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**THE ELIXIR OR BURDEN OF YOUTH? EXPLORING DIFFERENCES AMONG
START-UPS AND ESTABLISHED FIRMS IN INNOVATION BEHAVIOUR IN THE UK**

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Despite the widely acknowledged role of start-ups in economic development, we still know little about their innovative activities compared with those of established firms. Drawing upon a large scale sample of UK firms, this paper uses a matching estimator approach to explore the disparity between start-ups and established firms in terms of innovation performance. The paper demonstrates that start-ups do differ significantly from established firms in their innovation activities. We find that being a new firm increases the likelihood of being a radical product and process innovator in the service sector, while it decreases this likelihood in the manufacturing sector.

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Abstract

Despite the widely acknowledged role of start-ups in economic development, we still know little about their innovative activities compared with those of established firms. Drawing upon a large scale sample of UK firms, this paper uses a matching estimator approach to explore the disparity between start-ups and established firms in terms of innovation performance. The paper demonstrates that start-ups do differ significantly from established firms in their innovation activities. We find that being a new firm increases the likelihood of being a radical product and process innovator in the service sector, while it decreases this likelihood in the manufacturing sector.

Keywords: Innovation, Start-ups, Innovative Performance, Established Firms

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Introduction

Start-ups play an important role in economic growth and governments have made extensive efforts to help these firms innovate (see for example Shane, 2003). New firms are often seen to be the sources of ‘gales of creative destruction’ in industries as they introduce new products and process that disrupt or overturn the position of incumbent firms. It is frequently assumed in the literature that start-ups are more innovative than established firms; yet, the evidence for this view point is far from comprehensive.

This paper seeks to extend the previous research in three ways. First, we directly compare the innovative performance of start-ups and established firms, offering insights into the innovative potential of start-ups relative to established firms of a similar size and within the same sector. Second, by comparing start-ups and established firms, we are able to determine the comparative advantage of start-ups and established firms for different types (product versus process) and degrees (radical versus incremental) of innovation. In doing so, we are able to directly test expectations about the advantages of start-ups towards radical innovation over established firms. We are also able to compare the propensities for different types of innovation between start-ups and established firms. Lastly, we extend understanding of the differences between start-ups and established firms in manufacturing and services, discerning different patterns of advantage for start-ups and established firms in each sector. This approach suggests that industrial conditions facing start-ups and established firms differentially shape their potential to engage in innovative activities.

The analysis is based on the UK innovation survey for the period 2002-2004, which includes 16,160 firms in construction, manufacturing and services sectors. In order to compare start-ups and established firms, we use a matching estimator approach that controls for firm size, industry conditions, R&D expenditure and market orientation (Czarnitzki, 2005; Heckman, Ichimura, & Todd, 1997; Heckman, Ichimura, & Todd, 1999). By controlling for these factors, we are able to examine the performance differences between start-ups and

established firms for different types and degree of innovations in the manufacturing and service industries. Overall, we find that start-ups do differ considerably from established firms in their innovative activities. We find that being a new firm increases the likelihood of being innovation active in the services sector, while it decreases this likelihood in the manufacturing sector. Start-ups that are in services are more likely to introduce radical product and process innovations than established firms, whereas in manufacturing the situation is reversed. However, in both manufacturing and services, start-ups are more likely to introduce organisational innovations than established firms.

The paper is organized as follows. In section 2, we review the empirical and conceptual background to the study. Section 3 discusses the method of the study and outlines the descriptive and analytical approach. Section 4 reports the results of contains the econometric analysis. Section 5 outlines conclusions, limitations and future research challenges.

The Innovative Performance of Start-ups and Established Firms

Start-ups are vital for job generation and economic growth (Reynolds & White, 1997) and are becoming an increasingly important part of the economic arena. For example, the Global Entrepreneurship Monitor found that in the 34 countries surveyed almost 9.3% of the population are either nascent entrepreneurs or already involved in a start-up (Acs, Arenius, Hay, & Minniti, 2004). Similarly, small and medium enterprises account for approximately 59% of the employment and 51% of turnover in the UK (SBS, 2006); while, in the US, business owners constitute 13% of all non-agricultural employees (Hamilton, 2000).

