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Firm Maturity and Product and Process R&D in Swedish Manufacturing Firms[1]

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Firm Maturity and Product and Process R&D in Swedish Manufacturing Firms

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Abstract:

This paper investigates the commonly debated question about innovations and firm age. Are innovations made by incumbent firms, and does innovation therefore constitute a barrier to entry, or is innovation a way for new firms to successfully compete? The paper further investigates the relationship between firm size and innovation. Does innovation constitute a way for small firms to compete or are innovation a large firm phenomenon? In the analysis the paper explicitly distinguishes between product and process innovation. Data from 1997 and 1999 on product and process R&D, firm size and age in the Swedish manufacturing industry is used in the empirical analysis. A multinomial logit-model is used to estimate the probability of performing process and product R&D. The results show that there are complementarities between product and process R&D and very few firms conduct only process R&D. The probability of product R&D and combined product and process R&D is higher for large firms and firms that are older than 80 years. The size and age effects are more pronounced for firms that carry out both process and product R&D.

Keywords: Product, process, R&D, firm size, firm maturity
JEL-Codes: L11, O31, O33

1 Introduction

Innovations and new firm formation are both regarded as important factors for growth and development. Therefore many researchers have been interested in how they are interrelated. This question has been debated from a theoretical perspective. The outcome of this discussion is two major seemingly contradicting models or approaches. One is a barrier to entry approach, as suggested by early theoretical contributors such as Bain, (1956) and Yip (1982). According to this approach innovations work as a barrier to entry and imply that most innovations are made in incumbent firms. Empirical evidence and alternative theoretical models as suggested by, for example, Acs and Audretsch (1989) and Geroski, (1999) conclude that innovation can be an important way for new firms to compete with already incumbent firms. Therefore innovation could instead be expected to stimulate entry. The two theoretical explanations regarding the interrelationship between entry and R&D intensity give a somewhat confusing picture that indeed corresponds to the mixed empirical evidence that are available so far. In their review article of empirical studies on entry and exit studies Siegfried & Evans (1994) even state that: *"Overall, the empirical evidence about the role of research and development intensity is either encouraging or impeding entry is confusing, perhaps even chaotic."* (Siegfried & Evans, 1994, p. 142.) This paper will explicitly look at the advantages and disadvantages associated with being a new or an old firm concerning innovative behavior.

The question of innovations in large versus small firms is related to the question of firm maturity and innovative behavior. In the literature both advantages and disadvantages for large firms in performing R&D activities have been discussed. Large firms might have advantages in raising capital to finance their R&D investments, whereas small firms might have more incentives to innovate in order to reach a competitive advantage. All these issues will be discussed more thoroughly in the next section in the paper. A particularly interesting issue is to look at process innovations and product innovations separately. Product innovation can be defined as "the generation, introduction and diffusion of a new product (with the production process being unchanged" (Stoneman, 1995, p. 3) and process innovation is defined as "the generation, introduction and diffusion of a new production process (with the products remaining unchanged)" (Stoneman, 1995, p. 3). Distinguishing between product and process R&D, it is interesting to analyze the relation between process and product R&D and firm size and age. The empirical part of this paper will analyze the probability of making process R&D in Swedish manufacturing firms. Which are the firms conducting product and process R&D? Is it large or small firms that perform product and process R&D? Is it old and mature firms or is it recent entrants that conduct product and process R&D? Do the firms choose to perform either process R&D or product R&D or do they choose to combine them?

The paper is organized as follows: Section 2 presents the theoretical arguments regarding the relationship between firm size, age on the one hand and product and process innovations on the other hand. This section also presents earlier empirical findings regarding this issue. Section 3 describes the sources of data and the multinominal logit model that will be used in the empirical analysis paper, and Section 4 presents the empirical results. Finally conclusions and suggestions for future research are presented in Section 5.

2 Innovation and firm demography

In this section the theoretical issues and earlier empirical findings concerning the relationship between firm size and age will be discussed. The discussion will use the quite general notion of "innovation" since this is the terminology that is mainly used in the literature. In the empirical part later in the paper a more precise terminology is introduced and R&D is used as a measure of innovative activity.

2.1 Innovation and firm size

The issue of which firms that are more innovative than others has been discussed in a number of articles during recent years. A lot of the literature does not explicitly distinguish between process and product innovation, but rather discusses innovation more generally. The incentives, advantages and disadvantages connected to the firm characteristics to perform process and product innovationare in many cases similar. Therefore our discussion will also initially take a more general approach, but eventually be more explicitly focused on process and product innovation.

The discussion about the role of innovation usually takes its starting point in the writings of Joseph Schumpeter (1934, 1942). In Schumpeter, (1934) industry dynamics are described as a process of "creative destruction" where most new firms are created by "new men". In Schumpeter, (1942) this process is instead described as "creative accumulation" and in this description of how innovations are created, large established firms play an important role because they are able to accumulate knowledge (e.g. R&D, product-, and process knowledge) and financial resources. Cohen and Levin (1989) and Mansfield (1963) among others summarize a number of arguments regarding advantages that small firms and large firms can have respectively in the innovation process. Explanations to why large firms should perform a larger share of innovations are:

- *Capital market imperfections:* It is easier for large firms to finance risky R&D projects. One reason for this large-firm advantage is that many large firms have well-established contacts with, for example, banks that can provide financing. It is also plausible that large firms have larger and more stable internal funds available for financing these projects and they are therefore less dependent on external capital. The large firms can in this way afford large and expensive R&D projects. (Hoshi Kashyap and Scharpstein, 1991). An additional explanation to why large firms allocate more resources to inventions and R&D is, according to Arrow (1962), that R&D investments are very risky projects. A large firm can, in such situations, act as its own insurance company by investing in several small scale R&D and invention activities and therefore reduce the risk.

- *Innovation and industry competition:* An additional issue regarding the incentives to innovate is that the incentives to innovate are larger in more competitive industries than in monopolistic conditions. This issue has been debated by among others Arrow (1962) and Demsetz (1969). Arrow (1962) concluded that there are less incentives to invent in monopolistic conditions compared to a competitive environment. Demsetz (1969) stated that the theoretical analysis in the paper by Arrow (1962) suffered from some fallacies, and quite the contrary concludes that the incentives to innovate are the reverse. If Demsetz conclusions are correct one would expect an innovative advantage for large firms in monopolistic industries and a disadvantage for small firms that operate more competitive industries. In relation to this it is appropriate to mention that most empirical studies in this field report a positive relationship between market concentration and R&D. (Cohen, 1995) While discussing the relationship between R&D and industry concentration one must mention that there is also a discussion on causality issues. Sutton (1998), for example, thinks that the discussion of how technological competition shapes the size distribution of firms might have been emphasized too much. He does not find any significant differences regarding size inequality in industries where R&D has an important role compared to a group of control industries were R&D does not play any important role. Since it is possible that industry concentration also influence innovative behavior one could expect that there is a mutual relationship between these variables.

