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Innovation in Small-Sized High-Growth Firms

A Study of Norwegian Gazelle Firms

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Abstract

This thesis studies innovation within 280 small-sized high-growth firms in Norway, with a main focus on the relationship between firm size, customer knowledge and innovative activity. Innovation is a present and future need for Norway. A study of the innovative activity within the high-growth firms is done by applying a Probit and a Tobit Type I model for corner solutions. It is found that firm size as an explanatory variable does not have any statistical significant effect on innovative activity. Another finding in the context of customer knowledge on innovative activity is that cooperating with customers in the innovation process has a statistically significant positive impact on innovation. However, the degree of market acceptance of products made together with customers turns out to have no statistical significant effect on a firm's innovative activity. It is further found that having an R&D department has a statistically significant positive effect on a firm's probability of having innovation, but no statistically significant effect on the firm's amount of innovation. The results from the variables of customer knowledge together with the results from the variable R&D suggests that policy makers should give firms financial incentives to include customers in the innovation process, instead of giving incentives to invest in R&D departments. On the other hand, the validity of these estimated results is questioned for several reasons, for example the difficulty of measuring innovation and customer knowledge.

Keywords: Innovation, Gazelle firms, firm size, customer knowledge, corner solutions model

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1 – Introduction

In the globalized and competitive world of today, one of the main challenges for firms is the question of how to survive in the market. Companies must have the ability to innovate and develop themselves and their technologies in order to continue to exist. The theory of economic growth involves technological development and innovation. Examples of firms with positive economic growth are the so-called “gazelle” firms. These firms are fast growing companies that at least double their annual sales and show a significant positive economic growth over a short period of time. The phenomenon of the gazelle firms is highly new to academics and research fields. Only a few projects has been performed on gazelle firms in Norway (Haraldsen (2012), Kamsvåg (2015), Dahlin (2015)). Because of their high-growth ability over a short period of time, these firms are interesting as a whole. One source to this high economic growth might be the firms’ technological development and innovation, but it is important to notice that it is a complex matter, and that it is the combination of many things that determines the economic growth and success of a firm.

The traditional view has been that investing in research and development (R&D) is the way to innovate (Shefer & Frenkel, 2005). In today’s fast-changing, global and competitive markets, using innovation may be a challenge. One reason for this is that customers are aware and through the use of the Internet and technology have easy access to information. Another reason is the risk of consumers adopting a new product or not, but also the fact that it is difficult to know what the consumers really want. Turning these challenges around by involving external sources or partners in the innovation process has lately become a study of more interest in the literature (Tether (2002), Belderbos, Carree, and Lokshin (2004), Santamaría, Nieto, and Barge-Gil (2009), Cappelli, Czarnitzki, and Kraft (2014)). Using customers and their knowledge in the process of innovation is known as “open innovation” or “user innovation”, a term first introduced by Chesbrough (2006) and further developed by Von Hippel (2005). The degree of users in the innovation process differs within various industries and the products themselves, as there are some technologies and developments that it is easier to cooperate with partners about than others. In spite of this, cooperating with customers of the products reveals useful information and gives insights to the firm, such as customer- and market needs. In addition, the cost of having own R&D departments might be high, and small firms might not even have the capacity to have such departments. Then, as an alternative or in addition to having an R&D department, the firms may choose to involve its customers in the innovation process. Interesting questions arise. First, is customer cooperation important for firms' innovative activity? Second, is cooperation with customers replacing the traditional R&D departments, with regards to the importance in the innovation process? And third, and how do the answers to these question influence innovation-promoting policymaking? The available data gives a possibility of determining how this customer knowledge in a firm is related to its innovative activity. This information is exploited in trying to answer the above questions.

Another side of innovation is the view of Joseph Schumpeter. He is one of the main contributors to the theory of innovation and economic growth in context of industrial organization. He discusses competition and market structure in relation to innovation. According to him, the size of the firm has an impact on how much a firm innovates: Specifically, he argues that it is the large firms who are the most innovative. The reason is that large firms have the capital to finance their innovations (Martin, 2010). But can it be true that the large firms are those who are the most innovative? What about the possibility for small-sized firms in Norway to develop new products and services? These questions form the basis of this thesis, and this thesis then concerns the thoughts of Schumpeter on firm size and innovation on the one hand and R&D and innovation cooperation with customers on the other hand. Earlier economic literature has mostly considered the horizontal relationship between firms, whereas the vertical relationship between firms and its customers is the main focus of this study. The approach of the thesis is to use both economic literature on the relationship between firm size and innovation, and management literature on customer cooperation. This is put into an econometric framework to explore the different impacts of customer cooperation and firm size on innovation. First, it is of importance to determine what makes firms innovate. This is done by using a Probit model to estimate the probability of having innovation. A more ambitious project is to estimate how much innovation a firm makes. This is studied by use of Tobit type I model for corner solutions. The choice is to estimate both of these models, as the Tobit model estimates more parameters than the Probit, and therefore have less degrees of freedom, which could be a problem due to a low number of observations in the studied sample. In accordance with other empirical studies on innovation, the estimation is performed with control variables such as age, industry and capital localization (Balasubramanian & Lee, 2008). For the dependent variable a direct measure of the number of product innovations is used. This type of innovation occurs when new technology or connected technologies are brought out to meet demand from market or customers (Utterback & Abernathy, 1975).

The findings from this study may be useful information to firms, universities, and institutions working with innovation, technological development and R&D research, such as "Innovasjon Norge", "Norges forskningsråd". It may give suggestions to how Norway may stimulate the innovative performances of firms in the future. Studying innovation is important in Norway, because introducing new products is needed for the future. The reason for this is that much of the past revenues and economic growth in Norway has come from the oil industry. Due to the non-renewability of oil and possible future climate enhancing policies that limits oil extraction, Norway must find other sources to future economic growth. Consequently, there is a need to keep developing and innovating in other industries in order to keep track with competition and increased globalization. Today Norway has the oil, what do they have tomorrow?

2 – Background and concepts

This chapter is devoted to the conceptual framework used in this paper. Here, the goal is to present the views of Schumpeter, as this relationship is not to be overlooked in a study of innovation. The role of firm size is probably the most studied in relation to innovation (Balasubramanian & Lee, 2008). A theoretical model by d'Aspremont and Jacquemin (1988) is presented. The model shows that the R&D level in a firm, here interpreted as a firm's innovative activity, is higher under monopoly (large firm) than under duopoly (smaller firms). This model is chosen to illustrate the differences between innovation in large and small-sized firms. Further, various concepts of innovation and customer cooperation might seem abstract at first, and therefore the third section is devoted to explaining these concepts and how innovation has been measured in the literature. It should be noted that the management literature concerning innovation and open innovation, together with customer knowledge, is vast, thus only a small selection is presented. At first, high-growth firms, also known as gazelle firms, is defined.

2.1 Gazelle firms

The term 'gazelle' has been related to David Birch and his study about job generation, in which he use this term about few, rapid economically growing firms (Henrekson & Johansson, 2010). A definition made by Birch, Haggerty, and Parsons (1995) is the following ”*A business establishment which has achieved a minimum of 20% sales growth each year over the interval, starting from a base-year revenue of at least $100.000*” (p.46). This definition is in accordance with a proposed definition by the Organization for Economic Cooperation and Development (OECD), saying that high- growth enterprises are enterprises with an average employment growth rate that exceeds 20 percent annually over a period of 3 years. According to OECD, at the beginning of the period there should be ten or more employees (Ahmad, 2008). Henrekson and Johansson (2010) argue that these firms are small and young firms, whereas others do not draw attention to size and age in their explanation of a gazelle firm, for example in the Norwegian newspaper “Dagens Næringsliv”. On a yearly basis “Dagens Næringsliv” presents a list over Norwegian Gazelle firms. The criterias that the newspaper set to become a gazelle company are the following: Firms must at least have doubled their annual sales in a period of four years. Their annual sales must be over one million NOK within the first year. The operating result must be positive, and the firms must have shown that they have avoided negative growth. Finally, the firms are privately owned firms, and all publicly financed companies are excluded from the sample (Frantsvold, 2014). The studied sample in this thesis is based on the annual list of gazelle firms from “Dagens Næringliv”. It is also of importance to notice that these firms have become gazelle firms in a time in which parts of the world faced an economic crisis.

2.2 Schumpeterian competition

Joseph Schumpeter, one of the main inventors of the theories about market performance and economic growth, is highly studied in the literature of innovation and firm size (Acs and Audretsch (1988b), Cohen and Levin (1989), Bertschek and Entorf (1996)). “Schumpeterian Competition” is a term denoting competition in the outcome of new products or processes, and how to commercialize these (Martin, 2010). This Schumpeterian terminology is related to the view that market power can lead to improved performance in the market. The opinions of Schumpeter about the relationship between innovation and market structure changed along the years. Acs and Audretsch (1988b) present Schumpeter in what they call “The Two Schumpeters”. In Schumpeters’ first approach, it is the new firm that is central for innovation. This is referred to as Schumpeter Mark I, where the role of the entrepreneur’s social function is emphasized (Martin, 2010). The entrepreneur is a member of a social class that is central to self-generated growth in the economy, and the entrepreneur is the one who drives innovations.

The second approach, Schumpeter Mark II, is about the market structure, in which Schumpeter draws the attention to large (monopoly) firms. In his opinion, it is the large firms who primarily drive technological progress. The reason for this is that large, leading firms have the market power, earn economic profits and are therefore able to finance innovations (Martin, 2010). Another point in advantage of the large firms is that they are more likely to be diversified and because of this, their willingness to take on risk is higher than in small firms (Belleflamme & Peitz, 2010).

There is a large empirical literature on the relationship between firm size and innovation. In contrast to the view of Schumpeter, there are studies that do not find empirical support for his hypothesis about firm size and innovation. Scherer (1965) studies technological change, and from his findings he doubts the Schumpeterian hypothesis about the large, monopolistic firms as being the primary drivers of technological change. Similarly, Cohen, Levin, and Mowery (1987) find little support for this second view of Schumpeter by their study of R&D intensity. In a working paper by OECD it is pointed out that at an overall level, the empirical evidence for Schumpeter's hypothesis is limited (Symeonidis, 1996). This is also presented in the following quote by Martin (2010), where the empirical findings with regards to the Schumpeterian hypothesis are ambiguous, and in a way it confirms the difficulties in testing this relationship: "*The Schumpeter Mark II approach makes two distinct but related claims. The first is that large firms have a comparative advantage in innovation, compared with small firms. The second is that supply-side market concentration favours innovation, all else equal. On balance, neither claim has fared well in empirical tests*" (p. 459-460).