Despite this scholarly interest in entrepreneurship, there has been very little research that has compared the innovative activities of start-ups with those of established firms. This is important as there is some evidence to suggest that innovation can shape the survival chances of new firms. Indeed, Cefis and Marsili (2005; 2006) find that small young firms innovating increase their chances of survival by 22%. This result is consistent with UK studies using the

Centre for Business Research panel that show that survival by small and medium sized firms is significantly shaped by innovation (Cosh, Hughes, & Wood, 1996). This suggests that for some new firms innovation can be a matter of life and death.

Our study links four independent streams of research, all of which have contributed significantly to our understanding of innovation. The first has offered some theoretical suggestions as to why start-ups may be more innovative than established firms. This literature has not directly empirically addressed our research question but has offered some interesting theoretical perspectives as to whether it is start-ups or established firms that are more likely to be innovative. The second literature stream has suggested that the resolution of the argument may be contingent on the degree of innovation - i.e. incremental versus radical. The third stream of research has compared the innovative activities of large and small firms. The fourth literature stream has suggested that the innovative behaviour of firms may be contingent on industry context. We discuss these in turn.

Firstly, the literature has offered conflicting suggestions about the relationship between incumbency status and innovation. Some scholars have suggested that established firms are not well positioned to introduce innovative products and services. There are three main theoretical arguments underlying this position. First, incumbents have lower perceived incentives than non-incumbent firms to develop innovative products (Ali, 1994; Reinganum, 1983). An incumbent who is already making profits on existing products may be unwilling to invest if an innovation is highly uncertain (Berchicci and Tucci, 2006). Second, the core capabilities of established firms may become core rigidities that inhibit the process of developing new products (Leonard-Barton, 1992). Moreover, as organizations age they become increasingly prone to inertia (Hannan & Freeman, 1984). Third, established organizations suffer from organizational filters, 'cognitive structures that screen out information unrelated to the organization's important tasks, to focus its attention to these

tasks' (Chandy & Tellis, 2000: 3). This technological myopia hinders their ability to recognize the value of emerging technologies (Foster, 1986).

By contrast, established firms have greater financial, technological and market capabilities that make them more adept at introducing innovations (Berchicci & Tucci, 2006). First, established firms have greater financial resources available to put in the development of innovative products. Start-ups are particularly disadvantaged in areas where the availability of venture capital is low. Second, established firms have better technological capabilities that arise from years of "accumulating, codifying and structuring knowledge" (Leonard-Barton, 1992: 113). Third, established firms may have better market capabilities arising from asset complementarities (Tripsas, 1997) and preferential access to distribution channels (Mitchell, 1989).

Secondly, the resolution of the argument about whether it is start-ups or established firms that are the sources of innovative activities may be contingent on the type of innovation that is introduced – *radical versus incremental*. For example, established firms may be more likely to introduce incremental, rather than radical, innovations because radical innovations may cannibalise existing products and destroy organisational competencies (Afuah, 2003). Established firms may also fail to introduce disruptive technologies because they initially spend too much time listening to their existing customers who are not the initial adopters of the new technology (Christensen, 1997b; Christensen & Overdort, 2000). However, established firms may benefit from introducing radical innovations, even though an innovation may be competence-destroying to the established firm, because it may be competence-enhancing to its suppliers, customers and to the rest of the value chain (Afuah & Bahram, 1995). Sometimes, established firms may fail at what may initially appear as incremental innovation, because this destroys architectural knowledge – the knowledge that underlies the linkages between the components of a product (Henderson & Clark, 1990). A

major limitation of these studies is that they are mostly based on case study evidence and there is no large sample evidence to corroborate these effects.

Thirdly, a number of studies have investigated whether large firms are more innovative than small firms (e.g. Acs & Audretsch, 1987, , 1988; Jaffe & Lerner, 2004; Lerner, 2004). The inspiration for this line of work stems from Schumpeter's two contrasting philosophical positions on the relationship between firm size and innovation (Schumpeter, 1934, , 1942/87). The evidence does seem to suggest that firms become less innovative as they become larger, even though "there are not many large-sample studies that convincingly document a relationship between firm size and innovation output" (Kuemmerle, 2006). Large firm barriers to innovation can be both behavioural (e.g. complexity of corporate hierarchy, organizational inertia and lack of transparency) and contextual (e.g. industry contexts and national/regional factors) in nature (Kuemmerle, 2006).

