The dual Role of Innovation for Entry and Exit Behaviour

First draft

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1 Introduction

Entry and exit of firms are important aspects of industrial change and are closely related to innovations, both in terms of product and process innovations. This paper will discuss the role of R&D in exit and entry processes. The theoretical debate regarding this issue boils down to the question if industries with high investments in R&D have lower or higher entry and exit rates. An entry barrier approach, as suggested by early theoretical contributors such as Bain, (1956) and Yip (1982), would suggest that R&D works as a barrier to entry, and therefore entry and exit should be lower in R&D intensive industries. Empirical evidence and alternative theoretical models as suggested by, for example, Acs and Audretsch (1989) and Geroski, (1999) conclude that the issue is not that simple and that innovation can be an important way for new firms to compete with incumbent firms. Therefore innovation instead could be expected to stimulate entry.

A suitable theoretical model for investigating the relationship between entry, exit and R&D is the model presented by Klepper (1996). The model describes the evolution of industries over the product life cycle and incorporates the role of entry, exit, and different types of R&D (product and process R&D). In the evolutionary process of an industry, the early successful entrants invest in R&D and as their output increases their returns from R&D will increase. In the initial stage many firms enter in the profitable industry but at some point prices and profits are driven down and the number of firms decreases, resulting in an oligopoly in the maturity stage.

The paper is organized as follows: Section 2 presents the theoretical arguments regarding the role of R&D including the model by Klepper (1996). This section also presents the empirical findings regarding this issue. Section 3 describes the two major sources of data that will be used in this paper, and Section 4 presents the empirical analysis based on data covering the Swedish industrial sectors during the 1990:s. Finally conclusions and suggestions for future research are presented in Section 5.

2 The dual role of R&D for entry and exit behavior

Investments in innovations and R&D can, according to different theoretical views, have a dual role for the entry and exit of firms since it can both stimulate and be a barrier to entry and exit. It works as a barrier to entry of new firms since costly initial investments in R&D and innovation makes it more risky and less attractive to enter an industry. High initial R&D costs also deter exit since incumbent firms at length might try to avoid losing the investments in R&D if they exit. On the other hand, R&D can stimulate entry by way of product differentiation and product innovation. These two theoretical explanations regarding the interrelationship between entry, exit and R&D intensity give a somewhat confusing picture that indeed corresponds to the empirical evidence 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 in either encouraging or impeding entry is confusing, perhaps even chaotic."* (Siegfried & Evans, 1994, p. 142.)

Most of the literature on these issues investigates the relationship between entry and innovation, but it is important to note that innovation and exit is closely interrelated since innovation and the rate of survival is closely connected. For example, Audretsch (1995a) find that in industries were innovation is important (especially small firm innovation) the survival of new entering firms is lower than in industries with low innovation rates. An important point to make in this discussion is that factors that usually has been regarded as barriers to entry in some senses can be regarded as barriers to survival. For example, product differentiation, that can be regarded as one dimension of innovative activity, seem to constitute a barrier to survival. Audretsch (1995a)

An additional question concerns if the size of the firm entering or exiting influences the relationship between R&D investments and entry and exit patterns. This issue is especially interesting since entering firms in general tend to be small. In empirical studies by, for example, (Geroski, 1995) it has been found that small firms and entering firm make a substantial contribution to the generation and diffusion of innovations. The relationship between R&D entry and exit is, apparently closely connected to the relationship between innovation and firm size, since many of the entering firms are very small. Section 2.2 present theoretical issues related to entry, exit and R&D as well as empirical findings. Theoretical explanations and empirical results regarding the relationship between firm size and innovation are presented in Section 2.3.

2.1 Entry, Exit and R&D

The traditional entry barrier literature represented by for example Bain (1956), Orr (1974), and Yip (1982) suggest that innovations, along with, for example, high capital intensity, advertising, and scale economies, will work as barriers to entry and exit. Another type of literature is represented by, for example, Griliches (1979), Acs & Audretsch (1989) and Geroski (1999), and suggests instead that innovation can be a competitive advantage for entering firms. Acs & Audretsch (1989) suggest that potential small 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. The following section presents a commonly used theoretical model capturing both the dynamics of entry, exit and R&D. The model was presented by Klepper, (1996) and model the dynamics over the product life cycle.

