, after controlling for their initial size, the age of the firms did not have a significant influence on their growth. The OLS model found weak evidence (significant at the 10% level, but not at the 5% level) that, *ceteris paribus*, the youngest firms had, on average, grown more slowly than the other firms. However, this result was not supported by the "robust" regression estimation, so it should not be regarded as reliable, and it would be unwise to place an interpretation upon it.

Conclusions

Some rare empirical evidence on the growth of innovative small firms in the U.K. over a substantial time period has been presented in this paper. As this provides some objective evidence in an area of much speculation, there are some important conclusions to be drawn.

- As a group the innovative SMEs increased their employment considerably more rapidly than small firms from the general population (i.e., firms "not known to be innovative"). Although the comparisons made were imperfect, this implies that at least in terms of employment generation, and in relation to the general population of small firms, innovative small firms have performed well in the U.K. economy (cf. Cosh et al., 1996)
- But the employment created was highly concentrated. Thirteen firms (9% of the sample) were responsible for nearly half (48%) the employment created by the full sample of firms over the period of analysis.
- It was notable that eleven of these exceptionally fast growing firms were "technological innovators" (Queen's Award winners), a much larger proportion than the proportion of "technological innovators" in the sample as a whole. Furthermore, a disproportionately large share of the exceptionally fast growing firms were active in the "electronics and IT sector". Although ultimately the growth achieved by these exceptionally fast growing companies will have been due to their unique characteristics, this finding confirms what logic would suggest: that whilst the ability to innovate technologically is neither a necessary nor a sufficient condition for rapid growth, such a capability does increase considerably the probability of exceptionally rapid growth.
- However, even the fastest growing of the firms included in this study created hundreds rather than thousands of new jobs over the eleven-year period of analysis. By 1991, none had grown

into very large companies with over a thousand employees. Such growth is disappointing relative to the exceptionally rapid growth achieved by the some technologically innovative U.S. based firms that have been established in the last 25 years.

- The great majority of the firms in this study grew moderately or remained roughly stable in size. The analysis showed that in general the firms that were initially the smallest created the most jobs per firm.
- Lastly, it was notable that there was no general difference between the average rate of employment creation achieved by the technological innovators and that achieved by the design innovators. Instead, such a growth premium for the technological over the design innovators only existed for the firms in the "electronics and IT sector". This may indicate that it is only in rapidly evolving technological sectors that the ability to innovate technologically differentiates fast growing firms from their slower growing counterparts.

As a group the innovative small firms in this study were job creators, but whilst the number of jobs created per firm amongst this sample was large relative to the number of jobs creation per firm by small firms in general, the number was small relative to the employment lost from large firms over the same period (Tether, 1996). Innovative small firms certainly have a role to play in economic regeneration, but they are no panacea, especially if the government is indifferent to the rate at which larger firms are contracting (Storey, 1982; Oakey, 1991; Oakey, 1993).

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Notes

[1] In his review of the literature, Storey (1994, p. 118) argues that the appropriate period for examining employment change in smaller firms is at least one decade.

[2] Small or medium-sized, independently owned enterprises with less than 500 employees. The most recently established of the firms was formed in 1987.

[3] For example, service firms might be expected to grow less rapidly than manufacturing firms, due to the smaller minimum efficient scale of most service activities.

[4] It is apparent that the mean is always considerably greater than the median, which alludes to the concentration of employment creation in a small proportion of the firms (see Section 3).

[5] It is notable that the average rate of employment creation amongst the award winners was substantially lower in the 1986 to 1991 period than across the 1980 to 1991 period as a whole. This indicates that many of these firms experienced their most rapid growth in the first half of the 1980s.

[6] Cosh et al. did find that the mean rate of employment creation was greater amongst the innovative firms. It is important to note, however, that apart from the difference in the period of analysis, Cosh et al.'s study includes a larger proportion of service sector firms, and uses a different definition of innovation. Innovation in the Cosh et al.'s study is defined as the introduction of a product, service or process which is new to the firm, with the firms identifying themselves as innovative or non-innovative. Two thirds identified themselves as innovators.