Finally, differences in the innovative behaviour between established and start-up firms may be contingent on industry background. Research has shown that certain industries are more likely than others to favour new venture creation (Cooper, 1994; Shane, 2003; Taylor, 1996). These differences include industry life cycle, knowledge conditions, demand factors, appropriability conditions, and industry structure (Shane, 2003). These factors may also differentially impact the innovative behaviour of start-ups. Although the contingency approach has been a valuable area of investigation in organizational theory (Brush & Artz, 1999; Davis, Lawrence, Kolodny, & Beer, 1977; Pfeffer & Salancik, 1978; Priem & Butler, 2001), few studies have explored an industry contingency perspective in the context of innovation (Katila & Shane, 2005). This is important for a number of reasons. For example, liabilities of newness may be more pronounced in the manufacturing sector than in the service sector because the minimum efficiency scale may be more difficult to achieve. Also, the number of months after development until a new product is understood by competitors

varies between different industries (Mansfield, 1985). Moreover, the importance of complementary assets is greater in manufacturing than in services (Cohen, Nelson, & Walsh, 2000). Katila and Shane (2005) examined inventions licensed by MIT between 1980 and 1996 and found that the higher the manufacturing intensity of an invention the greater the likelihood that the invention was commercialised by an established firm than by a university spinout. Overall, “the growth of services to their dominant position in industrial economies means that we can no longer.... assume that [services innovation] follows the patterns and processes depicted in manufacturing production processes” (Miles, 2006: 451).

Data, econometric method and measures

Data

The data for the analysis is drawn from the 4th UK innovation survey. The survey was implemented in 2005 and is based on the core Eurostat Community Innovation Survey (CIS) of innovation (Robson & Ortman, 2006). The method and types of questions used in innovation surveys are described in the Organization for Economic Co-operation and Development’s (OECD) Oslo Manual (OECD, 2005). CIS surveys of innovation are often described as “subject-oriented” because they ask individual firms directly whether they were able to produce an innovation (Smith, 2005).

The CIS questionnaire draws from a long tradition of research on innovation, including the Yale Survey and the SPRU Innovation Database (for examples, see Cohen & Levinthal, 1990; Klevorick, Levin, Nelson, & Winter, 1995b; for examples, see Levin, Klevorick, Nelson, & Winter, 1987; Pavitt, Robson, & Townsend, 1989). CIS data provide a useful complement to the traditional measures of innovation output, such as patent statistics or product announcements. Patents vary in economic importance across different sectors and many patents do not herald commercially successful products (Levin *et al.*, 1987). As well, product announcements are a noisy indicator of innovative activity, often reflecting

marketing efforts and small incremental changes in existing products (Patel & Pavitt, 1995). CIS data offers “a direct measure of success in commercializing innovations for a broad range of industries...that more traditional measures may not capture” (Leiponen & Helfat, 2003). The questionnaire asks firms to indicate whether the firm has been able to achieve a product or/and a process innovation. Product innovation is defined as “...the market introduction of a new good or service or a significantly improved good or service with respect to its capabilities, such as quality, user friendliness, software or subsystems”, while process innovation is defined as “the use of new or significantly improved methods for the production or supply of goods and services”. (DTI, 2005b) Alongside these performance questions, there are a number of questions about the sources of knowledge for innovation, the effects of innovation, and expenditures on R&D and other innovative activities.

The 4th UK innovation survey is 13 pages long and it was sent by post to over 28,000 business units in the UK in April 2005. The survey received a response rate of 58%. The questionnaire was addressed to the firm’s official representative for filling in information on the firm’s activities, such as surveys for calculating the UK Gross Domestic Product and R&D expenditures. It was normally completed by the Managing Director, the Chief Financial Officer or by the R&D manager of the firm. The implementation of the survey was administered by the ONS and to guide respondents a help service was provided (Robson *et al.*, 2006). The responses were voluntary and respondents were promised confidentiality.

In order to ensure adequate regional and industry response rates, the ONS conducted a census of all firms with over 250 employees and a stratified sample of firms below 250 employees. The small and medium sized firms were sampled from 23 industries and 12 regions, using information from the ONS Inter-Departmental Business Register (DTI, 2005a). The response rates for different sectors, regions and size classes are consistent with the overall response pattern (Robson *et al.*, 2006). However, since the survey was carried out in

one wave, we have no possibility of comparing early and late respondents in order to examine the possibility of a non-response bias. However, the first best choice for avoiding a non-response bias is to achieve a high response rate (Armstrong & Overton, 1977: 396) — a 58 per cent response rate must be considered very good in this respect.