2.1.1 A theoretical model for entry, exit and R&D over the product life cycle

The model by Klepper (1996) describes the process of entry exit and R&D over the product life cycle and in each period incumbent firms decide if they want to remain in the industry and potential entrants decides if the will enter or not. The decision for firm i at time t, is made with respect to maximize the current expected profits $E(\pi_{it})$ which can be expressed as:

$$E(\pi_{it}) = [s_i + g(rd_{it})]G - rd_{it} + [Q_{it-1}(Q_t / Q_{t-1}) + \Delta q_{it}] \times [p_t - c + l(rc_{it})] - rc_{it} - m(\Delta q_{it}) - F \quad (1)$$

The model is based on the assumption that a firm can benefit from a one-period monopoly profit (G) by successfully develop a product innovation in terms of a unique distinctive product. A firm decides how much product R&D to perform but the firm's innovative capabilities is randomly determined s_i, and constant over time. rd_{it} represent the cost of performing product R&D and the function $g(rd_{it})$ represent the opportunities for product innovation. The expression $[s_i + g(rd_{it})]G - rd_{it}$ therefore represent the expected net profit from product R&D.

In Equation (1) $[Q_{it-1}(Q_t / Q_{t-1}) + \Delta q_{it}] \times [p_t - c + l(rc_{it})] - rc_{it} - m(\Delta q_{it})$ represent the net profit from producing the standard product after subtracting the cost of process R&D (rc_{it}) and the and the cost of adjusting the firm's output $m(\Delta q_{it})$. The model assumes that there is no additional costs for an individual firm to maintain it's market share. The total market share grows with (Q_t / Q_{t-1}) and the individual firm's output expansion is therefore $Q_{it-1}(Q_t / Q_{t-1})$ and Δq_{it} is the quantity expansion resulting that the firm increases it's market share. $c + l(rc_{it})$ is the average cost of producing the standard product where the function $l(rc_{it})$ represent the opportunities for process innovation. The last term in Equation (1) represent a fixed cost for the firm to monitor the other firms innovations in order to be able to imitate their innovations.

Let $E(\pi^*{}_{it})$ denote the expected profit when the firm maximizes it's expected profit with respect to rd_{it}, rc_{it} and Δq_{it}. Incumbent firms decide to stay in the industry if $E(\pi^*{}_{it}) > 0$, are indifferent if $E(\pi^*{}_{it}) = 0$ and decide to exit if $E(\pi^*{}_{it}) < 0$. Potential entrants decide to enter if $E(\pi^*{}_{it}) > 0$, are indifferent about entering if $E(\pi^*{}_{it}) = 0$ and do not enter if $E(\pi^*{}_{it}) < 0$.

According to the model presented above, Klepper (1996) is able to present and prove[1] 9 propositions regarding the entry, exit, and R&D dynamics over the product life cycle. 4 of

[1] For formal proofs se Klepper (1996)

these propositions are of special interest as regards R&D, and will be presented in the following section, starting with what is called proposition 4 in Klepper's article.

Proposition 4: After entry ceases, the expected number of product innovations of all firms, $\sum_{i,t}(s_i + g(rd_{it}))$ *declines over time.*

The explanation to this proposition is that since each firm performs a constant amount of product innovation, the total amount of product innovation will decrease when entry ceases.

Proposition 5: For each firm i that remains in the market in period t $rc_{it} / rd_{it} > rc_{it-1} / rd_{it-1}$.

This implies that firms that remains in the market increases its effort on process innovation relative to product innovation. One explanation to this proposition is that the returns of process R&D increases with firm size and as firms grow they perform an increasing share of process R&D relative to product R&D.

Proposition 6: For all periods t, $i_t^k < i_t^l$ *for k<l*

This means that entrants will be more innovative on average than incumbent firms. Since entrants are smaller than incumbent firms they earn less from producing the standard product than the other firms, and to compensate for this disadvantage entering firms have to be more innovative than incumbents.

Proposition 7: For each period t, the larger the output of the firm at the start of the period Q_{it-1}*, then the greater is its total spending on R&D,* $rd_{it} + rc_{it}$ *and the greater the fraction of its total R&D devoted to process innovation* $rc_{it} /(rd_{it} + rc_{it})$.

Also in this case the fact that the returns of process R&D increase as firm size increases are important. If the firm has a larger output to distribute their fixed cost of process R&D over, they tend to put more effort on process R&D.

Proposition 8: For each period t, the average product of process R&D, $l(rc_{it})/rd_{it}$*, and the average product of product R&D,* $s_i + g(rd_{it})/rd_{it}$*, vary inversely with the size of the firm,* Q_{it}*.*

This proposition states that the outcome of process and product R&D are higher in smaller firms. It is for example empirically found that the number of patents per dollar of R&D is larger in firms with small budgets for R&D. (e.g Acs & Audretsch, 1991). If the total R&D spending does not increase more than proportionally with size this also implies that larger firms will account for a disproportionately small share of process and product innovation.