Moreover, there are other empirical contributors to studies of firm size and innovation, like Acs and Audretsch (1987b), Acs and Audretsch (1988a) and Hansen (1992). Especially Acs and Audretsch (1987a, 1991) emphasize the small-sized firms in their studies. Arrow (1983) claims that decisions about funding R&D will differ between small and large firms, as large firms are able to generate more internal funds than small firms. The small firms with little or no financial reserves must seek external funding for innovation projects of large scale. Since it is hard to know whether or not a project is promising or not, the financial markets will raise the cost of capital for small borrowers, to compensate for risk. Thus, small firms pay higher interest rates, which makes it harder to get external funding at any rate of interest.

2.2.1. *A theoretical illustration of the innovative level between a monopoly (large) firm and duopoly (small) firms.*

In order to illustrate the argument of Schumpeter, this subsection approaches a theoretical model from d'Aspremont and Jacquemin (1988) of cooperation on R&D duopoly firms. The objective is to show the differences of innovation within a monopoly and duopolies, in which the monopoly is here considered to represent large firms and the duopolies are firms of a smaller size, since the model here is used as an illustration of the differences between small and large firms. In the original model by d'Aspremont and Jacquemin (1988) there is a spillover effect of R&D between the firms in the duopoly case. In the presented model below, the spillover effect, β, is set equal to zero, as this thesis does not concern spillover effects. The two cases presented below show that the level of R& is higher in the monopoly (large firm) case, than in the case of duopolies (small firms).

Consider two firms who interact in two stages, where the first stage involves firms' decisions to invest in R&D in order to reduce production costs, while the second stage involves determining their respective output levels. Assume a model of two firms in which the function $P\ (Q)$ denotes the inverse demand. Total produced quantity is given by $Q = q_1 + q_2$. Production cost for firm *i* is a function of own production, q_i, how much it spends on research, i.e. x_i. The total cost function of firm *i* is denoted $C_i(q_i, x_i)$. Firm *i* also have R&D costs, which are denoted $C_i^{RD}(x_i)$. Assume linearity of total demand and production costs, thus: $P\ (Q) = a - bQ$, where $a, b\ >\ 0$ and $C_i(q_i, x_i) = [A - x_i]q_i$, where $i \in \{1,2\}$. Finally, the R&D costs of firm *i* are assumed to be quadratic: $C_i^{RD}(x_i) = \frac{\gamma}{2}x_i^2, \gamma > 0, i \in \{1,2\}$. The parameters above are specified in the following way, $0 < A < a$. Consequently, the profit of firm *i* is given as:

$$\pi_i = [a - bQ]q_i - \ [A - x_i]q_i - \frac{\gamma}{2}x_i^2$$

The model is solved by use of backward induction, thus starting from the second-stage. The main focus for this thesis is a firm's equilibrium R&D level. First, the duopoly case is shown and thereafter the monopoly. In the case of duopoly, the profit for firm *i* is given by:

$$\pi_i = [a - bQ]q_i - \ [A - x_i]q_i - \frac{\gamma}{2}x_i^2$$

$$= \left[aq_i - bq_i^2 - bq_iq_j\right] - \ [Aq_i - x_iq_i] - \frac{\gamma}{2}x_i^2$$

The optimal produced quantity for firm *i* given its R&D level and the other firm's produced quantity is found by taking the first order condition with respect to q for firm i:

$$\frac{\partial \pi_i}{\partial q_i} = a - 2bq_i - bq_j - A + x_i = 0$$

$$\Leftrightarrow q_i(q_j, x_i) = \frac{a - A + x_i - bq_j}{2b}$$

Due to the symmetry between the firms, it follows that the corresponding expression for firm j is given by the following expression:

$$q_j(q_i, x_j) = \frac{a-A+x_j-bq_i}{2b}$$

Inserting the value of q_j in q_i yields:

$$q_i = \frac{a-A+x_i}{2b} - \frac{b(a-A+x_j-bq_i)}{4b^2}$$

$$= \frac{a - A + x_i}{2b} - \frac{a - A + x_j - bq_i}{4b}$$

$$= \frac{2(a - A + x_i)}{4b} - \frac{a - A + x_j - bq_i}{4b}$$

$$= \frac{2(a - A)}{4b} + \frac{2x_i}{4b} - \left(\frac{a - A}{4b}\right) - \frac{x_j}{4b} + \frac{1}{4}q_i$$

$$= \frac{a - A}{4b} + \frac{2x_i}{4b} - \frac{x_j}{4b} + \frac{1}{4}q_i$$

$$= \frac{1}{4b}\left[(a - A) + 2x_i - x_j\right] + \frac{1}{4}q_i$$

$$\Leftrightarrow q_i - \frac{1}{4}q_i = \frac{1}{4b}\left[(a - A) + 2x_i - x_j\right]$$

$$\Leftrightarrow \frac{3}{4}q_i = \frac{(a - A)}{4b} + \frac{(2x_i - x_j)}{4b}$$

$$\Leftrightarrow q_i(x) = \frac{(a - A)}{3b} + \frac{(2x_i - x_j)}{3b}$$

This is firm i's optimal choice of output given the firms' respective R&D levels. Then, inserting $q_i(x)$ into q_j yields:

$$q_j = \frac{a-A+x_j}{2b} - \frac{1}{2}\left[\frac{(a-A)}{3b} + \frac{(2x_i-x_j)}{3b}\right]$$

$$= \frac{a - A}{2b} + \frac{x_j}{2b} - \frac{(a - A)}{6b} - \frac{(2x_i - x_j)}{6b} = \frac{3(a - A)}{6b} + \frac{3x_j}{6b} - \frac{(a - A)}{6b} - \frac{2x_i}{6b} + \frac{x_j}{6b}$$

$$= \frac{a - A}{3b} + \frac{2x_j}{3b} - \frac{x_i}{3b}$$

$$\Leftrightarrow q_j(x) = \frac{(a-A)}{3b} + \frac{(2x_j-x_i)}{3b}$$

Similarly, this is firm j's optimal output given the R&D levels of the firms. From the above expressions of the firms' respective outputs, total output given R&D levels is found:

$$Q(x) = q_i(x) + q_j(x) = 2\left(\frac{a-A}{3b}\right) + \frac{x_i}{3b} + \frac{x_j}{3b}$$

Therefore,

$$\frac{\partial Q}{\partial x_i} = \frac{1}{3b} \wedge \frac{\partial q_i(x)}{\partial x_i} = \frac{2}{3b} = 2\frac{\partial Q}{\partial x_i}$$

Finally, in the first stage, the firms choose their respective levels of R&D. The obtained expressions for quantities are inserted into the profit function of firm *i* which yields the expression:

$$\pi_i(x) = [a - bQ(x)]q_i(x) - \ [A - x_i]q_i(x) - \frac{\gamma}{2}x_i^2$$

$$\frac{\partial \pi_i(x)}{\partial x_i} = [a - bQ(x)]\frac{\partial q_i(x)}{\partial x_i} - bq_i(x)\frac{\partial Q}{\partial x_i} - [A - x_i]\frac{\partial q_i(x)}{\partial x_i} + q_i(x) - \gamma x_i$$

$$= 2[a - bQ(x)]\frac{\partial Q}{\partial x_i} - bq_i(x)\frac{\partial Q}{\partial x_i} - 2[A - x_i]\frac{\partial Q}{\partial x_i} + q_i(x) - \gamma x_i$$

$$= \frac{\partial Q}{\partial x_i}\big[2[a - bQ(x)] - bq_i(x) - 2[A - x_i]\big] + q_i(x) - \gamma x_i$$

$$= \frac{1}{3b}\big[2(a - A) + 2x_i - b[q_i(x) + 2Q(x)]\big] + q_i(x) - \gamma x_i$$

$$= 2\left(\frac{a-A}{3b}\right) + \frac{2x_i}{3b} - \frac{1}{3}[q_i(x) + 2Q(x)] + q_i(x) - \gamma x_i$$

$$= 2\left(\frac{a-A}{3b}\right) + x_i\left(\frac{2}{3b} - \gamma\right) + \frac{2}{3}[q_i(x) - Q(x)]$$

$$= 2\left(\frac{a-A}{3b}\right) - x_i\left(\frac{3b\gamma-2}{3b}\right) - \frac{2}{3}q_j(x) = 0$$

$$\Leftrightarrow x_i\left(\frac{3b\gamma-2}{3b}\right) + \frac{2}{3}\left[\frac{a-A}{3b} + \frac{2x_j}{3b} - \frac{x_i}{3b}\right] = 2\left(\frac{a-A}{3b}\right)$$

$$\Leftrightarrow x_i\left(\frac{3b\gamma-2}{3b}\right) + \frac{2}{3}\left(\frac{a-A}{3b}\right) + \frac{4x_j}{9b} - \frac{2x_i}{9b} = 2\left(\frac{a-A}{3b}\right)$$

$$\Leftrightarrow x_i\left(\frac{3b\gamma-2}{3b} - \frac{2}{9b}\right) = \frac{4}{3}\left(\frac{a-A}{3b}\right) - \frac{4x_j}{9b}$$

$$\Leftrightarrow x_i\left(\frac{9b\gamma-8}{9b}\right) = \frac{4}{9b}\big[(a - A) - x_j\big]$$

$$\Leftrightarrow x_i(x_j) = \left(\frac{4}{9b\gamma-8}\right)\big[(a - A) - x_j\big]$$

This is the best response function of firm *i*, i.e. the R&D level of firm i given the R&D level of firm *j*. This function has slope $\frac{\partial x_i(x_j)}{\partial x_j} = -\left(\frac{4}{9b\gamma-8}\right)$, which is negative for $9b\gamma > 8$ or positive for $9b\gamma < 8$. In the former situation, the R&D levels of the firms are strategic substitutes, whereas they are strategic complements in the latter. Due to the symmetry between the firms, it follows that the corresponding best response function for firm *j* is given as the following expression:

$$x_j(x_i) = \left(\frac{4}{9b\gamma-8}\right)[(a - A) - x_i]$$

Inserting the value of x_j in x_i yields:

$$x_i = \left(\frac{4}{9b\gamma-8}\right)(a-A) - \left(\frac{4}{9b\gamma-8}\right)^2 [(a-A) - x_i]$$

$$\Leftrightarrow x_i = \left(\frac{4}{9b\gamma-8}\right)(a-A) - \left(\frac{4}{9b\gamma-8}\right)^2 (a-A) + \left(\frac{4}{9b\gamma-8}\right)^2 x_i$$

$$\Leftrightarrow x_i \left[1 - \left(\frac{4}{9b\gamma-8}\right)^2\right] = \left(\frac{4}{9b\gamma-8}\right)(a-A)\left[1 - \left(\frac{4}{9b\gamma-8}\right)\right]$$

$$\Leftrightarrow x_i \left[\frac{(9b\gamma-8)^2-4^2}{(9b\gamma-8)^2}\right] = \left(\frac{4}{9b\gamma-8}\right)(a-A)\left(\frac{9b\gamma-12}{9b\gamma-8}\right)$$

$$\Leftrightarrow x_i \left[\frac{(9b\gamma-8)^2-4^2}{(9b\gamma-8)^2}\right] = \left(\frac{4(9b\gamma-12)}{(9b\gamma-8)^2}\right)(a-A)$$

$$\Leftrightarrow x_i = \left(\frac{(9b\gamma-12)}{(9b\gamma-8)^2-4^2}\right) 4(a-A)$$

which is firm *i*'s equilibrium R&D level.