- *Economies of scale:* The returns from R&D are larger if output is large, since in the large firm the fixed cost of innovation can be spread over a larger output. This is especially true for process innovations (Cohen and Klepper, (1996) and Cohen, 1995). An implication of this advantage for large firms would be that the R&D increases more than proportionally with firm size.

- *Economies of scope:* Because of complementarities between R&D and other activities in the firm that might be more developed in large firms, R&D tends to be more productive in large firms. Cohen (1995) mentions that there might be complementarities between non-manufacturing activities such as marketing and the production of innovation. For the present discussion of process and product innovation the presence of economies of scope means that there might be advantages of performing product and process innovations simultaneously. This raises the question about how product and process innovations are related to each other. If there are complementarities between product and process innovation, a firm that chooses to conduct product or process innovation can expect the marginal profitability of the complementing innovation activity to increase. (Milgrom and Roberts (1990)

- *Access to knowledge networks and research co-operation:* Large firms can through their larger number of employees be expected to have access to a larger amount of knowledge sources. The probability that new information about product and process innovations in the industry can therefore more easily be accessed by the large firms. Larger firms can also be expected to be involved in research cooperation activities more frequently than smaller firms.(Karlsson, 1988)

- *Management advantages:* A large firm has better possibilities to respond to a new technology in terms of better access to managerial skills. (Mansfield (1971) If the managerial skills necessary to implement a new product or process innovation is still not available in the firm, the large firm has better possibilities to acquire these skills through the acquisition of specialized services.

According to the discussion above the advantages of being a large firm seems to be quite convincing, but the literature also provide some explanations to why large firms have some disadvantages in producing innovation i.e advantages for small firms. It is argued that:

- *Loss of managerial control:* As firms grow large, they tend to loose managerial control over the activities in the firm and therefore they might loose efficiency in R&D activities. (Cohen and Levin, 1989)

- *Higher R&D incentives for researchers:* The incentives for researchers and entrepreneurs to innovate decreases since their personal benefits from their research efforts usually are decreasing with firm size. A researcher employed in most large companies has smaller possibilities of patenting or benefiting in other ways from her achievements. (Cohen and Levin, 1989)

- *Co-operation opportunities:* One possibility for small firms to overcome their size disadvantages regarding R&D is to establish co-operation with other firms that have similar interests and complementary assets. The co-operation can result in different types of contracts between the collaborating firms, such as a joint venture.

The above described set of innovation advantages and disadvantages of being a large versus small firm has been empirically investigated in several studies. Before the empirical findings regarding R&D and firms size are presented it is important to note that empirically there are some difficulties of capturing R&D in small firms. Many small firms do not have a formal R&D function, i.e., a unit that explicitly works with product and process development, but considerable R&D can still be performed outside a formal R&D function. This means that there might be some problems with capturing all R&D expenditures in especially small firms. (Cohen and Levin, 1989).

The empirical evidence on the relationship between firm size and innovation has to some extent shifted during the years. From the mid 1960s to the mid 1980s most studies found that R&D intensity (R&D as a ratio of sales) was increasing with firm size. Many studies also found that R&D increased more than proportionately with firms size (Cohen, 1995). Studies performed after the mid 1980s show a somewhat different pattern. A U-shaped form for the relationship between R&D intensity and size was found such that initially R&D intensity decreases but then again starts to increase with size (Cohen and Levin, 1989). In his review article on the empirical evidence of studies of innovative activity, Cohen (1995) on the other hand concludes that there is a monotonic relationship between R&D and firm size and hence no particular advantage for large firms.

Acs and Audretsch, (1990) find that innovations in small firms, relative to their size, accounts for an disproportionately large share of the total amount of innovations. Other interesting evidence suggests that large firms are more innovative in concentrated industries with high entry barriers and small firms are innovative in less concentrated industries that are less mature. (Pavitt et. al., 1987 and Acs & Audretsch, 1987) Johansson, Lööf and Rader Olsson, (2005) discuss the importance of the corporate structure for innovative behavior and conclude that multinationals have a much higher R&D intensity than other firms.

Acs and Audretsch (1990) try to overcome the empirical difficulties of measuring R&D in small firms, mentioned above, and find that small firms make substantial contributions to technological change if one takes informal R&D activities into consideration. Audretsch et al. (2002) state that small firms use external sources as a source of knowledge input. More specifically, Audretsch and Feldman (1996) show that spillovers from universities are more important to small firms than to large firms.

Fritsch and Meschede (2001) investigate the relationship between product innovation, process innovation and size. They find that R&D expenditure rise less than proportionally to size for both product and process innovation, but the size effect is somewhat more apparent regarding process innovations. Several authors emphasize that the relationship between innovation and size is non linear e.g. Pavitt, Robson and Townsend (1987)

McGahan and Silverman (2001) study innovation (measured by patenting) from an industry life-cycle perspective and find no evidence that innovative activities are lower in mature industries than in emerging industries. They also distinguish between process and product innovations and do not find support for the hypothesis that firms shift form product to process innovations as the industry mature.

Mansfield (1981), Link, (1982) Scherer (1991) and Cohen and Klepper (1996) argue that firm size influences the composition of R&D. Mansfield (1981) found that product and process development increases less than proportionally with firm size. The choice between product and process innovation varies substantially between industries. The different types of innovative activities can be explained by the nature of the technology used in a specific industry but also, as emphasized by Link 1982), Mansfield (1981) and Scherer (1991) by the market structure.

A particularly interesting issue is the possible existence of complementarities between product and process innovations. Miravete and Pernias, (2004) studies the Spanish ceramic tiles industry and find that there are significant complementarities between process and product innovation. In their sample 50 per cent of the firms do not innovate at all and 30 per cent of the firms either do product innovation or process innovation, whereas 20 per cent conduct both product and process innovation. They also find that firms that conduct both process and product innovations are smaller than the firms that choose not to innovate. They also find that older firms invest more in cost reducing innovations. Process innovations are more profitable for multiproduct firms. Comparing the returns of process and product innovations they find that there are high returns to product innovations for multiproduct firms, and smaller firms obtain a larger return to product innovations. (Miravete and Pernias, (2004)

2.2 Innovation and firm age

The discussion about the relationship between firm size and innovative behavior can be more explicitly connected to theories of new firm formation. Innovations can, according to different theoretical views, have a dual role for the entry of firms since it can both stimulate and discourage entry. Below the advantages and disadvantages og being an old versus being a new or young firm will be discussed.

- *Innovation as a barrier to entry:* The traditional entry-barrier literature represented by for example Bain (1956), Orr (1974), and Yip (1982) suggests that innovations, along with, for example, high capital intensity, advertising, and scale economies, will work as barriers to entry and exit, since all these factors imply large costs associated with entering the market.. If potential firms need to do costly initial investments in R&D and innovation, it will become more risky and less attractive to enter an industry and hence innovations will work as a barrier to entry.