The interpretability, reliability and validity of the CIS questionnaire was established by extensive piloting and pre-testing before implementation within several European countries and firms from a variety of industrial sectors, including services, construction and manufacturing (Smith, 2005). In addition, the UK government commissioned two further pilots and a round of cognitive testing for the design of 4th Innovation Survey in 2004. One of them was these performed by the Office of National Statistics and the other by Cambridge University (Bullock, Cosh, & Hughes, 2004). To avoid common method bias due to common scale anchors and common scale formats, the questionnaire was constructed in such a way that the respondents had to answer in different ways in various parts of the questionnaire. In other words, a mix of Likert scales, yes/no questions, percentages and questions pertaining to absolute numbers were used throughout the questionnaire. In addition, however, we performed Harman's one-factor test on the items included in our models in this paper to examine whether common method bias may augment the relationships detected. Since we found multiple factors, and since the first factor did not account for the majority of the variance (the first factor accounts for 3 percent of the variance only), potential problems associated with common method bias were not indicated by the test (Podsakoff & Organ, 1986).

The sample of firms in the CIS only includes firms with over 10 employees and therefore they are not representative of the entire universe of start-ups. Given that most new firms fail or remain small, the start-ups within CIS 4 represent firms who have been relatively successful, growing quickly to 10 full time employees in less than five years. These factors

mean that it would be unwise to generalize from the experience of these firms for all start-ups in the UK. Indeed, many of these firms have been able to overcome many of the most significant liabilities that face new firms, before they have completed the survey. Since we have no information on firms with below 10 employees or firms that exited the market (through merger, acquisition or dissolution), we are unable to examine the impact of innovation on the success and failure of new ventures.

Econometric approach

In order to directly compare start-ups and established firms, we use a matching estimator. A matching estimator is usually applied to evaluate the effect of a policy intervention (treatment) on the sub-population of those individuals or firms exposed to the treatment (treated) and/or on the sub-population not exposed to it (non-treated) (see for example Heckman et al., 1997; Heckman et al., 1999). In this study, however, we follow Czarnitzki (2005) and use this method to separate differences based on observable characteristics between new firms and established firms from the gaps in innovative performance due to unobservable firm characteristics (for a similar application see Dachs & Ebersberger, 2005; Dachs, Ebersberger, & Kinkel, 2006).

The matching estimator is based on this formulation: let D be the treatment: an indicator denoting whether a firm is a new firm, let $Y_i(1)$ be the outcome of the treated, i.e. likelihood of introducing a new product, that would be observed if the firm was a new firm, and let $Y_i(0)$ be the outcome of the non-treated firm, i.e. the likelihood of introducing a new product for the same firm if it were not a new firm. What we would like to measure is the mean effect on the likelihood of a product innovation for new firms, what is called the sample average treatment effect on the treated:

$$SATT = E[Y_i(1) - Y_i(0) | D=1] = E(Y_i(1) | D=1) - E(Y_i(0) | D=1)$$

The SATT answers the following question: How does being a new firm change the likelihood that a firm will be innovative compared to what it would have experienced if it had not been a new firm?

The problem arises because it is impossible to observe the value of $Y_i(1)$ and $Y_i(0)$ for the same firm. So while we can estimate $E(Y_i(1) | D=1)$, we cannot estimate $E(Y_i(0) | D=1)$. The approach adopted by the matching estimator is to use the average outcome of some similar firms who were not exposed to the treatment. The basic idea is to find in the data for each new firm other established firms with similar observable characteristics. Let be X a vector of observed covariates. We can then condition on a set of covariates such that:

$$SATT = E(Y_i(1) | D=1, X) - E(Y_i(0) | D=1, X)$$

Traditional regression analysis could also be applied to estimate how differences between new firms and established firms are with respect to their innovative performance. In our example, we could estimate a logit model where the dependent variable equals to 1 if the firm is a product innovator and zero otherwise, and use as independent variables the set of observed covariates and the dummy variable D which captures whether the firm is a new firm. A significant coefficient estimate on the D would suggest that new firms and established firms have a different propensity to innovate.