Furthermore, since

$$\frac{(9b\gamma-12)}{(9b\gamma-8)^2-4^2} = \frac{(9b\gamma-12)}{(9b\gamma)^2+64-16(9b\gamma)-16} = \frac{(9b\gamma-12)}{(9b\gamma)(9b\gamma-16)+48}$$

$$= \frac{3(3b\gamma-4)}{3[(3b\gamma)(9b\gamma-16)+16]} = \frac{3b\gamma-4}{(3b\gamma)(9b\gamma-16)+16}$$

$$= \frac{3b\gamma-4}{27(b\gamma)^2-48b\gamma+16} = \frac{3b\gamma-4}{(3b\gamma-4)(9b\gamma-4)} = \frac{1}{9b\gamma-4}$$

it follows that the equilibrium R&D level of firm *i* in the duopoly is

$$x_i^D = \left(\frac{4}{9b\gamma-4}\right)(a-A)$$

where the superscript D denotes duopoly.

Inserting x_i^D into x_j yields:

$$x_j = \left(\frac{4}{9b\gamma-8}\right)(a-A) - \left(\frac{4}{9b\gamma-8}\right)\left(\frac{4}{9b\gamma-4}\right)(a-A)$$

$$\Leftrightarrow x_j = \left(\frac{4}{9b\gamma-8}\right)(a-A)\left(\frac{9b\gamma-8}{9b\gamma-4}\right)$$

$$\Leftrightarrow x_j^D = \left(\frac{4}{9b\gamma-4}\right)(a-A)$$

so that both firms have the same level of R&D:

$$x_i^D = x_j^D = x^D = \left(\frac{4}{9b\gamma-4}\right)(a-A)$$

Since the levels of R&D cannot be negative, this expression is only meaningful when $b\gamma > \frac{4}{9}$.

In order to have a stable equilibrium in R&D levels, the best response functions of the firms must have a slope less than 1 in absolute value (Henriques, 1990). In this setup, this condition corresponds to:

$$\frac{\partial x_i(x_j)}{\partial x_j} = \left|-\left(\frac{4}{9b\gamma - 8}\right)\right| < 1$$

$$\Leftrightarrow \begin{matrix} 4 < 9b\gamma - 8 \ \wedge -4 < 9b\gamma - 8 \quad for\ 9b\gamma > 8 \\ 4 > 9b\gamma - 8 \ \wedge -4 > 9b\gamma - 8 \quad for\ 9b\gamma < 8 \end{matrix}$$

$$\Leftrightarrow \begin{matrix} 12 < 9b\gamma \ \wedge 4 < 9b\gamma \quad for\ 9b\gamma > 8 \\ 12 > 9b\gamma \ \wedge 4 > 9b\gamma \quad for\ 9b\gamma < 8 \end{matrix}$$

$$\Leftrightarrow \begin{matrix} b\gamma > \frac{4}{3} \quad for\ strategic\ substitutes \\ b\gamma < \frac{4}{9} \quad for\ strategic\ complements \end{matrix}$$

As mentioned above, in order to have non-negative levels of R&D in equilibrium, $b\gamma > \frac{4}{9}$. This contradicts the stability condition for the situation where R&D levels are strategic complements. This, in turn, means that the equilibrium can only be stable and have non-negative R&D levels in the situation where the R&D levels are strategic substitutes.

For the condition to be satisfied when the R&D level are strategic substitutes, the values of b and γ must be relatively high. From the model specification, it is known that $b, \gamma > 0$. Thus, this is more likely to be the case when the marginal cost of R&D increases relatively fast and the (direct) demand curve is relatively flat. That is an inelastic demand curve, which implies that the quantity demanded is relatively unaffected by changes in the price of the product. A stable system is shown in figure 1 below.

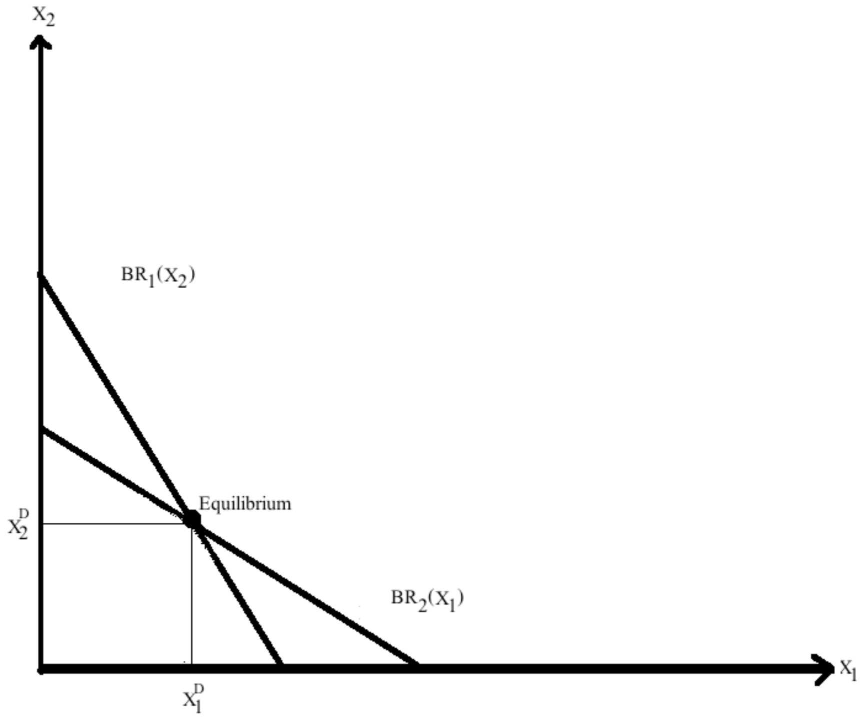

Figure 1. *Stable equilibrium where the R&D levels are strategic substitutes.*

Next, for the monopoly case, the profits is given by quantity demanded minus the costs of production and R&D, thus:

$$\pi = (a - bq)q - (A - x)q - \gamma \frac{x^2}{2} = aq - bq^2 - Aq + xq - \gamma \frac{x^2}{2}$$

In the second stage, the firm choose its quantity. This optimal value of this, given the R&D level, is found by setting the derivative of the profit function with respect to quantity, q, equal to zero:

$$\frac{\partial \pi}{\partial q} = a - 2bq - A + x = 0 \Leftrightarrow a - A + x = 2bq \Leftrightarrow q(x) = \frac{a-A+x}{2b}$$

Inserting this into the profit function gives the following expression:

$$\pi(x) = \left[a - A + x - \left(\frac{a-A+x}{2}\right)\right] q(x) - \frac{\gamma}{2} x^2$$

$$= \left(\frac{a-A+x)}{2}\right)\left(\frac{a-A+x}{2b}\right) - \frac{\gamma}{2} x^2$$

$$= \frac{1}{4b}(a - A + x)^2 - \frac{\gamma}{2} x^2$$

$$= \frac{1}{4b}[(a - A)^2 + x^2 + 2(a - A)x] - \frac{\gamma}{2} x^2$$

Taking the first order condition with respect to R&D level, i.e. x, yields:

$$\frac{\partial \pi(x)}{\partial x} = \frac{1}{4b}[2x + 2(a - A)] - \gamma x = 0$$

$$\Leftrightarrow \frac{1}{2b}[x + (a - A)] = \gamma x$$

$$\Leftrightarrow \frac{a - A}{2b} = \gamma x - \frac{x}{2b} \Leftrightarrow a - A = 2b\gamma x - x$$

$$\Leftrightarrow x^M = \left(\frac{1}{2b\gamma - 1}\right)(\mathrm{a - A})$$

where the superscript M denotes monopoly, which here represents a large single firm.
For this to be meaningful, a requirement is that $b\gamma > \frac{1}{2} = \frac{4}{8}$. Comparing this requirement with the one for the duopoly case ($b\gamma > \frac{4}{9}$), it is seen that the "monopoly requirement" is stronger than the "duopoly requirement". A preliminary conclusion is that the R&D levels are strategic substitutes and that the equilibrium is stable for $b\gamma \in \left]\frac{4}{3}, \infty\right[$. The R&D levels are also strategic substitutes for $b\gamma \in \left]\frac{8}{9}, \frac{4}{3}\right[$, but in this situation the equilibrium is unstable.

The second order conditions for the monopoly and the duopoly case is derived in Appendix 1. For the monopoly case it is shown to be $\frac{\partial^2 \pi(x)}{\partial x^2} = \frac{1}{2b} - \gamma < 0 \Leftrightarrow b\gamma > \frac{1}{2}$

and for the duopoly case $\frac{\partial^2 \pi_i(x)}{\partial x_i^2} = \frac{8}{9b} - \gamma < 0 \Leftrightarrow b\gamma > \frac{8}{9}$. It is seen that in the case of duopoly the condition is more stringent than in the monopoly case, but that these conditions do not change the above findings. Consequently, R&D levels are strategic substitutes for $b\gamma > \frac{8}{9}$, but the equilibrium is only stable when $b\gamma \in \left]\frac{4}{3}, \infty\right[$.