- *Innovation as a competitive advantage:* Another type of literature is represented by, for example, Griliches (1979), Acs & Audretsch (1989) and Geroski (1999). These contributions suggest instead that innovation can be a competitive advantage for entering firms. Acs & Audretsch (1989) suggest that small potential firm entrants can compensate for their size disadvantage by having higher innovation intensity. Geroski (1999) states that entrants can be "forced" to product differentiation, (and high initial R&D investments) since they cannot compete with price in an already heavily competitive market situation.

- *Capital market imperfections:* In the previous section it was claimed that larger firms can have better access to capital due to their well established contacts with banks or other external sources of financing. A similar argument can also be used when discussing innovation and firm age. To a certain extent older firms might also be able to accumulate internal capital that could be used for R&D projects that feature large risks.

- *Learning-by-doing economies*: It is reasonable to expect that the productivity of R&D projects increases as the skills and experiences of people involved in the R&D projects increase with time. This would constitute an advantage for older firm compared to new and young firms.

- *The business stealing effect:* Tirole, (1988) and Aghion and Howitt(1992) discuss the incentives for incumbent firms to innovate. The business stealing effect refers to the fact that as a new innovation is created, old innovations will become obsolete. This means that existing rents from previous innovations will be destroyed when the new innovations are created. This can be seen as a disincentive for old firms to innovate since they probably have a larger amount of "rents from previous innovations" whereas the new or young firms have less accumulated rents that will be destroyed if they innovate.

- *The stage of the product life-cycle:* The decision to undertake product or process innovations, or perhaps both, can be expected to depend on the stage of the product life-cycle of the market in which a potential entrant or incumbent firm is competing. Agarwal and Gort, (1996) describes a stylized pattern of how the number of incumbent firms and entry and exit vary over the product life-cycle. According to these stylized patterns a lot of firms are entering during the initial stages of the product life-cycle. In the initial stages firms compete mainly by offering differentiated products and hence product innovations are important. In the later stages it becomes more important to reduce production costs since the firms compete with lower prices. Hence, in order for the firms to survive, it becomes more important with process innovations. (Karlsson 1988) According to these stylized facts, we can expect that the young firms in an early stage of the product life cycle should have a higher probability to conduct product innovations, whereas older firms in later stages of the product life cycle conduct process innovations.

The general empirical evidence on the relationship between entry and innovation is, as mentioned earlier, a bit mixed. Orr (1974) finds, for example, that entry in Canadian manufacturing was deterred by high R&D rates. A similar conclusion was made by Baldwin and Gorecki (1987), who found plant creation to be negatively correlated with R&D. Researchers such as Gort and Klepper (1982), on the other hand, find a positive causal relationship between innovations and entry. Empirical studies by, for example, Geroski (1995), show that small firms and entering firms make a substantial contribution to the generation and diffusion of innovations. Apparently the relationship between R&D, entry and exit is closely associated with the relationship between innovation and firm size, since many of the entering firms are very small.

Geroski, (1995), also discusses the issue of causality between entry and innovation. Does innovation open up market opportunities that small firm are quick and well suited to exploit, or does entry stimulate innovation? The initial empirical analysis shows that entry causes innovation but innovation does not cause entry. However, if the empirical analysis is corrected for entry conditions and technological opportunities (industries with rich technological opportunities also have lower entry barriers) entry has a weak negative effect on innovativeness. (Geroski, 1995)

Audretsch (1995b) distinguishes between industries that can be classified as belonging to a high technological opportunity class or an entrepreneurial technological regime. In his empirical study he finds that new firm start-ups are deterred in industries belonging to a high technological opportunity class (industries where the total innovation rate is high but the small firm innovation rate is low). In the entrepreneurial technological regime (industries where innovation in small firms is relatively high in relation to innovation in the total industry) the number of start-ups tend to be high (Audretsch, 1995b).

What happens to innovation and performance of entrants after they have entered? An empirical study by Baldwin and Johnson, (1999) shows that fast growing entrants are more innovative than slow growing entrants. This conclusion they find to be valid for both new and mature markets.

Recent empirical work by Huergo, and Jaumandreu, (2004) shows that the relationship between firm age and product and process innovations can be characterized as non-linear. In their empirical analysis they show that the probability of both product and process innovation is higher in the early years of the life of a firm, but that it decreases with age and then starts to increase again when the firm has reached the age of about 20 years. They also show that the pattern differs substantially between industries.

2.3 Summing up and formulation of hypotheses

Before turning to the empirical part of this paper it is appropriate to summarize the previous discussion and formulate some explicit hypotheses that will be tested. Table 1 summarizes the advantages and disadvantages related to firm size and age that was discussed in the previous section.

Table 1: Innovation and firm size and age.

	Advantages	Disadvantages
Small firm	*Innovation as a competitive advantage. *Higher R&D incentives for researchers *Co-operation opportunities can compensate for the scale disadvantages	
Large firms	*Capital market imperfections (Easier to find capital for R&D projects) *Innovation and industry competition *Economies of scale *Economies of scope. *Access to knowledge networks and research co-operation *Management advantages (Better opportunities to respond to new technology.)	* Loss of managerial control
New/Young firm	*Innovation as a competitive advantage *The stage of the product life cycle (Higher probability of product innovations.)	* Innovation as a barrier to entry * The business stealing effect (Accumulated rents from old innovations are destroyed)
Old firms	*Learning-by-doing economies *Capital market imperfections (Easier to find capital for R&D projects) *The stage of the product life-cycle (Higher probability of process innovations.)	

The theoretical discussion above and the lessons from previous empirical studies can be summarized by formulating the main hypotheses that will be tested in the empirical part of the paper. A first hypothesis concerns the relationship between process and product R&D and the economies of scope between these two activities.

Hypothesis 1: Process and product R&D are complementarities.

As mentioned earlier, the relationship between innovation and firm size has been extensively investigated. This paper will contribute to this discussion by investigating this relationship for the Swedish manufacturing industry and explicitly distinguish between process and product R&D.

Hypothesis 2: The probability of the firm conducting process and product R&D increases with firm size, possibly in a non-linear pattern.

The third hypothesis concerns the relationship between firm maturity and the probability of doing process and product R&D.

Hypothesis 3: Old and mature firms are expected to have a higher probability of conducting process and product R&D, but the relationship between firm age and R&D can be expected to exhibit a non-linear pattern.

3 Data, method and description of variables

In order to empirically investigate the propositions stated in the previous section, data from two different sources will be used. The datasets “Research and development in the business enterprise sector” and “Financial accounts for enterprises” are both collected by Statistics Sweden and are described below.