However, the matching estimator has a number of advantages over traditional regression techniques. Firstly, the matching estimator is a non-parametric method and as such it has the advantage of not requiring a functional form specification. In our study, this method does not require us to specify an innovation function or a function explaining innovative performance. Secondly, regression analysis is not concerned with how similar treated and untreated groups are in the distribution of the covariates, and as such it can result in identification of effects solely by projections into regions where there are little or no actual data points. In other words a regression model with a dummy variable capturing start-ups

companies would not be able to account for the dissimilarity between start-ups and established companies. Third, the matching estimator addresses directly the question of “what type of innovative performance could be expected from a firm with given characteristics if it had not been a new firm?”.

In this study, we apply the matching estimator as implemented by Abadie et al. (2001) in the Stata programme called *match*. This programme runs a nearest neighbouring matching procedure which consists in matching each new firm to the nearest established firms. For each new firm i , there are two potential outcomes, one is observed and the other one needs to be estimated. The observed outcome is its own estimate, while the unobserved outcome is estimated by averaging the outcome of the other most similar established firms. We opted for this non-parametric matching technique over the propensity score matching method (Rosenbaum & Rubin, 1983) because the control group (i.e. the number of established firms) is significantly large and also because the neighbouring matching procedure does not require us to specify and estimate a model describing the selection mechanism.

Let N_1 be the number of new firms and $w(i,j)$ the weight placed on the j th observations of established firms used to construct the counterfactual, i.e. the nearest neighbours, for the i th new firm. This weight is constructed using the distance from the vector of covariates of the new firm i , X_i , to the one of the j nearest established firms (see Abadie et al. 2001 for details). The sample average treatment effect will then be equal to:

$$\text{SATT} = \frac{1}{N_1} \sum_{i \in (D_i=1)} [Y_i(1) - w(i,j)Y_j(0)]$$

This method requires choosing the vector of covariates X used to match new firms with established firms. These measures are described below. The matching estimator requires as well to choose how many nearest neighbours we want to use, i.e. how many established firms we want to match with a particular new firm. Matching one new firm with only one established firm will minimise the bias since we would match the new firm with the most

similar established firm. However, using more than one matched established firm will decrease the variance since more information is used to derive the counterfactual for each start-up. We choose to use four matches given that, in our sample, established firms are over-represented in comparison to new firms. This approach allows us to ensure that we rely on robust information without incorporating observations that are not sufficiently similar. We also ran some robustness checks by using six matches. The results were consistent with the findings reported here. Finally, we use the bias corrected matching estimations as implemented by Abadie et al. (2001) and also correct for heteroskedasticity. This approach allows us to compare a number of different measures of innovative performance and behaviour between new firms and established firms.

Measures

Independent variables: Since our focus is on the differences in the innovative performance of start-ups and established firms, we use a variety of measures of innovative performance to capture the different types and effects of innovation. Table 1 outlines the variables used in the analysis.

Table 1. Variables used in the matching estimator

First, we use a measure of whether the firm is *innovative active*. In this case, ‘innovative active’ is measured by whether the firm has innovated or has abandoned its innovation projects during the period of the survey. We then include a number of variables to capture different types and degrees of innovation, focusing on product and process innovation. *Product innovation* is measured using an item on the survey that asked firms whether during the three-year period from 2002 to 2004 they had introduced any technologically new or significantly improved products (goods or services) (Cassiman & Veugelers, 2006). *Process innovation* is measured in a similar way, using an item on the questionnaire that enquired whether firms had used any new or significantly improved

technology for production, or for the supply of products (goods or services), during the period 2002 to 2004 (Reichstein & Salter, 2006). Thus, these two variables are equal to 1 if the firm introduced a new product or a new process, and 0 otherwise. To explore the incidence of both *product and process innovation* we included a dummy for all firms who indicated they were able to achieve both types of innovations.

We examined the propensity to achieve a *radical product innovation* by using an item of the questionnaire that asked firms whether they have introduced during the period 2002-2004 “a new good or service onto their market before their competitors”, i.e. whether the new product or service was new to the market. Similarly we explore the incidence of *radical process innovation* by using an item of the questionnaire that asked firms whether they have introduced during the same period “any new or significantly improved processes for producing or supplying products (goods or services) which were new to their industry”. Each of these variables is dummy coded and they are equal to 1 for all firms who were able to reach this level of innovative performance.