Finally, the R&D level for a given firm in the duopoly case is compared with the R&D level of the monopoly firm. It is seen that

$$x^M = \left(\frac{4}{8b\gamma - 4}\right)(a - A) > x^D = \left(\frac{4}{9b\gamma - 4}\right)(a - A)$$

i.e. the R&D level of a firm is higher in the monopoly case than in the duopoly case. To summarize, the presented model above without spillover effects shows that the level of R&D in a firm is higher in the case of monopoly, than in the case of a duopoly. This model is suggested to illustrate the theory that is presented about firm size and innovation, as the monopoly case represents a situation with one large firm, whereas the duopoly case represents a situation with two relatively smaller-sized firms. Finally, for the model to fulfill this purpose, R&D is assumed to represent a firm's level of innovation.

2.2.2. *An alternative to Schumpeter*

One of the sources to develop new products is by investing in research and development (R&D). R&D may affect the innovation directly in the way that it simply contributes to a new product or service. On the other hand, recent literature devoted to product development moves away from the traditional, endogenous innovation view, and claim that new inventions occurs by external interaction and knowledge (Nieto and Quevedo (2005), Chesbrough (2006), Von Hippel (2005)). R&D is not only useful for own innovative performance and developments, but also from other various actors, either they are related to the firm as competitors (horizontally) or as suppliers and customers (vertically). In the economic literature, the effects of internal and external knowledge have typically been studied separately, because of various approaches in the empirical examination (Brandenburger and Nalebuff (1995), Nieto and Quevedo (2005)). In the view of Schumpeter, innovation is typically endogenous and not a result of external sources (Acs & Audretsch, 1988b). This is leading to one-sided illustrations and skewed understanding of how firms' innovation processes occur (Nieto & Quevedo, 2005). Thus, the need for combining economic theory with variables of managerial interest, such as customer cooperation, seems to be of relevance in order to determine innovation in small sized firms.

2.3 Definitions

2.3.1. *Innovation*

Innovation generally means ‘something new’ (Peters, 2008), and might give various associations between different persons and their knowledge about the topic. Measuring innovation might seem abstract and therefore difficult. Being precise in the definition can be a challenge for researchers and innovation performers. Innovation as a field of study is broad and complex. The reason for this is that innovation comes in different stages, forms or processes, like product or process innovation, incremental and radical, market-pull and technology-push, and closed and open innovation (S. Lee, Park, Yoon, & Park, 2010). Innovation refers to various changes. Innovation is also used about significant changes in traditional ways of performance. Additionally, developments inside an organization, its business design and structures may also be considered as innovations (Johnson, 2001). A change in an already existing product or service is commonly done by a department of R&D, and that is the reason why many studies have used R&D expenditures as a measure of innovation, as is mentioned later in the thesis. This thesis will focus on *product* innovation, where product innovation involves introduction of a completely new products or services to the market, or it may be changes of characteristics in already existing products (Utterback & Abernathy, 1975).

Much of the empirical literature on innovation today focus on the sides of economic growth, in context of increased competition and globalized markets (Peters, 2008). Literature on innovation also involves the growth process of new developments (Balasubramanian & Lee, 2008). However, the approaches to test for innovative performance vary among the empirical studies. A general focus has been on the relationship between firm size and technological development, the extent of entry barriers and level of industry concentration (Scherer (1965), Acs and Audretsch (1987b), Cohen et al. (1987), Acs and Audretsch (1988a), Hansen (1992)) The firms’ ability to carry out product innovation has been tested by studying characteristics between different countries at regional and national levels (Frenkel, Shefer, Koschatzky, and Walter (2001), Santarelli and Sterlacchini (1990)) and also by age and innovation (Balasubramanian & Lee, 2008).

2.3.2. *Open innovation*

Innovation in its traditional way is known as closed innovation. This refers to situations where firms bring out their ideas on their own, and relies on internal knowledge, such as R&D departments, for further developments of the products and reach of customers. On the other side, there is open innovation. Open innovation, a term introduced by Chesbrough (2006) has lately become a field of interest (Von Hippel (2005), S. Lee et al. (2010)). The term defines the concept of firms using external resources in the innovation process. Involving external resources may imply co-working directly with customers in the innovation process in order to get a product that the customers request. It may also imply the use of feedback from customers after having bought a new product or service. As the literature on this topic has grown, so has the number of concepts within this topic. An example is Von Hippel (2005) who talks about innovation that is user-centered. He points out the need for users, as it is beneficial for both the users and the firms. Involving users in the innovation process gives them more of what they exactly wants. Firms, meanwhile, obtains useful and worthy information about their customers. He even claims that user innovation gives rise in social welfare. However, as he further points out, the downside of user-innovation is that it requires changes in the traditional manufacturing firms, which may be difficult and challenging for some firms. Another critique is made by Laursen and Salter (2014), who study open innovation and what they call a paradox within this type of innovation. They claim it to be a paradox in context of open innovation, because collaboration with external actors is often useful to firms. The firms need to make sure that they are getting paid for their innovative ideas. Thus, there is a potential conflict between openness and protection of innovations.

The idea of user-innovation comes from the more informative societies and the developments of software-knowledge around the world; Computers and advanced software make creation of innovations easier, in addition to feedback-channels that are reached more easily by the customer, for example through the Internet (Von Hippel, 2005). Additionally, economic and social concepts have changed, which also makes open innovation more feasible. For example, because of globalization the division of labor is increased, and trading ideas over different geographical areas is possible (Huizingh, 2011).

2.3.3. *Customer knowledge*

The constant change and developments in products involve shorter-lived products and services. The movements and transformations comes from the consequence of customers' demands are getting more characteristic and special (Wilde, 2011). In their paper, Cohen and Levinthal (1990) use research and development to capture the aspects of knowledge, and claim that crucial for innovative performance is external knowledge. Knowledge as an important side of the innovation process is also discussed by Wallin and Von Krogh (2010). As a matter of fact, they claim that innovation is not possible unless there exists knowledge. They point out two important factors to consider. First, innovation is all about knowledge as the innovators and firms must search and understand their markets, customers and competitors. In other words, firms must collect information and knowledge about their environments, which is then used to produce new products, services and processes. Second, customers' use of the product is based on their individual needs. This last point is also known as 'customer knowledge' in the management literature (Wilde, 2011). This term involves information and knowledge from both employees and customers in behavior and organizational context, also beyond firm borders. Customers are the foundation of economic achievements in firms and are therefore important for future firm success. The reason for this is that the use of customers in the innovation process gives firms the ability to understand and implement adaptions as early as possible. Building relationships with customers consisting of trust and integration of routines between the customers and firms is important, not only for innovation itself, but for winning new customers and keep loyal relations with already existing ones. Together with knowledge from and about customers, and constant development of new products and services, the firms are more rousted for the changes in their surroundings (Wilde, 2011).

2.3.4. *Measuring innovation and customer knowledge*

As mentioned earlier, research that concerns innovation may be a challenge because of difficulty in measuring and distinguishing the various types hereof. According to Acs and Audretsch (1988b), there does not exist established literature of identifying conditions either to hinder or lead to innovative activity. This means that there are different types of innovations being studied, and it does not exist any specific 'measure' of innovation in the economic literature. As Hansen (1992) argues, even if it was possible to find an appropriate measure for innovation, it would still be necessary to take into account the fact that some innovative activity has much smaller impact on economic performance. Because of this, the result for some time has been to collect various pieces of information that in some way indicates the level of innovation. For example, Frenkel et al. (2001) consider product innovation as involving both improvements in existing products and new products to the market, and the adaption of the product. Thus, empirical papers differs in the use of response variables; some looks at patens (Scherer (1965), Pakes (1985), Balasubramanian and Lee (2008)), whereas others rely heavily on R&D-expenditures, such as Connolly and Hirschey (1984), Scherer (1984), and Cohen et al. (1987). In his paper, Hansen (1992) explains that using R&D-efforts has been criticized, because this is only a measure of innovation inputs, and not outputs. Coad and Rao (2008) suggest to use both patents and the performed volume of R&D. Further they discuss the use of patents and they point out that using patents may be misleading to measure innovations, as not all innovations and new developments are being patented or also not able to be patented. The reason for this is the cost of patenting, especially for small-sized firms. In addition, the process of patenting might also take a lot of time, so for impatient firms this may not be suitable. Another thing to consider is the possibility of copyright. Firms who have copyrighted their innovation will then be excluded if one uses patents as a measure of innovative activity. Also, as Archibugi (1992) points out, many firms are not patenting their new products, but still they might be innovations.

The different approaches to represent product innovation are also reflected in studies that concerns open innovation and customer knowledge. S. Lee et al. (2010) suggest combining relationships between objects, events and persons into a network model to foster innovation in small-and medium sized enterprises (SMEs). Laursen and Salter (2006) study innovative performance, constructed as the firms' search for external ideas in combination with intensity of R&D. In their paper, a quantitative measure is applied for the number of the firms' external sources used for innovation (known as 'external search breadth'), and the extent to which the firms rely on various external resources (known as 'external search depth'). External sources here involve suppliers, customers and competitors, as well as private and public R&D laboratories and institutions such as universities and government offices. Additionally, a wide definition is also reflected in the study of open innovation by Mina, Bascavusoglu-Moreau, and Hughes (2014), where the studied firms stated to which extent external resources were used in the innovation process. In addition to this, measuring the use of customers is also performed differently. Tomlinson (2010) measures customer cooperation from three variables; The degree to which i) cooperation involved exchanges of knowledge and experiences, ii) cooperation with customers had improvements on quality of the product and iii) cooperation with customers turned into a completely new product.

For this thesis, innovative performance is studied by a variable that denotes product innovation. The variable is a direct measure in which respondents have answered whether they had product innovation or not, and if so, how many innovations they made. The measure of customer knowledge is based on questions concerning the use of customers in the innovation process, its importance, and how this process has affected the product in the market. The measure consists of numbers, thus a quantitative measure is obtained as in Laursen and Salter (2006). However, the questions from the survey contain abstract concepts like 'success' and 'acceptance', which in turn is difficult to define precisely. More about this is emphasized in the data section.