3.1 Financial accounts for enterprises (FA)

The dataset “Financial accounts for enterprises”, denoted FA, makes it possible to identify entering and exiting firms since it includes individual firm level data coded in order to make it possible to identify entry and exit. In the dataset information regarding the financial situation of enterprises outside the financial sector is available. This means that financial information from joint-stock companies, cooperatives, partnerships, limited partnerships, associations and some foundations is included in the dataset. All industries except Financial intermediation (SIC[2]-code 65-67) and Real estate activities (SIC-code 70) are included in the dataset. The FA dataset includes financial information from the profit and loss account and the balance sheet but also information about the industrial classification according to the SIC-code at the 5-digit level, the number of employees and sales value. For firms with more than 50 employees the data is based on a survey conducted by Statistics Sweden, and for firms with less than 50 employees the data is based on other administrative sources.

3.2 Research and development in the business enterprise sector (RD)

The dataset “Research and development in the business enterprise sector”, denoted RD is based on a biannual survey covering enterprises in the non-financial sectors with more than 50 employees. Data for 1997 and 1999 are used in the empirical study. Firms that in the FA-database declare that they had R&D expenditures or firms that previously reported R&D expenditures in the RD database are included in the survey. The firms that satisfy the above description and reports R&D expenditures exceeding 5 million SEK are included in the survey. In addition all firms with more than 200 employees are also included. For firms with 50-199 employees and R&D expenditures less than 5 million SEK a selection of firms is surveyed. With this survey method the total number of observations for 1999 sum to 1.096 firms. The survey includes questions about, for example, the number of persons in the R&D-staff and their education, R&D-expenditures, and the distribution of R&D expenditure by type of activity.

The questionnaire includes questions about the purpose of the R&D activities. Because of this it is possible to characterize activities in terms of product or process R&D. Product R&D is defined as development of new products (not existing on the market), development of products that are new to the firm (but already existing on the market) and improvement of already existing products. Process development is defined as development of new processes and improvements of already existing processes.

[2] Standard Industrial Classification

The empirical part in this paper focuses on the manufacturing industry. This focus is motivated by the fact that most R&D is conducted within the manufacturing industries and that the recorded observations are more reliable for these industries than others. The data from the two databases described above have been complemented by information from a third database[3] providing data about age. An interesting characteristic about the age structure of the firms are that many of the largest firms are old firms. Henreksson, (2003) shows that 31 of the 50 largest firms in Sweden were established before 1913. Appendix B presents the relationship between size and age for the sample of the 573 firms included in paper. The figure shows that the age and size structure is not as pronounced as in the study by Henreksson, (2003). For the purpose of this paper it is still interesting to investigate if the very oldest firms have a higher probability of conducting R&D. Therefore a dummy variable for firms that are older than 80 years are included in the empirical analysis.

Since the number of firms included in the survey increases each year, the data from the latest year available, 1999, was used as a starting point, in order to match as many firms as possible from the two databases. For the year 1999 it was possible to match 573 manufacturing firms in the databases FA and RA.[4] 362 of these firms were also present in the 1997 survey. In the empirical analysis in section 4 the results for the year 1999 is emphasized, since the statistical material can be considered better for this year The purpose of including the material from 1997 is to strengthen the implications and conclusions presented.

In addition to the size and age variables, industry specificities such as capital intensity and the profitability of the industry can be expected to influence the probability of innovation. In the theoretical section it was also emphasized that the innovative behavior can be expected to differ substantially between industries. Hence, dummy variables for each 2-digit SIC-level industry are also included in order to account for additional industry-specific effects. The detailed construction of variables used in the regression analysis is described in Table 2 below. The correlation matrix for the variables is presented in Appendix A, and it does not indicate any severe multicollinearity problems.

Table 2: Description of explanatory variables

Variable name	**Description**	**Expected sign**
Size	Number of employees	Positive
Size2	Squared number of employees	Open question
Capital intensity	Fixed assets divided by sales value	Positive
Profitability	Profit margin defined as the firms result before financial revenues and expenses divided by production value	Positive
Age80	Dummy variable 1 if the firm is older than 80 years, 0 otherwise.	Positive
Industry dummy	Industry dummy variables for each 2-digit SIC industry. Manufacturing of fabricated metal products is the base category (SIC-code 28).	Positive or negative

[3] "The database "Affärsdata" provides information from the patent and registration office.
[4] Special thanks to Martin Andersson at Jönköping International Business School, Sweden for his assistance with the data.

3.3 Multinomial logit model of R&D decisions

Each individual firm has four different choices with regard to R&D: to conduct no R&D at all (outcome 1 denoted NO R&D) to conduct only process R&D (outcome 2 denoted PROC. R&D), to conduct only product R&D (outcome 3 denoted PROD. R&D) or to combine product and process R&D (outcome 4 denoted COMB. R&D). An appropriate model when the dependent variable consists of a choice set with several outcomes, is the multinomial logit model. Let Y_i denote the outcome of the different choices denoted *j*. In this case *j*= 1, 2, 3, and 4. Let X denote a set of explanatory variables (in our case the variables defined in Table 3) then a the multinomial logit model can be formulated (see for example Train, (1993) and Green, (2003) as:

$$\Pr ob(Y_i = j) = \frac{e^{\beta'_j x_i}}{\sum_{k=1}^{4} e^{\beta'_k x_i}} \qquad (1)$$

With this formulation the probability of choosing the different alternatives is determined in the model, and four vectors of coefficients β_1, β_2, β_3 and β_4 corresponding to the different choices are estimated. The model formulated in equation (1) is unidentified. This can be resolved by setting the coefficients in one of the β -vectors equal to zero. In this case β_1 (corresponding to the choice NO R&D) was chosen as the zero vector, which means that the remaining coefficients should be interpreted as the change relative to β_1 . The probabilities for each of the four choices respectively are then:

$$\Pr ob(Y_i = 1) = \frac{1}{1 + \sum_{k=2}^{4} e^{\beta'_k x_i}}$$

$$\Pr ob(Y = 2) = \frac{e^{\beta'_j x_i}}{1 + \sum_{k=2}^{4} e^{\beta'_k x_i}}$$

$$\Pr ob(Y = 3) = \frac{e^{\beta'_j x_i}}{1 + \sum_{k=2}^{4} e^{\beta'_k x_i}}$$

$$\Pr ob(Y = 4) = \frac{e^{\beta'_j x_i}}{1 + \sum_{k=2}^{4} e^{\beta'_k x_i}} \qquad (2)$$

The multinomial logit is estimated by a maximum likelihood procedure. The β -coefficients resulting from this estimation are difficult to interpret and can not be interpreted as we are accustomed to analyze coefficients. In order to be able to analyze the results, marginal effects have to be calculated. These marginal effects can then be interpreted as usual. In order to evaluate the estimated model further, A goodness of fit measure (called pseudo R^2) is also calculated. This goodness of fit measure is a log likelihood measure and is defined as $1-\frac{LnL}{LnL_o}$ were, L_0 is the log likelihood for a model including only a constant, and L is the log likelihood of the full model. This log likelihood measure is bounded between zero and one and can be interpreted in a similar way as the R^2-measure.