We also examined whether the firm has made major changes to its business structure and practices during the period of the survey. In particular firms were asked whether they have implemented: ‘a new or significantly changed corporate strategy’; ‘advanced management technique, e.g. knowledge management systems’; ‘major changes to the organisational structure, e.g. introduction of cross-functional teams, outsourcing of major business functions’; ‘changes in marketing concepts or strategies, e.g. packaging or presentational changes to a product to target new markets, new support services to open up new market’. We created a variable which capture these types of *organisational innovations* by adding the number of times a firm indicated they made these changes, giving us a cumulative score spanning from 0 to 4 for each firm.

Matching variables: In order to control for differences between start-ups and established firms that are relative to their structural characteristics, we used a number of variables available in the survey. First, we match firms according to whether they are part of a wider enterprise group. This should take account of the fact that firms who are part of group are likely to show different innovative performance with respect to start-ups because they can draw upon ideas and knowledge from the wider corporate enterprise. This dummy variable is constructed from a survey question that asks whether a firm is ‘independent’ or ‘part of a wider group’.

Second, since firm size is an important factor in shaping innovative activities, it is important to compare firms of a similar size (Cohen, 1995). This approach helps removing the effects of the liability of smallness from our analysis, while focusing directly on the liability of newness (Baum & Oliver, 1991). Accordingly, we measure firm size as the log of the number of employees in 2004. Firms who invest in R&D are likely to have a superior capacity to innovate. R&D may allow firms to more effectively develop new products and processes, and more effectively absorb knowledge from outside the firm (Cohen *et al.*, 1990). Our measure of R&D intensity is calculated by dividing the total R&D expenditures of the firm for 2004 by its sales in the same year (Cohen, 1995; Kleinknecht, 1996). We also matched the observations using the size of the perceived product market to take account of the fact that, as shown by MacGarvie (2006) firms operating in the international market are more likely to be more innovative. This variable is measured using an item on the questionnaire asking firms to indicate which of four markets (local, regional, national, or international) they perceive to be the largest for their products. This variable takes values of 1 if the firm is oriented toward the international market and 0 otherwise. Finally, we include 14 regional and 46 industry dummy variables to account for different propensities to innovate across regions (Love & Roper, 2001) and across industries (Klevorick, Levin, Nelson, &

Winter, 1995a). By matching start-ups with established firms operating in the same 2-digit industry we are able to control for the sector-specific appropriability strategies, technological opportunities, and market conditions, such as level of concentration and growth rates, which can profoundly shape the firm's ability to create new products and/or new processes (Breschi, Malerba, & Orsenigo, 2000).

Summarising, by using the nearest neighbouring matching procedure we are comparing the innovative performance of start-ups with that of four established firms, which have the same organizational autonomy, the same market orientation (national vs. international), similar size and R&D investment, are allocated in the same region, and are operating in the same industry as the start-up firm.

Results

In the CIS 4 dataset, we found that there are 2,417 start-ups and 13,643 established firms. Table 1 reports the number of start-ups and established firms by size, sector and innovative active. We divided the sample of services firms into two groups: traditional services and knowledge intensive services. This classification is based on the OECD's industry classification (Hatzichronoglou, 1997). Knowledge intensive services include R&D, consulting services and engineering consultancies, whereas traditional service include retail, hotels and restaurants and real estate.

Overall, start-ups are concentrated in services both traditional and knowledge intensive, and in construction. As expected, they are often in general smaller than established firms, although there are some notable exceptions in textile, basic metals, fuels & plastic products, and machinery equipment. The number of product innovators as a share of total firms is considerably higher for start-ups than established firms in not metallic mineral products, transport equipment, and both knowledge-intensive and traditional services. We also find that start-ups in chemicals and fuels & plastic products are appreciably more likely to introduce a

new process. Spin-outs appear to have been more active than established firms in introducing significant managerial and/or organisational changes in their practices.

Table 2. Descriptive table here

Table 3 reports the sample average treatment effect of being a new firm in the manufacturing sector on the different innovative performance measures. The findings indicate that being a new firm reduces the likelihood of being innovative active and of coming up with a radical product innovation. Therefore, in manufacturing, newness has a negative effect on innovative performance, especially for product innovation. This result contradicts the conventional wisdom that new firms are likely to be more innovative than established firms (Christensen, 1997a). There were also no significant differences between young and established firms in the incidence of process innovation in manufacturing. These results may reflect the costs of scaling up in manufacturing, placing large pressures on new firms that limit their ability to develop innovations. We did find that young firms have significantly higher level of managerial and organisational changes, indicating that new firms may be more willing to adopt new organisational arrangements than established firms. These firms appear to be less bound by organisational inertia than existing firms.