2.1.2 Empirical findings

The general empirical evidence on the relationship between entry, exit and innovation is 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 to R&D. Researchers such as Gort and Klepper, (1982) on the other find a positive causal relationship in the direction from innovation to entry.

Geroski, (1995), also discuss 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 innovation stimulate innovation? The initial empirical analysis show that entry causes innovation but innovation does not cause entry, but if the empirical analysis is corrected for entry conditions and technological opportunities (industries with rich technological opportunities does also have lower entry barriers) entry have a weak negative effect on innovativeness. (Geroski, 1995)

The theoretical model by Klepper (1996) described above does not distinguish between different types of industries. Audretsch (1995b) distinguish 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 in industries belonging to a high technological opportunity class (industries were the total innovation rate is high but the small firm innovation rate is low) new firm start-ups are deterred. 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).

Another interesting issue is how entry and innovation varies across industries and across time. Geroski (1995) find in his empirical study that variations in entry across industry over time are rather unstable and within industry variation is large and rather unsystematic, whereas variations in innovative activities within industries are rather stable, and tend to be more systematic across industries and over time. His interpretation of these findings is that structural factors (such as technological opportunities) play a more important role in determining the conditions for innovation than entry barriers do in determining entry and that current market conditions play a larger role in determining entry rates than innovation rates. He also suggests that the market conditions that matter for entry appear to be more idiosyncratic than those that matter for innovation (Geroski 1995).

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

2.2 R&D innovation and firm size

The issue whether small firms are more innovative than large firms has been discussed in a number of articles during recent years. This issue was discussed already by Schumpeter (1934, 1942). In his book “The Theory of Economic Development” (Schumpeter, 1934) industry dynamics is described a process of “creative destruction” a process where most new firms are created by “new men”. In “Capitalism, Socialism and Democracy” (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 since they are able to accumulate knowledge (e.g. R&D, product-, and process knowledge) and financial resources. Cohen and Levin (1989) summarize a number of arguments regarding the advantages for small firms and large firms in the innovation process. Explanations to why large firms should perform a larger share of the innovations are:

- Capital market imperfections make it easier for large firms to finance risky R&D projects.
- The presence of economies of scale in the production of R&D.
- The returns from R&D are larger if output is large.
- Because of complementarities between R&D and other manufacturing activities that might be more developed in large firms, R&D tend to be more productive in large firms.

There are some reasons for why large firms easier can finance risky R&D project. Large firms can have larger and more stable internal funds available for financing these projects. It is also possible that they already have well-established contacts with, for example, banks that can provide financing. The returns from R&D are larger if output is large since the then the fixed cost of innovation can be spread over a larger output. According to Cohen and Klepper, (1996) this is especially true for process innovations.

An additional explanation to why large firms devote more resources to inventions and R&D is, according to Arrow (1962), is that R&D and investments are very risky projects. A large firm can, in such a situation, act as its own insurance company by investing in several small scale R&D and invention activities and therefore reduce the risk.

Cohen and Levin (1989) also provide some explanations to why large firms have some disadvantages in producing innovation i.e advantages for small firms. They argue that:

- 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.
- The incentives for researchers and entrepreneurs decreases as their personal benefits from their research efforts are usually decreasing with firm size.

2.2.1 Empirical findings

The relationship between firm size and innovation has been empirically investigated in several studies. The empirical evidence on the relationship between firm size and entry 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. Studies performed after the mid 1980s show a somewhat different pattern since it was found that R&D intensity initially decrease but then increase with size (Cohen and Levin, 1989). Other interesting evidence suggests that both very small and very large firms perform a disproportionate share of innovations. Pavitt et. al., (1987) and Acs & Audretsch (1987) find 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.

While discussing empirical findings regarding R&D in entering small firms it is important to note that there are some difficulties of capturing R&D in new firms. As mentioned above most of the entering firms are small. Since many small firms does not have a formal R&D function but considerable R&D are performed outside a formal R&D function there might be some problems with capturing all R&D expenditures in especially small firms. (Cohen and Levin, 1989).

3 Data and method

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 will be described below.

3.1 Financial accounts for enterprises

This dataset makes it possible to identify entering and exiting firms since it includes individual firm level data coded in order to be able to identify entry and exit. The data consist of information regarding the financial situation of non-financial enterprises in the corporate sector, including information from joint-stock companies, cooperatives, partnerships, limited partnerships, associations and some foundations. This means that all industries except Financial intermediation (SIC[2]-code 65-67) and Real estate activities (SIC-code 70) are included in the dataset. The dataset includes financial information from the profit and loss account and balance sheet as well as some basic data such as 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. This data collection method was introduced in 1996 and in this way all firms could be included in the dataset. The new data collection method makes comparisons with earlier data very difficult. Data for 1996, 1997, 1998 and 1999 will be available to use in the empirical analysis.