4 Empirical findings

Before we consider the results from the estimation of the multinomial logit model, it is interesting and necessary to take a look at the statistics used in the empirical analysis at a more aggregated level. Tables 3 and 4 present some descriptive statistics for 1999 and 1997 respectively. These tables show clearly that there seems to be substantial complementarities in combining both process and product R&D. During both years less than one percent of the firms choose to carry out only process R&D. It is however more common to constrain efforts to only product R&D, but of those firms that make some process R&D efforts at all, most of them combine process and product R&D. The latter firms are also on average larger and older than the other firms. An exception is the set of firms that only conduct process R&D in 1999. These firms are on average larger than the other firms. The very few firms that concentrate on process R&D only are on average more capital intensive than the other firms.

Table 3: Descriptive statistics 1999

	Number of firms	Per cent share	Average size	Average age	Average capital intensity	Average profitability
NO R&D	325	56.72	198.49	41.12	0.21	0.05
PROC. R&D	3	0.52	2039.33	44.33	0.37	0.10
PROD. R&D	74	12.91	537.03	44.36	0.21	0.07
COMB. R&D	171	29.84	1064.90	50.04	0.25	0.07
Total	**573**	**100.00**	**511.71**	**44.32**	**0.22**	**0.06**

Table 4: Descriptive statistics 1997

	Number of firms	Per cent share	Average size	Average age	Average capital intensity	Average profitability
NO R&D	163	45.03	262.08	45.10	0.21	0.10
PROC. R&D	3	0.83	652.33	47.00	0.37	0.09
PROD. R&D	64	17.68	576.44	47.05	0.17	0.09
COMB. R&D	132	36.46	1382.02	56.17	0.24	0.06
Total	**362**	**100.00**	**730.40**	**49.60**	**0.21**	**0.08**

Table 5 and 6 present the results from the estimation of the multinomial logit model for 1999 and 1997 respectively. As mentioned in section 3.3, a vector of coefficients, β_j , for each choice is estimated. Note that the results regarding the different choices should be interpreted compared to the choice NO R&D. Since the number of observations for the choice PROC. R&D is so small (only 3 firms for each year), the estimation for this choice does not provide any results that can be meaningfully interpreted.[5] The analysis therefore concentrates on the choices PROD. R&D and COMB. R&D

[5] The results from the regression results of the choice PROC. R&D for 1999 and 1997 are presented in Appendix C and D.

In hypothesis 2 it was suggested that the probability of conducting process and product R&D increases with firm size and that there is a possibility that the relationship has a non-linear pattern. The empirical analysis shows that the size and the squared size variables are significant both 1997 and 1999 for both the alternative PROD. R&D and COMB. R&D. The size variable has a positive sign, whereas the squared size variable has a negative size, which implies that there is a non-linear relationship between the probability to innovate and firm size. Hence, the probability of conducting R&D increases with size but at a decreasing rate.

The theoretical section of this paper concludes that the empirical evidence on the relationship between innovations and firm maturity is rather unclear. Therefore hypothesis 3 has been given a quite general formulation, regarding the possibly non-linear pattern. The result from estimation adds to the previous literature in one respect by making use of the distinction between product and process R&D. The regression shows that the age variable is significant only regarding the choice COMB. R&D. In both the regression 1999 and 1997 the firms that are older than 80 years has a higher probability of conducting combined process and product R&D.

One may compare the size of the marginal effects for the choice PROD. R&D and COMB. R&D. Such a comparison shows that the marginal effects for the COMB. R&D are generally higher for both years. Thus, the size and age effects are more pronounced for firms that choose to combine process and product R&D. This result may be interpreted in the framework of a product life cycle perspective by observing that as firms that grow old and large they do not stop doing product innovation. They rather continue with product R&D while combining this with process R&D.

Finally, a few words about the capital and profitability variables which do not have any significant coefficients at the 5 percent level for any of the choices. The profitability variable is however significant at the 10 percent level for the choice of COMB. R&D. These results could have been suspected already when we studied the descriptive statistics in table 4, which showed very small differences in the average capital intensity and profitability between the four different types of firms.

Table 5: Results of the multinomial logit model 1999

Variable	Coef	Std. Err.	z	p	Marginal effects
PROD. R&D					
Constant	-3.528	.726	-4.86*	0.000	
Size	.005	.001	7.19*	0.000	$1.30*10^{-4}$
Size2	$-2.07*10^{-7}$	$5.08*10^{-8}$	-4.09*	0.000	$-5.82*10^{-9}$
Cap	.406	1.067	0.38	0.703	.014
Age80	.832	.555	1.50	0.134	.014
Profit	2.165	1.486	1.46	0.145	.063
Manufacture of food products and beverages (SIC 15)	-2.356	1.335	-1.76**	0.078	-.042
Manufacture of textiles (SIC 17)	-35.674	$5.29*10^{7}$	-0.00	1.000	-.104
Manufacture of wearing apparel; dressing and dyeing of fur (SIC 18)	-35.593	$1.07*10^{8}$	-0.00	1.000	-.051
Tanning and dressing of leather (SIC 19)	-35.833	$1.48*10^{8}$	-0.00	1.000	-.047
Manufacture of wood and of products of wood and cork (SIC 20)	-2.996	1.517	-1.97*	0.048	-.042
Manufacture of pulp, paper and paper products (SIC 21)	-3.105	1.399	-2.22*	0.027	-.047
Publishing, printing and reproduction of recorded media (SIC 22)	-38.414	$9.34*10^{7}$	-0.00	1.000	-.052
Manufacture of coke, refined petroleum products and nuclear fuel (SIC 23)	-34.896	$1.22*10^{8}$	-0.00	1.000	-.052
Manufacture of chemicals and chemical products (SIC 24)	1.391	.780	1.78**	0.075	.031
Manufacture of rubber and plastic products (SIC 25)	.993	.832	1.20	0.232	.024
Manufacture of other non-metallic mineral products (SIC 26)	-.806	1.016	-0.79	0.428	-.023
Manufacture of basic metals (SIC 27)	-.626	1.057	-0.59	0.554	-.022
Manufacture of machinery and equipment (SIC 29)	1.451	.707	2.05*	0.040	.034
Manufacture of office machinery and computers (SIC 30)	3.614	1.087	3.32*	0.001	.129
Manufacture of electrical machinery and apparatus (SIC 31)	.3883	.925	0.42	0.675	-.010
Manufacture of radio, television and communication equipment (SIC 32)	1.342	.922	1.45	0.146	.035
Manufacture of medical, precision and optical instruments (SIC 33)	1.656	.875	1.89**	0.058	.027
Manufacture of motor vehicles (SIC 34)	.294	.917	0.32	0.748	.021
Manufacture of other transport equipment (SIC 35)	2.174	1.293	1.68*	0.093	.082
Manufacture of furniture (SIC 36)	.006	1.289	0.00	0.996	.004