<Table 3. Effects of being a new firm in the manufacturing sector>

Table 4 reports the results of the matching estimate for service firms. The most striking finding is that, contrary to what we found in the sample of manufacturing firms, being a new firm in services increases the likelihood of being more innovative, regardless of the innovation outcome measure. Indeed, young firms were more likely to be both product and process innovators. This was also true for radical innovation – innovations that are new for the market. These results suggest that new firms in services may have considerable advantages over established firms in generating and commercialising innovations. Consistent

with manufacturing, young service firms were more likely to adopt new managerial and organisational practices.

<Insert Table 4: Effects of being a new firm in the services sector>

Conclusions, limitations and future research

The analysis demonstrates that start-ups do differ considerably from established firms in their innovative activities, indicating that understanding the role of firm age in shaping patterns of innovation is a valuable approach. By using the UK innovation survey, we were able to establish that, in manufacturing, start-ups tend to be less innovative than established firms. By contrast, in services, start-ups tend to be more innovative than established firms. These results suggest the nature of the industrial environment strongly shapes the effects of age on innovative performance. We also found that new firms differed from established firms in their innovative strategies. Start-ups are more likely to adopt new forms of organisational and managerial practices.

There are several policy implications arising from this research. Firstly, strategies to support innovation among UK firms may need to take account of the structural differences between new firms and established firms. The traditional distinction in policy between firms by size (SMEs vs. large) may be less relevant for innovation than firm age. Secondly, the research shows that many young firms are already highly innovative, especially in services, and therefore policy efforts may be more successfully directed at increasing innovativeness in established firms, rather than new firms. Thirdly, new firms in manufacturing may suffer from considerably more liabilities and challenges than new firms in services. Given the low barriers to entry in many knowledge intensive service sectors, new firms in services are able to quickly translate their innovations into successful products and processes. However, in manufacturing, new firms are severely constrained by access to suppliers and markets and policy efforts may need to be targeted at these firms.

There are several limitations to our study. We are unable to directly compare firms of different ages and therefore some firms may be five years old and others may be two years old at the time of the CIS survey. A few years can make a major difference in the life of a new firm. As well, given that the CIS population only includes firms with over 10 employees, our sample is not representative of the entire range of start-ups in the UK and this limits the ability to generate useful insights for public policy. Indeed, many of the policies of the UK government are directed at firms who have failed to reach 10 employees. We have also not sought to explain why some start-ups are more innovative than others. This would require a different approach to the one we have followed here. In addition, the differences between start-ups and established firms may also be explained by the characteristics of the founders and founding team of the start-up (Klepper, 2001). New firms that are established by individuals from established but failing companies often have a different pattern of behaviour than those firms founded by individuals from established firms with high levels of economic success. Indeed, there is some evidence that failure in a parent firm can be transmitted to the new firm (Dahl and Reichstein, 2007). Since we have no information on the founding team, we are unable to control for this effect.

There are a number of future research questions that lead from this study. It would be useful to conduct a similar type of analysis as Cefis and Marsili (2005; 2006) for UK start-ups to determine the role of innovation in firm survival. With the link between the Inter-Departmental Business Register (IDBR) and the CIS 3 and 4 at the Office of National Statistics, there is considerable opportunity to extend future analysis to survival, a key measure of performance for new firms. Linking the data would also ensure that it was possible to determine more accurately the date of birth of the firm and therefore compare cohorts of firms of different ages (such as firms at three, five and seven years). In addition, future research could explore the sources and determinants of innovation among the

population of start-ups. This analysis could draw from the diverse and eclectic research tradition in entrepreneurship and innovation studies. Future research could also explore industry conditions, such as rate of entry and exit, shaping the innovative behaviour of new firms. There is still much to be learnt about start-ups and innovation and the CIS may provide a useful tool in this search. Indeed, there is a significant opportunity for CIS data to make a major contribution to our understanding of the entrepreneurial process.