3 – Studies of customer cooperation

This chapter provides an overview of the literature that concerns innovation and cooperation with customers. Cooperation can happen both horizontally and in a vertical way. From the literature of industrial organization, horizontal R&D spillovers are highly studied theoretically, where the firms' products are either substitutes or complements to each other (Belderbos, Carree, & Lokshin, 2004). Examples of such are d'Aspremont and Jacquemin (1988), Kamien, Muller, and Zang (1992), Amir and Wooders (1998), Salant and Shaffer (1998) and Amir (2000) which investigate how cooperation on R&D affects social welfare, profit maximization, and competition, and how competing firms decide to invest in R&D in order to reduce cost and therefrom arising spillovers. However, vertical spillovers between customers and firms is lacking in the industrial organization literature, both theoretically and empirically. On the other hand, the management literature has highlighted the importance of cooperation with customers. For this reason, the management literature is also included. R&D is often used as a measure of innovation, and therefore studies of R&D and customer cooperation are also considered. As seen from chapter 2, there is little direct measure of customer cooperation. Therefore, the studied papers do differ in their approach to both measure and estimate customer cooperation and innovation. This shows some of the challenges to the topic.

In the context of open innovation, the traditional view that innovation only happens with a production manufacturer is now challenged. The need for changes in how to think about developing new products and services is highly relevant in a globalized, thus more competitive world. It is therefore of importance that firms build relationships with external sources, such as customers. Networks with other agents, or open innovation, involves looking beyond the traditional feature, and open up to the use of firms' surroundings in the innovation process, with an objective of faster adaption to changes and customer needs (Chesbrough, 2006). Results from empirical studies of R&D and customer cooperation show that cooperation on R&D differs between the choice of external sources (Belderbos, Carree, & Lokshin, 2004). An example is Fritsch and Lukas (2001), who study manufacturing firms in Germany and discover that cooperating with customers happens in product innovation, whereas working together with suppliers is more present for firms having process innovations. Furthermore, Kang and Kang (2009) find that the effect on innovative performance from external sources depends on what kind of source method that is used, which is of importance for firms in their decisions of using outside resources. This proposes a relationship between customer cooperation and innovation for the firms considered in this thesis.

The positive sides of customer cooperation are pointed out in the literature. For instance, cooperation with customers can reduce some of the risk that arises from innovation (Belderbos, Carree, & Lokshin, 2004). This is especially the case for specialized products where adaption by customers is requested (Tether, 2002). As Belderbos, Carree, Diederen, Lokshin, and Veugelers (2004) state, for the customer side, a reason to cooperate might be that there is a greater focus of improving product and getting them accepted by the market. Another to makes this point is Tether (2002). Moreover, if the firms are able to develop new products and adapt these to the customer needs in a quicker way than its competitors, it is a market success (Becker & Peters, 1998). Furthermore, getting one step ahead and cooperating with the customers in order to better satisfy their needs, might give the firms a higher competitive advantage. Cooperation with customers is expected to increase the customers' willingness to pay because the products are specialized to the customers' need. On the other hand, cooperation with customers is likely to increase the marginal costs of the firms, which may result in increased prices of the products at market. This again may result in lower demand. Hence, at an overall level, cooperation with customers may not be profitable for the firms.

On the contrary, the downside of cooperation with customers is also pointed out in the literature. Christensen and Bower (1996) state that firms might fail in the innovation process if they are too closebounded with their customers. One reason for this is that it may be unclear who owns the innovation. An example of this comes from Cassiman and Veugelers (2002), who show that it is of importance to have identified the limits of property rights. They also show that before entering in cooperation with customers, the firms should know how to protect the information that arises from this process. Thus firms cooperating with customers should stress to protect their innovations.

Finally, there is no direct measure of how the firms use and implement information and feedback from the customers for this thesis. This shows some of the challenges in relation to determination of relationships between innovation and cooperation.

4 – Method

This chapter presents the statistical models used in this thesis. The goal is to estimate the effects of primarily firm size and customer knowledge on firms' innovative activity. In deciding which statistical model to choose for this purpose, there are three things to consider. First, while the data is collected over a time period, it is treated as cross-sectional data. Second, it is of interest to know the probability of a firm having innovation. The class of models considered estimating probability of an event to occur is known as binary choice models, where the dependent variable takes on the value 1 if the event occurs (here if a firm has innovation) and 0 otherwise. Three different models are considered: The Linear Probability Model (LPM), Logit and Probit. A limitation with the LPM model is that the predicted values may lie outside the probability interval [0,1] (Maddala and Lahiri (1992) Amemiya (1981)). In addition, a criticism to this model is that a unit increase in x_j, all else equal, will always change the probability $P(y = 1|\boldsymbol{x})$ by the same magnitude, no matter what the initial value of $\boldsymbol{x}$ is, i.e. the partial effect of x_j is constant over the range of $\boldsymbol{x}$ (J. M. Wooldridge, 2010). This reduces the choice of model to one between the Logit and the Probit model, respectively. These models are derived under different assumptions about the error terms: In the Probit model, the error terms are standard normally distributed, while they are standard logistically distributed in the Logit model, i.e. the error terms have fatter tails in the latter than in the former. As the studied sample is not of large size, this means that using either the Probit or the Logit model will give similar results (Maddala & Lahiri, 1992). As will be seen later, the Probit model is implicitly estimated in the Tobit model (which is the main model of this thesis), and therefore the Probit model is chosen over the Logit model. Specifications of the Probit model is presented below.

Third, it is not only of interest to discover whether or not firms innovate, but also to determine how many innovations a firm is expected to make. In fact, the data set contains such information. This provides more knowledge of the innovative activity of the gazelle firms. Since the distribution of number of product innovations is roughly continuous, but has probability mass at the value 0 (the lowest possible number of product innovations), a Tobit Type I model is used to take into account this corner solution outcome. Initially, the Probit model is introduced, and thereafter the Tobit model is presented. Estimation is carried out by use of maximum likelihood. The focus is on the average partial effects (APEs) that denote the marginal effect for a given variable on the quantity of interest over the sample as a whole. For the Tobit model, there are three effects of interest, and one of them is the same as in the Probit model.

4.1 Probit model

To determine the probability of having product innovation, a Probit model is estimated. For this model, the dependent binary variable is product innovation, where the outcome is 1 if a firm has innovation, and 0 otherwise (J. Wooldridge, 2012). The model is specified as

$$P(y = 1|\boldsymbol{x}) = G(\boldsymbol{x\beta}) \qquad (1)$$

where, the cumulative distribution function $G(\cdot)$ lies in the open interval from 0 to 1, for all real numbers of the index $\boldsymbol{x\beta} = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k$ (J. Wooldridge, 2012). As mentioned above, in the Probit model, $G(\cdot)$ is the standard normal cumulative distribution (CDF) and is expressed as an integral:

$$G(z) = \Phi(z) \equiv \int_{-\infty}^{z} \phi(v)dv \qquad (2)$$

in which the standard normal density function, $\Phi(z)$, is given by:

$$g(z) = \phi(z) = \frac{\partial \Phi(z)}{\partial z} = (2\pi)^{-\frac{1}{2}} \exp(-z^2/2) \qquad (3)$$

According to J. M. Wooldridge (2010), the magnitudes of the estimated coefficients of the Probit is not particularly useful. In stead, the average partial effects (APE) and the partial effect at the average (PEA) are suitable measures to interpret (J. M. Wooldridge, 2010). PEA measures the marginal effect at the mean of the independent variables. The drawback of the PEA is the fact that it is measured at the mean, even though these characteristics may not be reflected by any firm in the sample. This will in particular be a problem for the binary variables where each outcome is observed at *least* once. For example, the binary variable that determines industry of the firm, may have a mean value of 50 percent. No firm can actually have this value (either the firm is a manufacturing firm (1) or not (0)). For this reason, it is questionable whether the PEA is an informative measure. Consequently, for the rest of this thesis only the APEs are estimated and interpreted. An APE makes an average over the individual partial effects (here, averaging over all the firms). For a continuous variable, x_K, the APE is given by the formula:

$$\hat{\beta}_K [N^{-1} \sum_{i=1}^{N} g(\boldsymbol{x}_i \hat{\boldsymbol{\beta}})] \qquad (4)$$

whereas if x_K is binary, the formula is:

$$N^{-1} \sum_{i=1}^{N} [G(\hat{\beta}_1 + \hat{\beta}_2 x_{i2} + \cdots + \hat{\beta}_{K-1} x_{i,K-1} + \hat{\beta}_K) - G(\hat{\beta}_1 + \hat{\beta}_2 x_{i2} + \cdots + \hat{\beta}_{K-1} x_{i,K-1})] \quad (5)$$

(J. M. Wooldridge, 2010). For a binary variable, the APE is interpreted as the change in probability of having innovation, when the binary indicator is equal to 1 compared to when it is equal to 0. For a continuous variable, the APE is the marginal probability of having product innovation for a marginal change in the variable x_K.

As mentioned, the Probit model is estimated by maximum likelihood estimation (MLE). The log-likelihood contribution for each observation *i* is

$$\ell_i(\boldsymbol{\beta}) = y_i \log[G(\boldsymbol{x}_i \boldsymbol{\beta})] + (1 - y_i) \log[1 - G(\boldsymbol{x}_i \boldsymbol{\beta})] \qquad (6)$$

Consequently, for a sample of size N the log-likelihood function of $\mathcal{L}(\beta) = \sum_{i=1}^{N} \ell_i(\boldsymbol{\beta})$ and this value is reported in the results, and can be used for testing multiple exclusion restrictions and calculating the Pseudo-R^2. The log-likelihood function is maximized by $\hat{\boldsymbol{\beta}}$, which is the Maximum likelihood estimator of $\boldsymbol{\beta}$, where $\hat{\boldsymbol{\beta}}$ is known to be asymptotically normal (J. M. Wooldridge, 2010). The Pseudo-R^2 measures the goodness-of-fit of the model to the data, but is not to be compared to the R^2 from estimation using OLS. It can be interpreted as the improvement from the null model (with only a constant) to the fitted model (which is the estimated model). This is a measure between 0 and 1, and a low (high) value corresponds to a relatively small (large) improvement from the null model to the fitted model.