Variable	**Coef**	**Std. Err.**	**z**	**p**	**Marginal effects**
COMB. R&D					
Constant	-3.424	.664	-5.16*	0.000	
Size	.005	.001	8.08*	0.000	.001
Size2	$-2.25*10^{-7}$	$4.99*10^{-8}$	-4.52*	0.000	$4.28*10^{-8}$
Cap	.208	.888	0.23	0.815	.037
Age80	1.281	.438	2.93*	0.003	.278
Profit	2.199	1.253	1.75**	0.079	.416
Manufacture of food products and beverages (SIC 15)	-1.087	.946	-1.15	0.250	-.161
Manufacture of textiles (SIC 17)	.659	.970	0.68	0.497	.181
Manufacture of wearing apparel; dressing and dyeing of fur (SIC 18)	-35.068	$7.02*10^{7}$	-0.00	1.000	-.331
Tanning and dressing of leather (SIC 19)	-35.194	$9.85*10^{7}$	-0.00	1.000	-.304
Manufacture of wood and of products of wood and cork (SIC 20)	-3.905	1.544	-2.53*	0.011	-.230
Manufacture of pulp, paper and paper products (SIC 21)	-1.343	.925	-1.45	0.147	-.189
Publishing, printing and reproduction of recorded media (SIC 22)	-38.367	$6.08*10^{7}$	-0.00	1.000	-.336
Manufacture of coke, refined petroleum products and nuclear fuel (SIC 23)	2.759	1.530	1.80**	0.071	.592
Manufacture of chemicals and chemical products (SIC 24)	1.718	.716	2.40*	0.016	.366
Manufacture of rubber and plastic products (SIC 25)	1.240	.756	1.64	0.101	.267
Manufacture of other non-metallic mineral products (SIC 26)	-.275	.838	-0.33	0.742	-.046
Manufacture of basic metals (SIC 27)	.221	.849	0.26	0.795	.053
Manufacture of machinery and equipment (SIC 29)	1.779	.651	2.73*	0.006	.369
Manufacture of office machinery and computers (SIC 30)	3.222	1.087	2.96*	0.003	.486
Manufacture of electrical machinery and apparatus (SIC 31)	1.474	.748	1.97*	0.049	.339
Manufacture of radio, television and communication equipment (SIC 32)	1.514	.848	1.79**	0.074	.321
Manufacture of medical, precision and optical instruments (SIC 33)	2.148	.781	2.75*	0.006	.449
Manufacture of motor vehicles (SIC 34)	-.532	.988	-0.54	0.590	-.098
Manufacture of other transport equipment (SIC 35)	1.951	1.280	1.52	0.127	.373
Manufacture of furniture (SIC 36)	-.332	1.282	-0.26	0.796	-.062
Number of observations:530 Log likelihood function:-373.092 Log likelihood ratio statistics (chi 2):299.65 Pseudo R2: 0.287					

* denotes significance at the 5 percent level. ** denotes significance at the 10 percent level

Table 6: Results of the multinomial logit model 1997

Variable	Coef	Std. Err.	z	p	Marginal effects
PROD. R&D					
Constant	-2.663	.785	-3.39*	0.001	
Size	.004	.001	5.05*	0.000	$1.41*10^{-6}$
Size2	$-1.57*10^{-7}$	$5.09*10^{-8}$	-3.10*	0.002	$-6.37*10^{-11}$
Cap	-.223	1.535	-0.15	0.884	$-2.8*10^{-4}$
Age80	.201	.619	0.32	0.746	$-1.82*10^{-4}$
Profit	1.734	2.053	0.84	0.398	.001
Manufacture of food products and beverages (SIC 15)	-1.182	1.143	-1.03	0.301	$-4.13*10^{-4}$
Manufacture of textiles (SIC 17)	-.113	1.280	-0.09	0.930	$-6.00*10^{-5}$
Manufacture of wearing apparel; dressing and dyeing of fur (SIC 18)	-42.233				-.001
Tanning and dressing of leather (SIC 19)	-42.724				-.001
Manufacture of wood and of products of wood and cork (SIC 20)	-45.784	$2.80*10^{9}$	-0.00	1.000	-.003
Manufacture of pulp, paper and paper products (SIC 21)	-45.195	$2.36*10^{9}$	-0.00	1.000	-.007
Publishing, printing and reproduction of recorded media (SIC 22)	-44.826				-.001
Manufacture of coke, refined petroleum products and nuclear fuel (SIC 23)	-43.441				-.001
Manufacture of chemicals and chemical products (SIC 24)	.987	.829	1.19	0.234	$2.89*10^{-4}$
Manufacture of rubber and plastic products (SIC 25)	.236	1.049	0.22	0.822	$-1.60*10^{-4}$
Manufacture of other non-metallic mineral products (SIC 26)	-1.176	1.280	-0.92	0.358	$-4.30*10^{-4}$
Manufacture of basic metals (SIC 27)	-.113	1.074	-0.11	0.916	$-1.78*10^{-4}$
Manufacture of machinery and equipment (SIC 29)	1.385	.741	1.87**	0.062	.001
Manufacture of office machinery and computers (SIC 30)	0.257				.999
Manufacture of electrical machinery and apparatus (SIC 31)	-43.639	$2.21*10^{9}$	-0.00	1.000	-.007
Manufacture of radio, television and communication equipment (SIC 32)	2.193	1.150	1.91**	0.057	.001
Manufacture of medical, precision and optical instruments (SIC 33)	1.346	.956	1.41	0.159	$8.88*10^{-5}$
Manufacture of motor vehicles (SIC 34)	.0263	1.036	0.99	0.322	.001
Manufacture of other transport equipment (SIC 35)	-.995	1.863	-0.53	0.593	$-3.40*10^{-4}$
Manufacture of furniture (SIC 36)	-44.870				-.001