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Table 1. Variables Used in Matching Estimator

<i>Matching variables</i>	<i>Description</i>
Firm size	Number of employees*
R&D intensity	R&D spending over turnover*
Market orientation	Dummy equals to 1 if a firm operates on the international market
Regional location	14 regions as defined in the CIS
Sector	2 digit sic code
Part of a group	Dummy equals to 1 if a firm is part of an enterprise group
<i>Outcome variables</i>	
Innovative Active	Equals to 1 if a firm introduced either a product or a process innovation or has undertaken some innovative activities
Product innovation	Equals to 1 if a firm introduced a product innovation
Process innovation	Equals to 1 if a firm introduced a process innovation
Product & process innovation	Equals to 1 if a firm introduced both a product and process innovation
Radical product innovation	Equals to 1 if a firm introduced a product innovation new for the market
Radical process innovation	Equals to 1 if a firm introduced a process innovation new for the market
Organizational innovation	Number of significant managerial or organisational changes

*Turnover and employment figures were provided by the DTI together with the responses to the CIS 4.

Table 2. Firms size and innovative performance by sectors

Sector	Number of start-ups	Proportion of start-ups	Average size [^]		Proportion of Product Innovators		Proportion of Process Innovators		Average Number of Organisational Innovations	
			Established Firms	Start-ups	Established Firms	Start-ups	Established Firms	Start-ups	Established Firms	Start-ups
Food, Beverages & Tobacco	44	9.6	408.5	289.8	46.1	34.1	31.80	22.73	0.94	1.23
Textile, Leather & Clothing	30	12.9	116.1	120.6	35.0	33.3	23.65	26.67	0.68	1.03
Wood, Paper & Publishing	91	12.7	150.7	114.7	32.1	29.7	28.27	28.57	0.80	0.86
Basic Metals	34	10.1	147.7	190.3	46.9	44.1	27.39	29.41	0.94	0.79
Not Metallic Mineral Products	12	6.5	376.8	232.1	65.1	83.3	40.70	41.67	1.33	2.17
Fuels & Plastic Products	17	9.3	206.4	250.4	37.3	35.3	28.31	41.18	0.77	0.59
Chemicals	10	11.5	337.3	178.1	29.9	30.0	31.17	60.00	1.01	1.50
Fabricated Metals & Other Machinery Equipment	104	9.7	99.6	115.5	36.3	30.8	25.28	21.15	0.78	0.77
Electrical, Medical & Optical Equipment	65	9.9	172.0	122.8	58.1	53.8	34.46	26.15	1.13	1.42
Transport Equipment	59	15.0	340.9	255.4	42.1	52.5	28.66	28.81	0.95	1.29
Construction & Public Utilities	256	15.9	157.3	84.0	13.5	14.8	8.34	7.42	0.60	0.54
Traditional Services	773	18.3	365.0	179.7	34.0	37.5	26.35	30.79	1.03	1.10
Knowledge Intensive Services	788	15.1	404.4	151.6	19.9	21.1	13.08	9.52	0.62	0.62
Total	2417	15.0	299.6	151.5	29.8	29.8	20.99	19.98	0.81	0.86

Source: CIS 4 Dataset, Department and Trade and Industry

[^]Average number of employees

Table 3. Effects of being a new firm in the manufacturing sector

<i>Measures</i>	SATT	Std. Err.	z	P> z 	[95% Conf. Interval]	
Innovation active	-0.053	0.024	-2.25	0.024	-0.100	-0.007
Product innovation	-0.025	0.023	-1.08	0.278	-0.070	0.020
Process innovation	-0.012	0.021	-0.58	0.562	-0.054	0.029
Product & process innovation	0.005	0.019	0.26	0.792	-0.033	0.043
Radical product innovation	-0.040	0.020	-2.04	0.041	-0.079	-0.002
Radical process innovation	0.002	0.013	0.12	0.903	-0.024	0.027
Organisational innovations	0.188	0.057	3.28	0.001	0.075	0.300

Source: CIS 4 Dataset, Department and Trade and Industry

Table 4. Effects of being a new firm in the services sector

<i>Measures</i>	SATT	Std. Err.	Z	P> z 	[95% Conf. Interval]	
Innovation active	0.043	0.013	3.36	0.001	0.018	0.068
Product innovation	0.042	0.012	3.45	0.001	0.018	0.065
Process innovation	0.023	0.01	2.26	0.024	0.003	0.044
Product & process innovation	0.024	0.009	2.74	0.006	0.007	0.042
Radical product innovation	0.018	0.010	1.81	0.070	-0.001	0.037
Radical process innovation	0.016	0.007	2.35	0.019	0.003	0.029
Organisational innovations	0.141	0.033	4.25	0.000	0.076	0.206

Source: CIS 4 Dataset, Department and Trade and Industry