4.2 Tobit Type I for corner solutions

The next step is to determine how much innovation firms have. The choice of statistical model here is based on the characteristics of the data set. Since the total number of observations is 280, the sample of data is considered to be small. Maddala and Lahiri (1992) suggest using ordinary least squares (OLS) when the studied sample is of small size. As with the LPM model discussed earlier, this will give the coefficients directly and these are easily interpreted (remember that OLS is the same model as the LPM, but where the dependent variable is now roughly continuous instead of binary). However, because of a probability mass (approximately 46 percent of the observations) at zero, this suggests use of a corner solution model. Consequently, the model of Tobin (1958) is estimated. This model can also be used in estimation where there is censoring problem. The censored and corner solution models have similar statistical structure, but are different in the underlying assumptions (J. M. Wooldridge, 2010). Following J. M. Wooldridge (2010), this thesis labels the model as 'Tobit Type I', emphasizing that this is the corner solution model. The dependent variable is the number of product innovations, which is roughly continuous. The Tobit Type I model will take into account the corner solution at zero and estimate how much innovation a firm makes.

4.2.1. *Model specification of Tobit Type I*

Following J. M. Wooldridge (2010), the Tobit Type I model is a corner solution model for a nonnegative variable, y, with an approximately continuous distribution. However, the probability that the dependent variable is equal to zero, is strictly positive: $P(y = 0|\boldsymbol{x})$. In this case, the corner is at zero. The objective of this model is to find the estimated parameters $\boldsymbol{\beta}$ and σ (Maddala & Lahiri, 1992).

The Tobit model is used to identify relations between a dependent variable, y, and a row vector of covariates $\boldsymbol{x}$ (independent variables). The dependent variable, y, is linear dependent on the independent variables, $\boldsymbol{x}$, and the estimated coefficients, $\widehat{\boldsymbol{\beta}}$. In addition, an error term, u, is assumed to be normally distributed given $\boldsymbol{x}$. Then the corner solution is given by:

$$y = \max(0, \boldsymbol{x\beta} + u), \ \ u|\boldsymbol{x} \sim \text{Normal}(0, \sigma^2) \qquad (7)$$

The fact that the error term is independent of $\mathbf{x}$ and by the assumption of normality, the probability is always positive, $P(y = 0|\boldsymbol{x}) > 0$. There are three quantities of interest in this model. First, is the probability of having innovation, $P(y > 0|\boldsymbol{x})$, which is also found in the Probit model. Second, $E(y|\boldsymbol{x})$, which is the expected number of innovations made by the firm, and third is the expected number of innovations made by the firm, given that they actually innovate, $E(y|\boldsymbol{x}, y > 0)$. The Tobit model uses features from the Probit model. Consider a model of the form:

$$P(w = 1|\boldsymbol{x}) = P(u > -\boldsymbol{x\beta}|\boldsymbol{x}) = P(u/_{\sigma} > -\boldsymbol{x\beta}/\sigma) = \Phi(\boldsymbol{x\beta}/\sigma) \ \textbf{(}8\textbf{)}$$

where the variable $w = 0$ if $y = 0$, and $w = 1$ if $y > 0$. This is the Probit model expressed earlier. From this model, the expected value of y given $\boldsymbol{x}$, where y is strictly positive, $(E(y|\boldsymbol{x}, y > 0))$, is found by using that for the normal distribution (when $z \sim Normal(0,1)$):

$$E(z|z > c) = \frac{\phi(c)}{1-\Phi(c)} \text{ for any constant } c. \qquad (9)$$

Thus, when $u|\boldsymbol{x} \sim \text{Normal}(0, \sigma^2)$ applies, then the expected number of innovations made, given that the firms are innovating, $E(y|\boldsymbol{x}, y > 0)$, is given as:

$$\text{E}(\text{y}|\mathbf{x}, \text{y} > 0) = \boldsymbol{x\beta} + E(u|u > -\boldsymbol{x\beta}) = \boldsymbol{x\beta} + \sigma \left[\frac{\phi\left(\frac{\boldsymbol{x\beta}}{\sigma}\right)}{\Phi\left(\frac{\boldsymbol{x\beta}}{\sigma}\right)}\right] \quad (10)$$

As there now exist expressions for $P(y > 0|\boldsymbol{x})$ and $\text{E}(\text{y}|\mathbf{x}, \text{y} > 0)$, the rules of expected values is applied to obtain the last value, $E(y|\boldsymbol{x})$:

$$E(y|\boldsymbol{x}) = P(y = 0|x) \cdot \underbrace{E(y = 0|x)}_{=0} + P(y > 0|x) \cdot E(y|x, y > 0)$$
$$= P(y > 0|x) \cdot E(y|x, y > 0)$$
$$= \Phi(\boldsymbol{x\beta}/\sigma)[\boldsymbol{x\beta} + \sigma\lambda(\boldsymbol{x\beta}/\sigma)]$$
$$= \Phi(\boldsymbol{x\beta}/\sigma)\boldsymbol{x\beta} + \sigma\phi(\boldsymbol{x\beta}/\sigma) \qquad (11)$$

Where $\lambda(\cdot)$ is known as the inverse Mills ratio, given by the formula:

$$\lambda(c) \equiv \phi(c)/\Phi(c) \text{ for any constant } c. \qquad (12)$$

In addition to the three expressions, the partial derivatives of these are also of interest. For a continuous explanatory variable, x_j, the partial derivatives are summarized as follows:

i) $\frac{\partial E(y|\boldsymbol{x})}{\partial x_j} = \Phi(\boldsymbol{x\beta}/\sigma)\alpha_j$

ii) $\frac{\partial P(y>0|\boldsymbol{x})}{\partial x_j} = (\alpha_j/\sigma)\phi(\boldsymbol{x\beta}/\sigma)$

iii) $\frac{\partial \text{E}(\text{y}|\text{x,y}>0)}{\partial x_j} = \alpha_j \left\{1 - \lambda\left(\frac{\boldsymbol{x\beta}}{\sigma}\right)\left[\boldsymbol{x\beta}/\sigma + \lambda\left(\frac{\boldsymbol{x\beta}}{\sigma}\right)\right]\right\}$

where $\alpha_j \equiv \frac{\partial(\boldsymbol{x\beta})}{\partial x_j}$. These shows the marginal change in $E(y|\boldsymbol{x}), P(y = 0|\boldsymbol{x})$ and $E(y|\boldsymbol{x}, y > 0)$, respectively, for a marginal increase in x_j, i.e. how each of the quantities change as x_j increases marginally. For a binary variable, x_k, the partial effects are:

iv) $\Delta_k E(y|\boldsymbol{x}) = \left[\Phi\left(\frac{\boldsymbol{x\beta}}{\sigma}\right)\boldsymbol{x\beta} + \sigma\phi\left(\frac{\boldsymbol{x\beta}}{\sigma}\right)\right]_{x_k=1} - \left[\Phi\left(\frac{\boldsymbol{x\beta}}{\sigma}\right)\boldsymbol{x\beta} + \sigma\phi\left(\frac{\boldsymbol{x\beta}}{\sigma}\right)\right]_{x_k=0}$

v) $\Delta_k P(y > 0|\boldsymbol{x}) = [\Phi(\boldsymbol{x\beta}/\sigma)]_{x_k=1} - [\Phi(\boldsymbol{x\beta}/\sigma)]_{x_k=0}$

vi) $\Delta_k E(y|\boldsymbol{x}, y > 0) = [\boldsymbol{x\beta} + \sigma\lambda(\boldsymbol{x\beta}/\sigma)]_{x_k=1} - [\boldsymbol{x\beta} + \sigma\lambda(\boldsymbol{x\beta}/\sigma)]_{x_k=0}$

The interest is to estimate the average partial effects (APEs). The APE for a variable x_j is found by computing the marginal effect for each firm in the sample and then taking the average over these.

The average partial effect for *i)-iii)* is for a continuous variable x_j given by the formulas:

i.i) $$N^{-1}\sum_{i=1}^{N}\Phi(\boldsymbol{x}_i\widehat{\boldsymbol{\beta}}/\hat{\sigma})\hat{\alpha}_{ij}$$

i.ii) $$N^{-1}\sum_{i=1}^{N}(\hat{\alpha}_{ij}/\hat{\sigma})\phi(\boldsymbol{x}_i\widehat{\boldsymbol{\beta}}/\hat{\sigma})$$

i.iii) $$N^{-1}\sum_{i=1}^{N}\hat{\alpha}_{ij}\{1-\lambda(\boldsymbol{x}_i\widehat{\boldsymbol{\beta}}/\hat{\sigma})[\boldsymbol{x}_i\widehat{\boldsymbol{\beta}}/\hat{\sigma}+\lambda(\boldsymbol{x}_i\widehat{\boldsymbol{\beta}}/\hat{\sigma})]\}$$

where $\widehat{\boldsymbol{\beta}}$ and $\hat{\sigma}$ are the estimated parameters. Interpretation of these three APEs is as follows: when x_j increases marginally, *i.i)* is the marginal change in the expected number of innovations that a gazelle firm makes, *i.ii)* is the marginal probability of having innovation, and *i.iii)* is the marginal expected number of innovations that a gazelle firm makes, given that it has innovations.

For the binary variable, x_K, the average difference for *iv)-vi)* is given by:

i.iv) $$N^{-1}\sum_{i=1}^{N}\{[\Phi(\widehat{w}_{i1}/\hat{\sigma})\widehat{w}_{i1}+\hat{\sigma}\phi(\widehat{w}_{i1}/\hat{\sigma})]-[\Phi(\widehat{w}_{i0}/\hat{\sigma})\widehat{w}_{i0}+\hat{\sigma}\phi(\widehat{w}_{i0}/\widehat{\sigma})]\}$$

i.v) $$N^{-1}\sum_{i=1}^{N}\{\Phi(\widehat{w}_{i1}/\hat{\sigma})-\Phi(\widehat{w}_{i0}/\hat{\sigma})\}$$

i.vi) $$N^{-1}\sum_{i=1}^{N}\{[\widehat{w}_{i1}+\sigma\lambda(\widehat{w}_{i1}/\sigma)]-[\widehat{w}_{i0}+\sigma\lambda(\widehat{w}_{i0}/\sigma)]\}$$

which is the estimated average partial effect, where $\widehat{w}_{i1} = \boldsymbol{x}_{i(K)}\widehat{\boldsymbol{\beta}}_{(K)} + \hat{\beta}_{(\boldsymbol{K})}$ and $\widehat{w}_{i0} = \boldsymbol{x}_{i(K)}\widehat{\boldsymbol{\beta}}_{(K)}$, and $\boldsymbol{x}_{i(K)}$ is the vector $\boldsymbol{x}$ with x_{iK} dropped. When $x_K = 1$, then $\widehat{w}_{i1}$ denotes the estimated index for firm *i*, and $\widehat{w}_{i0} = 0$ denotes the estimated index for firm *i* when $x_K = 0$ (J. M. Wooldridge, 2010). Similarly, when x_K changes from 0 to 1, *i.iv)* is the average change in the expected number of innovations that a gazelle firm makes, *i.v)* is the average change in the probability of having innovation, and *i.vi)* is the average change in the expected number of innovations that a gazelle firm makes, given that it has innovations.