Variable	Coef	Std. Err.	z	p	Marginal effects
COMB. R&D					
Constant	-2.667	.7363	-3.62*	0.000	
Size	.0040	.001	5.93*	0.000	$8.98*10^{-4}$
Size2	$-1.77*10^{7}$	$4.98*10^{8}$	-3.55*	0.000	$-3.93*10^{8}$
Cap	.641	1.235	0.52	0.604	.143
Age80	1.206	.462	2.61*	0.009	.287
Profit	-1.331	1.631	-0.82	0.415	-.297
Manufacture of food products and beverages (SIC 15)	-.987	.995	-0.99	0.321	-.182
Manufacture of textiles (SIC 17)	-.0476	1.145	-0.04	0.967	-.011
Manufacture of wearing apparel; dressing and dyeing of fur (SIC 18)	-41.865.				-.363
Tanning and dressing of leather (SIC 19)	-42.972				-.364
Manufacture of wood and of products of wood and cork (SIC 20)	-2.666	1.303	-2.05*	0.041	-.317
Manufacture of pulp, paper and paper products (SIC 21)	-1.209	1.009	-1.20	0.231	-.209
Publishing, printing and reproduction of recorded media (SIC 22)	-46.927				-.367
Manufacture of coke, refined petroleum products and nuclear fuel (SIC 23)	.376	2.236	0.17	0.866	.089
Manufacture of chemicals and chemical products (SIC 24)	1.310	.787	1.66**	0.096	.313
Manufacture of rubber and plastic products (SIC 25)	1.132	.890	1.27	0.203	.274
Manufacture of other non-metallic mineral products (SIC 26)	-.517	.985	-0.53	0.599	-.105
Manufacture of basic metals (SIC 27)	.522	.923	0.57	0.572	.123
Manufacture of machinery and equipment (SIC 29)	1.254	.728	1.72**	0.085	.294
Manufacture of office machinery and computers (SIC 30)	-5.591				-.358
Manufacture of electrical machinery and apparatus (SIC 31)	1.221	.895	1.36	0.173	.297
Manufacture of radio, television and communication equipment (SIC 32)	2.269	1.117	2.03*	0.042	.499
Manufacture of medical, precision and optical instruments (SIC 33)	2.159	.883	2.44*	0.014	.486
Manufacture of motor vehicles (SIC 34)	.619	1.105	0.56	0.576	.147
Manufacture of other transport equipment (SIC 35)	-1.055	1.803	-0.59	0.558	-.188
Manufacture of furniture (SIC 36)	-44.737				-.496
Number of observations:333 Log likelihood function:-251.764 Log likelihood ratio statistics (chi 2):213.18 Pseudo R2:0.297					

* denotes significance at the 5 percent level. ** denotes significance at the 10 percent level

Before we summarize the empirical results and conclude the paper it is interesting to take a closer look at the industry-specific dummy variables that were included in the multinomial logit model to control for differences between industries. Table 7 summarizes the industry dummy variables that were significant at the 5 or 10 percent level 1999 for the choices PROD. R&D and COMB. R&D. The industries for which the industry dummy variables have negative marginal effects are industries that can be regarded as "process oriented". Industries which have positive marginal effects are industries that can be expected to have a high technological content. These are usually considered to be innovative industries. In 1997 very few industry dummies were significant at the 5 or 10 percent level. The few industry dummy variables that were significant in 1997 were also present as significant dummy variables in 1999. Moreover, these variables have invariant signs both years.

Table 7: Summary of significant industry dummy variables 1999

	Positive sign	**Negative sign**
PROD. R&D	Manufacture of chemicals and chemical products (SIC 24) Manufacture of machinery and equipment (SIC 29) Manufacture of office machinery and computers (SIC 30) Manufacture of medical, precision and optical instruments (SIC 33) Manufacture of other transport equipment (SIC 35)	Manufacture of food products and beverages (SIC 15) Manufacture of wood and of products of wood and cork (SIC 20) Manufacture of pulp, paper and paper products (SIC 21)
COMB. R&D	Manufacture of coke, refined petroleum products and nuclear fuel (SIC 23) Manufacture of chemicals and chemical products (SIC 24) Manufacture of machinery and equipment (SIC 29) Manufacture of office machinery and computers (SIC 30) Manufacture of electrical machinery and apparatus (SIC 31) Manufacture of radio, television and communication equipment (SIC 32) Manufacture of medical, precision and optical instruments (SIC 33)	Manufacture of food products and beverages (SIC 15) Manufacture of wood and of products of wood and cork (SIC 20)

5 Conclusions and suggestions for future research

The primary focus of this paper has been to investigate the relationship between firm size and age and the probability to conduct process and product R&D. A number of advantages and disadvantages of being a small versus large and old versus new firm has been presented. The issue about complementarities between process and product R&D has also been discussed.

The empirical results show that we can expect substantial complementarities between the two. This synergy is apparent for process R&D since almost no firm chooses to concentrate only on process innovation. Another interpretation would be that there are very few industries where price competition is so important that the firms are able to concentrate on process R&D. Product innovations have to be conducted in order to remain competitive, which also explains the more pronounced effect of size and age on the probability of firms conducting both process and product innovations.. These findings question the previously described stylized facts about technological change over the product life cycle. This is also in line with recent research by Filson (2002), who shows that not all industries follow the pattern of the product life cycle. In his study he finds that the early automobile industry is an industry that follows the pattern of the product life cycle theory, whereas the modern microelectronics industry has a different pattern. In the microelectronics industry quality improvements do not decrease over time and cost improvements are not always increasing over time.

The importance of continuous and combined product and process R&D discussed in this paper has additional aspects that could be interesting to elaborate further. One issue that could be to investigate further concerns how the firm's decision process regarding innovation can be expected to occur in more detail. Is the choice of conducting certain R&D conditional on previous choices? That is, do the firm first choose between conducting no R&D and conducting R&D and then in a second step choose between process, product or combined R&D. In order to investigate such conditional decisions a nested multinomial model could be specified and estimated.

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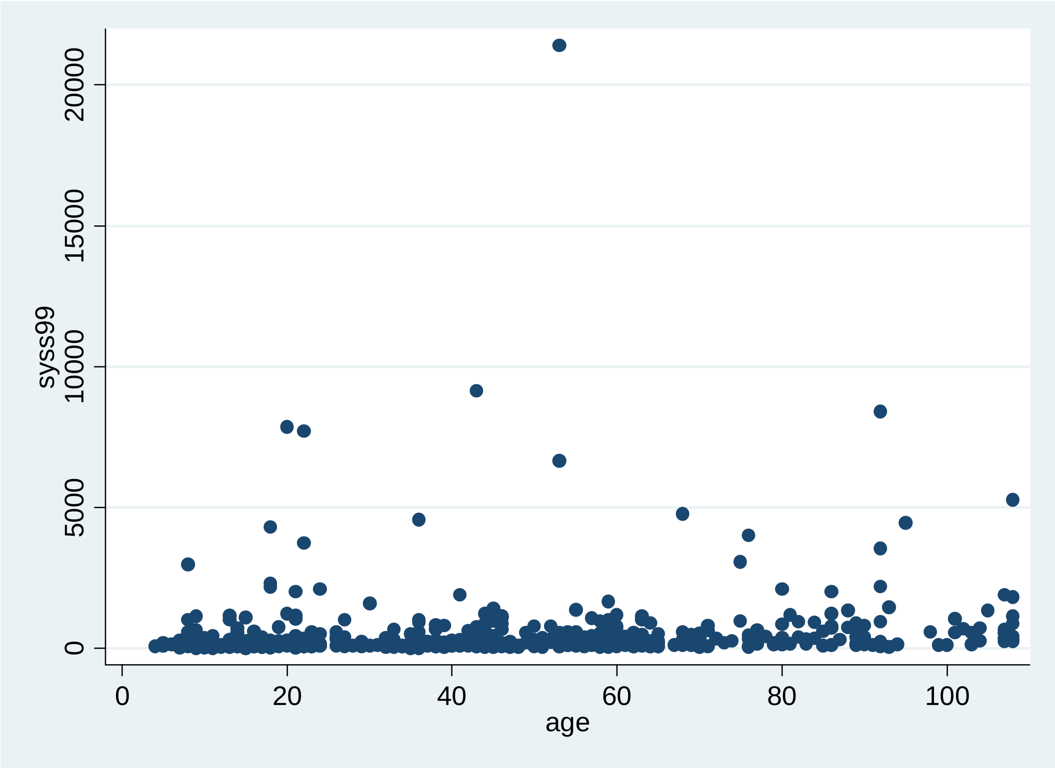
APPENDIX A: Correlation Matrix for 1999