[7] Storey (1994) lists 15 factors: motivation, unemployment, education, management experience, number of founders, prior self employment, family history, social marginality, functional skills, training, age, prior business failure, prior sector experience, prior firm size experience and gender.

[8] Storey (1994) lists 6 factors: age, sector, legal form, location, size and ownership.

[9] Storey (1994) lists 14 factors: workforce training, management training, external equity, technological sophistication, market positioning, market adjustments, planning, new products, management recruitment, state support, customer concentration, competition, information and advice, and exporting.

[10] This is partially reflected by the small number of innovations which won both awards, which shows the schemes were broadly complementary rather than recognising the same innovations.

[11] Such innovations have some parallels with what Henderson and Clark (1990) refer to as "architectural innovations".

[12] Storey et al.'s argument is based on new firms, and the four percent is based on the initial population of firms which includes those that subsequently close. The analysis undertaken here, and the results from North et al. and Westhead and Cowling, are based on surviving companies, so the level of concentration is reduced.

[13] However, the degree to which employment creation was concentrated in a few of the award winners was lower than that in Westhead and Cowling's other sample of firms, the off-science park firms. Amongst those, the five fastest growing companies (16% of the whole sample, 26% of those that increased their employment) were responsible for 84% of the jobs created.

[14] Simply ignoring the problem of normality would have led instead to misleading regression coefficients.

[15] We are grateful to the anonymous referee for this sug-

gestion. By using the dummy variables S_i and R_i in the OLS models (see Models 2 and 2a below), we effectively gave the observations a weighting of either 0 (if $S_i = 1$ or $R_i = 1$) *or* 1 (if $S_i = 0$ and $R_i = 0$). With "robust" regression, an initial screening is first performed to eliminate gross outliers (based on Cook's distance > 1, the weights for these observations are set to 0), and the final weightings for the remaining observations are derived through a series of Huber and biweight iterations. We used the STATA5 statistical package, the reference book for which contains a helpful guide to the technique.

[16] In the "robust" regression estimations of models 1-R and 1a-R, 8 of these fast growing firms were eliminated as "gross outliers" (Cook's distance > 1), whilst the other 5 were assigned low weights ($0.001 < w_i < 0.22$). The next lowest weight was over 0.5, after which the weights rose rapidly towards 1. There therefore appears to be some justification for dividing the sample at this point.

[17] Over the eleven year period of analysis, these six firms created 70% more employment than all 164 firms which grew over a similar period amongst North et al.'s (1994) sample of 302 small manufacturing firms in the U.K.

[18] In a study of the "Creative Destruction" in the Fortune list of the largest industrial enterprises in the United States between 1963 and 1987, Simonetti (1996) found that, in 1987, eleven of the 300 largest firms on the list had been established as new firms after 1956. The smallest of the eleven by employment was Compaq, which, having been established in 1982, had 2,209 employees in 1987. Another of the eleven was Apple Computers which had 5,586 employees in 1987. Kirchhoff (1994) reports that Apple had 12 employees in 1976. Thus, Apple grew at a mean annual rate of over 500 new jobs a year between the late 1970s and mid 1980s, while Compaq grew by a mean rate of over 400 new jobs a year during its first five years of existence.

[19] Although one of these was also a Design Award winner.

[20] Of the five Queen's Award winners, two were in "instruments" and one were in each of the "chemicals", "electronics and IT" and "medical equipment" sectors. Of the seven firms, one was established in the 1950s, two in both the 1960s and 1970s, and two in 1980. These latter two both had less than 50 employees in 1980, the other five firms all had between 50 and 199 employees in that year.

[21] Simonetti (1996) found that of the eleven new entrants established as new firms after 1956 amongst the 300 largest industrial firms in the United States and on the Fortune list in 1987, eight or nine (depending on the chosen classification) were primarily engaged in information technology.

[22] With the obvious exception that neither dummy variable S_i or R_i was in the model, so their coefficients did not a rise. Similarly, a version of Model 2a which excluded these variables was estimated for the 136 "other" observations, and again the coefficients were insignificantly different from those reported for Model 2a in Table IX.

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