Similar to the Probit model, the maximum likelihood estimation is also used in the Tobit model. Consequently, one needs to derive a density of y_i given x_i. Taking the log of this gives the following log-likelihood contribution for each observation *i*:

$$\ell_i(\boldsymbol{\beta},\sigma) = 1[y_i = 0]\log[1-\Phi(\boldsymbol{x}_i\boldsymbol{\beta}/\sigma)] + 1[y_i > 0]\{\log\phi\,[(y_i-\boldsymbol{x}_i\boldsymbol{\beta})/\sigma] - \log(\sigma^2)\}$$

Now the log-likelihood function becomes $\mathcal{L}(\boldsymbol{\beta},\sigma) = \sum_{i=1}^{N}\ell_i\,(\boldsymbol{\beta},\sigma)$. Further, to test single exclusion restriction, the asymptotic t-statistic is used, while multiple restrictions are tested with use of Wald- statistics.

5 – Data

5.1 Data source

The School of Business and Economics, University of Tromsø (UIT) provided the data used in this study. The data was collected in September 2013 from a digital survey among 1651 gazelle companies in Norway, and spans from the years 2008 to 2012. Despite the fact that the collected data spans over a four-year period of time, it is treated as cross-sectional data and study specifically the year of 2011. Total number of complete questionnaires was 333, just over 20 percent. Reported back from the School of Business and Economics, UIT, was that 89 percent of the responded questions were filled out by CEOs. A requirement for a firm to be labeled a gazelle is annual sales over 1 million NOK in 2008. A gazelle firm should also have at least doubled its annual sales over the past four years. Furthermore, it must also show to have positive growth and positive operating result in the period of 2008 to 2012.

5.2 Data preparations

In order to have a complete data set and values of relevant informational character, some adjustments of the variables needed to be done. First, additional variables were generated by use of external information. Then information on already existing variables was used to generate dummy variables. Finally, observations with missing values on the variables of interest were taken out of sample.

5.2.1. *Generating additional variables*

According to the literature, firm size and age are both believed to have an impact on innovation. As the data set did not contain observations on these variables, these two variables was then generated by using the public service-site, Proff Forvalt (https://www.forvalt.no/), that contains accounting and credit information about Norwegian firms. Observations on year of startup, the number of employees and man-year in 2011 were added to the data set. The number of employees, together with man-year, then determines the variable ‘firm size’. This is because the number of man-year replaced the missing values of the number of employees. The distribution of this variable ‘firm size’ is shown in table A.1. in Appendix 2. There are two reasons for why man-year is included with the number of employees: First, in order to have a sample size of 280 observations instead of 200 observations, which would be the case with using only the number of employees. Second, the number of man-years will always be lower than or equal to the number of employees. This will make the estimated coefficient of firm size on innovation, a lower bound on its true value. Additionally, firm size is squared in order to capture a potential nonlinear effect. Finally, subtracting the year of startup from the sample year, 2011, generated the variable 'age'. This variable is also squared for the same reason as with firm size. Furthermore, a dummy variable labeled 'micro' is generated, in which the variable takes the value 1 if firms has less than 10 employees, and 0 otherwise (a micro firm is by the European Union defined as a firm with less than 10 employees (EuropeanCommission, 2015). This is done in order to check if being a so-called micro firm has an effect on the level of innovation.

5.2.2. *Transformation of information into dummy variables*

Further, existing information were used to transform other variables of interest. First, a dummy variable for firms that was located in Norway's two most populated counties, Oslo and Akershus, was generated. The reason for this is to capture a possible effect of localization on innovation, as geography is expected to affect innovative performance (Audretsch & Feldman, 2004). These two counties may be comparable to an urbanized area, but the variable is here defined and implemented as a variable for capital area, where the variable takes the value 1 if firms are located in either of the two capital counties and zero otherwise. Also, the data set contained observation on firms' industry placement by NACE-codes (Standard Industrial Classification Codes). This information was used to classify the firms into three industries: agricultural (primary), manufacturing (secondary) and services (tertiary), which here is based on Statistics Norway's categorization (E-mail correspondence with Statistics Norway confirming industry classification was done). The aim with this is to determine whether differences between the industries affect the level of innovation. The variables are specified as dummies, meaning that the variable takes value 1 if it is in the studied industry, and 0 otherwise. For example, if the studied industry is manufacturing, the variable for this industry gets the value 1, and the other two industry dummies a value 0. Furthermore, a dummy variable for CEO is generated. One reason for this is that CEOs may not be directly involved in the innovation process, and if these have answered the questions, there might be biased or not correctly specified answers. Another possible reason is that CEOs might have incentives to overstate the number of innovations, for example in order to promote themselves. The variable takes the value 1 if the respondent of the survey is the CEO of the firm, and 0 otherwise.

5.2.3. *Transformation of existing variables*

The variable on number of innovations was coded as a categorical variable: Respondents could choose the following categories in number of product innovations: 1,2,3,4,5-10,11-20,21-30, ‘more than 50’ and ‘Don`t know’, but these were coded 1,2,3,4,5,6,7,10,11 in the provided data set. As statistical software would treat the absolute difference of e.g. moving from category 1 to 2, in the same way as moving from category 4 to 5, the variable in its existing form would be misleading. For this reason, two variables were generated. These turned the grouped observations into single, numeric values for the number of product innovations. The ordinal values are kept in its origins, whereas the groups of innovations are divided into two variables, where they get the lowest and the highest value of the grouped observations. These are further denoted as *low* and *high* number of innovations, and the specified values are shown in table 1.

Table 1. *Specified values to variable ‘number of product innovations’.*

Original	Low	High
1	1	1
2	2	2
3	3	3
4	4	4
5-10	5	10
11-20	11	20
21-30	21	30
More than 50	50	100

From table 1 it is seen that for *low* the group of 5 to 10 innovations was given numerical value 5, 11 to 20 was given numerical value 11, 21 to 30 got the value 21 and ‘more than 50’ was assigned the numerical value 50. For *high* the group of 5 to 10 innovations was given numerical value 10, 11 to 20 was given numerical value 20, the group of 21to 30 got 30, and ‘more than 50’ was given numerical value 100. What seems to be the most problematic is the value for *high* and the group ‘more than 50’ as there is not defined any upper limit. The choice of an upper limit at 100 implies that it is assumed that this value is the largest possible number of innovations for a firm in the sample. The choice of this upper value can of course be questioned as unrealistic and random. Only the variable *low* was used in (actual) estimation, but *high* is additionally made in purpose to test the validity of the estimated results. The results from estimation with the *high* value are shown in table A.2 in Appendix 3 and its APEs are given in table A.3. Comparing the results in chapter 6 where *low* is used, with these results for *high*, it is seen that the estimated coefficients have the same signs in the two cases. Therefore, the result is argued to be robust. Additionally, using *low* gives a lower bound of the actual effect. This means that the absolute magnitude of the estimated effect will be lower than or equal to the true value of the effect, and this would not hold if the variable *high* had been used. This can therefore be seen as a theoretical argument for using *low* instead of *high* in the actual estimation.

Three questions were asked concerning the firms' relationship with their customers, where responses were given on a scale from 1 to 7. The questions are shown in table 2. The questions are asked in a way in which it may be difficult to separate them for several reasons: Do respondents have the same perception of the keywords in the questions? In which way is 'success' quantified? And what is meant by 'acceptance' in the market? Acceptance might be that the innovation is out on the market, or it might be depending on how much the product has sold, or even how much profit the product has generated for the firm. This 'diffusion' and 'subjectivity' in the given questions may be overcome by transforming these three variables into one overall variable, by taking the mean of the answers. On the other hand, the downside of one broad definition is that three effects are reduced to one, if it were to be assumed that the respondents exactly understand the questions. As the three effects is to be assumed more informative on their own than together in one variable (where one may end up not be able to say anything specific at all), the choice is to use all three variables separately rather than the mean of them in the estimation. This is suggested to yield specific information and a more precise analysis than the alternative. In the following, the term 'customer knowledge' is used to denote the three variables together, whereas on their on own they are denoted by 'C1: Customer Cooperation', 'C2: Customer Importance' and 'C3: Acceptance by the Market', and their distributions are shown below in figure 2 of section 5.4. Due to the issues discussed above, caution is needed when interpreting the results.

Table 2. *Survey questions regarding firms' relations with customers, i.e. customer knowledge.*

Q.1: Overall, involving customers into the innovating process has been a success?
Q.2: The contribution of various customers has been very important for developing products/services?
Q.3: Products and services that have been developed in a way that considers customer participation and knowledge have been accepted by the market?

5.3 Variables

5.3.1. *Dependent variables*

The goal is to estimate both the probability of having product innovation, and to estimate how many innovations a firm is expected to make. With this in mind, there are two dependent variables to consider. First, for the probability of having innovation, a binary variable labeled 'product innovation' takes the value 1 if the firm has product innovation, and 0 otherwise. The respondents were given three questions in which they chose whether they did product-, process- or no innovations. Additionally, they could answer with 'don't know'. As is mentioned in the literature, defining innovation may be difficult. For instance, how can one be sure about the perception of innovation is similar between the respondents? There is also a possibility that some of those who said they did not do any innovation actually did, or vice versa, or that some responded to do product innovation whereas it might have been a process innovation. These difficulties are a downside of the data set and should be kept in mind for conclusions.