	Size	Size2	Cap	Age80	Profit
Size	1.000				
Size2	0.861	1.000			
Cap	0.0758	-0.029	1.000		
Age80	0.111	0.011	0.120	1.000	
Profit	-0.000	-0.020	-0.006	0.029	1.000

APPENDIX B: The relationship between firm age and size 1999.



APPENDIX C: Results of the multinomial logit model 1999. (The choice of PROC. R&D)

Variable	**Coef**	**Std. Err.**	**z**	**p**	**Marginal effects**[6]
PROC. R&D					
Constant	-29.694	2.195	-13.53*	0.000	
size	.003	.0021	1.41	0.158	
Size2	$3.01*10^{7}$	$4.46*10^{7}$	0.67	0.500	
Cap	4.268	4.132	1.03	0.302	
Age80	-50.337	$2.21*10^{7}$	-0.00	1.000	
Profit	.891	7.528	0.12	0.906	
Manufacture of food products and beverages (SIC 15)	24.160	2.343	10.31*	0.000	
Manufacture of textiles (SIC 17)	-12.997	$2.35*10^{8}$	-0.00	1.000	
Manufacture of wearing apparel; dressing and dyeing of fur (SIC 18)	-12.019	$4.75*10^{8}$	-0.00	1.000	
Tanning and dressing of leather (SIC 19)	-12.919	$7.05*10^{8}$	-0.00	1.000	
Manufacture of wood and of products of wood and cork (SIC 20)	-13.197	$1.60*10^{8}$	-0.00	1.000	
Manufacture of pulp, paper and paper products (SIC 21)	-16.966	$1.05*10^{8}$	-0.00	1.000	
Publishing, printing and reproduction of recorded media (SIC 22)	-10.499	$2.09*10^{8}$	-0.00	1.000	
Manufacture of coke, refined petroleum products and nuclear fuel (SIC 23)	-12.134	$5.53*10^{8}$	-0.00	1.000	
Manufacture of chemicals and chemical products (SIC 24)	24.399	2.291	10.65*	0.000	
Manufacture of rubber and plastic products (SIC 25)	-12.729	$1.63*10^{8}$	-0.00	1.000	
Manufacture of other non-metallic mineral products (SIC 26)	-13.712	$1.42*10^{8}$	-0.00	1.000	
Manufacture of basic metals (SIC 27)	-25.502	$5.10*10^{7}$	-0.00	1.000	
Manufacture of machinery and equipment (SIC 29)	-11.873	$7.64*10^{7}$	-0.00	1.000	
Manufacture of office machinery and computers (SIC 30)	-11.994	$2.74*10^{8}$	-0.00	1.000	
Manufacture of electrical machinery and apparatus (SIC 31)	-12.245	$1.43*10^{8}$	-0.00	1.000	
Manufacture of radio, television and communication equipment (SIC 32)	-204.547	$6.68*10^{7}$	-0.00	1.000	
Manufacture of medical, precision and optical instruments (SIC 33)	-11.638	$1.52*10^{8}$	-0.00	1.000	
Manufacture of motor vehicles (SIC 34)	-35.350	$5.88*10^{7}$	-0.00	1.000	
Manufacture of other transport equipment (SIC 35)	26.154		.		
Manufacture of furniture (SIC 36)	-12.573	$2.97*10^{8}$	-0.00	1.000	

* denotes significance at the 5 percent level. ** denotes significance at the 10 percent level

[6] Note that the marginal effects from the choice PROC. R&D could not be calculated due to the very low number of firms choosing this outcome.

APPENDIX D: Results of the multinomial logit model 1997. (The choice of PROC. R&D.)

PROC. R&D	**Coef.**	**Std. Err.**	**z**	**p**	**Marginal effects**[7]
Constant	-29.667	1.980	-14.98*	0.000	
size	.006	.005	1.23	0.218	
Size2	$-2.30*10^{-6}$	$3.71*10^{-6}$	-0.62	0.534	
Cap	2.874	3.840	0.75	0.454	
Age80	-41.037	$8.41*10^{8}$	-0.00	1.000	
Profit	1.420	11.122	0.13	0.898	
Manufacture of food products and beverages (SIC 15)	24.640				
Manufacture of textiles (SIC 17)	-18.644				
Manufacture of wearing apparel; dressing and dyeing of fur (SIC 18)	-15.500				
Tanning and dressing of leather (SIC 19)	-16.523				
Manufacture of wood and of products of wood and cork (SIC 20)	-19.705				
Manufacture of pulp, paper and paper products (SIC 21)	-18.267	$1.01*10^{9}$	-0.00	1.000	
Publishing, printing and reproduction of recorded media (SIC 22)	16.389				
Manufacture of coke, refined petroleum products and nuclear fuel (SIC 23)	-17.256				
Manufacture of chemicals and chemical products (SIC 24)	25.531	1.483	17.21*	0.000	
Manufacture of rubber and plastic products (SIC 25)	-18.908				
Manufacture of other non-metallic mineral products (SIC 26)	-19.051				
Manufacture of basic metals (SIC 27)	-17.700	$2.18*10^{9}$	-0.00	1.000	
Manufacture of machinery and equipment (SIC 29)	-18.139	$1.77*10^{9}$	-0.00	1.000	
Manufacture of office machinery and computers (SIC 30)	20.181				
Manufacture of electrical machinery and apparatus (SIC 31)	-18.833				
Manufacture of radio, television and communication equipment (SIC 32)	-15.430	$1.55*10^{9}$	-0.00	1.000	
Manufacture of medical, precision and optical instruments (SIC 33)	-18.489				
Manufacture of motor vehicles (SIC 34)	-18.240				
Manufacture of other transport equipment (SIC 35)	-17.772				
Manufacture of furniture (SIC 36)	-18.626				

[7] Note that the marginal effects from the choice PROC. R&D could not be calculated due to the very low number of firms choosing this outcome.