3.2 Research and development in the business enterprise sector

The dataset on "Research and development in the business enterprise sector" is based on a biannual survey covering enterprises in the non-financial sectors with more than 50 employees. Data for 1991, 1993, 1995, 1997 and 1999 can be used in the empirical study. Firms that in the survey "Financial accounts for enterprises", described above, declared that they had R&D expenditures, or previously reported R&D expenditures in the "Research and development in the Business enterprise sector" survey were considered for the survey. All firms fulfilling the above requirement, and reporting R&D expenditures exceeding 5 million SEK, or with more than 200 employees are included in the survey. 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 method described above applies to the data from 1999, but are mainly the same from 1995-1999, and are therefore comparable. The data collected before 1995 mainly covered the manufacturing industry (SIC-code 15-37) and therefore the data for 1991-99 is comparable only for these sectors. The survey includes questions about, for example, the number of

[2] Standard Industrial Classification

R&D-personnel and their education, R&D-expenditures, and the distribution of R&D expenditure by type of activity.

Since the questionnaire included questions regarding the purpose of the R&D activities, 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, for the firm new products (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.

4 Empirical findings

This section intends to test the 5 propositions from Klepper's model, presented in Section 2.2.1

To be completed…

Table 1: Share of process R&D 1991-1999 (%)

SIC-code	**Industry**	**1991**	**1993**	**1995**	**1997**	**1999**
1	Agriculture, hunting and related service activities	34	59	33	32	26
2	Forestry, logging and related service activities				100	44
10	Mining of coal and lignite; extraction of peat		40	9		
13	Mining of metal ores	86	43	88	75	38
14	Other mining and quarrying		41			
	Average (SIC-code 10-14)	**60**	**46**	**43**	**69**	**36**
15	Manufacture of food products and beverages	24	31	33	27	27
16	Manufacture of tobacco products	33	11	17	58	0
17	Manufacture of textiles	13	14	0	0	9
18	Manufacture of wearing apparel		0			
19	Tanning and dressing of leather		6			
20	Manufacture of wood and	44	13	11	12	4

	of products of wood and cork					
21	Manufacture of pulp, paper and paper products	32	32	28	27	24
22	Publishing, printing and reproduction of recorded media	38	17	23	5	28
23	Manufacture of coke	8	11	6	32	14
24	Manufacture of chemicals and chemical products	22	18	22	18	15
25	Manufacture of rubber and plastic products	23	20	21	16	8
26	Manufacture of other non-metallic mineral products	36	20	23	18	12
27	Manufacture of basic metals	32	43	50	44	36
28	Manufacture of fabricated metal products	7	13	10	6	8
29	Manufacture of machinery and equipment	12	6	11	9	12
30	Manufacture of office machinery and computers	6	7	1	10	7
31	Manufacture of electrical machinery and apparatus	23	17	14	18	14
32	Manufacture of radio, television and communication equipment and apparatus	16	14	16	7	8
33	Manufacture of medical, precision and optical instruments	5	8	11	7	6
34	Manufacture of motor vehicles	4	11	14	13	12
35	Manufacture of other transport equipment	34	30	21	21	30
36	Manufacture of furniture	15	19	17	0	0
37	Recycling					
	Average manufacturing industry (SIC-code 15-37)	**21**	**16**	**17**	**17**	**14**
40	Electricity, gas, steam and hot water supply	100	96	74	83	85
41	Collection, purification and distribution of water					
45	Construction	61	22	28	42	31
50	Sale, maintenance and repair of motor vehicles		33			

	and motorcycles					
51	Wholesale trade and commission trade	0	16	9	9	10
52	Retail trade, except of motor vehicles and motorcycles	100	100	100	100	100
55	Hotels and restaurants					
60	Land transport	0	0			100
61	Water transport					
62	Air transport					
63	Supporting and auxiliary transport activities	35	77	23	79	
64	Post and telecommunications	76	81	63	55	63
71	Renting of machinery and equipment					
72	Computer and related activities	38	29	35	41	44
73	Research and development	53	52	55	50	44
74	Other business activities	51	46	45	35	25
80	Education					52
85	Health and social work		9			
90	Sewage and refuse disposal		100			
91	Activities of membership organizations	78	67	55	56	56
92	Recreational, cultural and sporting activities		62	100	0	
93	Other service activities					
	Average service sector (SIC-code 40-93)	**54**	**53**	**53**	**54**	**55**
	Average all industries (SIC-code 10-93)	**34**	**32**	**30**	**33**	**28**

5 Conclusions and suggestions for future research

To be completed…

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