5.3.2. *Explanatory variables*

The explanatory variables used in this study is in accordance with other empirical papers such as firm size together with micro size, customer knowledge, R&D, export, age, capital localization and industry placement (Shefer & Frenkel, 2005). In addition, the number of times a firm has been a gazelle is included, together with the CEO dummy variable. The number of times a firm has been ranked as a gazelle is also included as a squared variable, to capture possible nonlinear effects. The following variables are specified as dummy variables: R&D, capital localization, CEO, industry placement, micro size and export. The remaining variables are treated as continuous variables.

The role of an R&D department is highly studied in relation to innovation and firm performance (Shefer and Frenkel (2005), Clausen (2009), Santarelli and Sterlacchini (1990)) and should play a role on innovation. The question is whether its impact on product innovation is positive or negative. As is found in Acs, Audretsch, and Feldman (1994), the number of innovations made increases with R&D inputs. They study R&D spillovers in large and small-sized firms, and suggest that for small-sized firms R&D expenditures in collaboration with universities is important, whereas for large firms it is R&D expenditures from private firms that is the main focus. Thus, the large firms are expected to exploit knowledge within the firms' own R&D departments. Further, in Santarelli and Sterlacchini

(1990) it is pointed out that innovative activities in small-and medium sized enterprises (SMEs) often are performed without the formalized routines and concrete financial and administrative resources. This implies that in the SMEs innovative activities are not necessarily happening in the R&D department (if the firm has one), but rather in departments of product, design and sales. The impact of having a R&D department on firms' product innovation is therefore ambiguous.

Another explanatory variable is export. One may argue that firms who are exporting products are to be more innovative, because of higher global competition. On the other hand, there is a possibility that firms in the market of export are manufacturing industries, thus their products are produced in a traditional way and the incentive to make product innovation is rather limited. C. Lee (2004) finds that innovation is more present for firms producing for the domestic market, compared to firms that are exporting. From this it is of interest to see how export will affect innovation performance in the gazelle firms. Rogers (2004) finds that the exporting firms have more innovation than the non-exporting firms. Further, as is pointed out in Wakelin (1998), it is suggested that small sized firms who do not make many innovations, seems to serve the domestic market in stead of being an exporting firm. The argument is that there are high costs of entering export markets. Thus, there are reasons to believe that export is too costly for the small sized firms. On the contrary, as this thesis concerns gazelle firms, it is also possible that the firms can finance the cost of entry at the export markets. It follows that the impact on innovation of having export is ambiguous, and it will therefore be interesting to estimate this relationship.

The industry affiliation of a firm is expected to play a role on its number of innovations made. The first industry, denoted the agricultural industry, includes the fishery industry. Norway's role in this industry may suggest a continuous search for new products and technologies, thus a high activity of innovation relative to the manufacturing industry. In the latter, there are often traditional products and potential innovative activity is suggested to be related to the production process rather than the actual products. Further, the service industry is also expected to have a high level of innovative activity with regards to products relative to the manufacturing industry. The reason is that within the service industry many of the firms' products do not have physical character. Consequently, there is a constant need for development in this industry. Furthermore, it seems plausible that the service industry also has a higher level of innovative activity compared to the agricultural industry, since the possibilities of product line extension is higher in the former industry than in the latter.

Capital as an explanatory variable is expected to contribute positively on firms' probability of being innovative. In the study of Audretsch and Feldman (2004), it is found that the role of geography and localization has an influence on innovation. The reason for this may be that firms operating in the same geographical areas are either faced with more competition or they experience spillovers between each other. With regards to regional externalities in the economic literature, it is argued that there exist knowledge spillovers among firms. The argument is that firms who are located within the same city area, are able to benefit from the externalities, which again may stimulate the innovative activity (Glaeser, 2000).

There is a potential that high-growth firms have a greater innovative activity than other firms. Consequently, a variable for the number of times a firm has been ranked as a gazelle is included in the estimation. On the other hand, it may be that the main focus for the gazelle firms is not to innovate, but instead to spend their resources on other promoting activities such as marketing or sales. Therefore, it will be interesting to see if the number of times a firm has been a gazelle influences its innovative activity.

The variable CEO is added in order to capture if it has any effect whether the CEO responded to the survey. As mentioned earlier, it is a possibility that CEOs have a 'wish' to show externally that the firms are innovative. Additionally, it may be that CEOs not necessarily know how much the role of its customers has on their level of innovation. On the contrary, as the studied firms are relatively small, it can also be that the CEOs are more or less directly involved in the firms' innovation process. Thus there are difficulties in concluding which effect this variable is expected to have.

Another explanatory variable is age and in the study of C. Lee (2004) it is found that younger firms have a higher potential of innovation than older firms. Furthermore, it is suggested that older firms, who are usually larger than younger firms (because they have had more time to expand its workforce) contribute to more R&D (Shefer & Frenkel, 2005). If one assumes that R&D is one source to innovative behavior, then this suggests that age in the studied sample of small firms will affect the innovative activity of a firm.

As mentioned, firm size is squared and in addition a dummy variable labeled 'micro' for firms who have less than 10 employees is included. This is done to see if so-called micro firms have an impact on the level of innovation. Furthermore, size is expected to have an influence – either positive or negative – on the innovation activity of a firm. Furthermore, it is expected that the three variables of the importance of customers, known as customer knowledge, are all expected to have a positive impact on the level of innovation.

5.4 Descriptive statistics

Table 3 presents descriptive statistics of the variables used in estimation. The total number of observations is 280. As is seen from table 3, about 56 percent of the firms have product innovation. This indicates that having product innovation is not a necessity to become a gazelle firm, i.e. to become a firm with high economic growth. Furthermore, the average number of innovations is around 2.8 innovations. Only around 10 percent of the firms have an R&D department, which may be due to the fact that it is costly. Further, it is seen that around 33 percent of the firms where exporting, and almost 91 percent of the surveys was answered by CEOs. Moreover, approximately 23 percent of the firms were located in the capital area, and on average the firms had been ranked as gazelles almost 2 times each. For the industries, it is seen that most of the firms in the sample are within the service industry, approximately 70 percent. Then follows firms within the manufacturing industry, with approximately 26 percent of the firms, whereas the final 4 percent of the firms are within the agricultural industry. The distribution of the three variables describing customer knowledge is presented in figure 2,3 and 4, and it is seen that the peaks in these variables occur between the values 4 and 7. This might suggest that customers and cooperation is important for the firms. On the other hand, it is difficult to know how the respondents perceive the issues of moving from for example 4 to 5 to 6 on the scale. Additionally, almost 60 percent of the firms have less than 10 employees, which is confirmed by the median value of firm size that has a value of 8. Furthermore, it is seen that the highest number of employees is 511, and from table A.1 in Appendix 2 it is seen that 6 firms had more than 100 employees. In order to account for these "large" firms, a dummy variable that represents firms with more than 100 employees is made. Estimation with this variable included shows that the coefficient corresponding to this firm is insignificant in the Tobit model, see table A.6 in Appendix 3. Consequently, the 'large' dummy variable is not included in the estimation.

Table 3. *Descriptive statistics (N=280).*

Variable	**Mean**	**Std. Dev.**	**Median**	**Min**	**Max**
Product Innovation	0.557	0.498	1	0	1
# Product Innovations	2.796	6.758	2	0	50
R&D	0.104	0.305	0	0	1
Export	0.332	0.472	0	0	1
Capital	0.232	0.423	0	0	1
# Times a Gazelle	1.829	1.278	1	1	8
CEO	0.907	0.291	1	0	1
Age	9.836	10.649	6	3	111
Firm Size	17.536	40.672	8	0.5	511
Micro Firms	0.604	0.490	1	0	1
Industries					
Agriculture	0.043	0.203	0	0	1
Manufacturing	0.256	0.436	0	0	1
Services	0.704	0.457	1	0	1
Customer Knowledge					
C1: Customer Cooperation	4.550	1.630	4	1	7
C2: Customer Importance	4.861	1.577	5	1	7
C3: Acceptance by Market	4.975	1.508	5	1	7

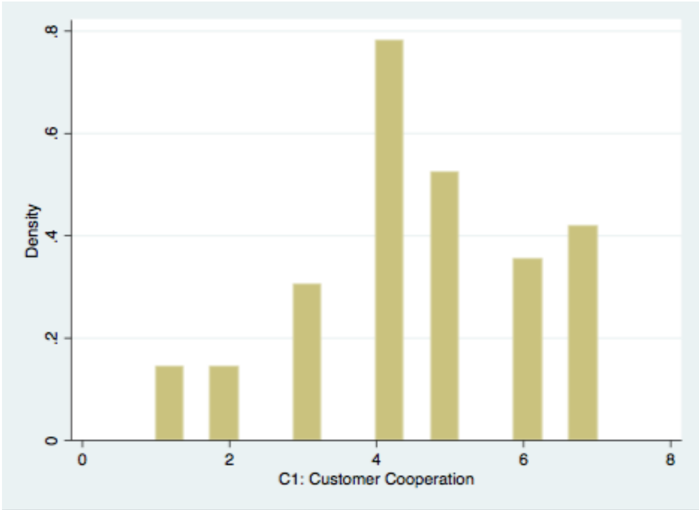

Figure 2. *Distribution of the variable 'C1: Customer Cooperation'*

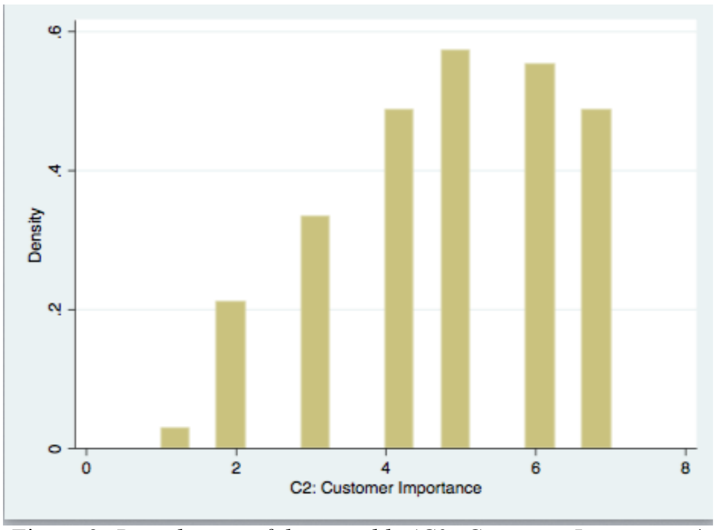

Figure 3. *Distribution of the variable 'C2: Customer Importance'*

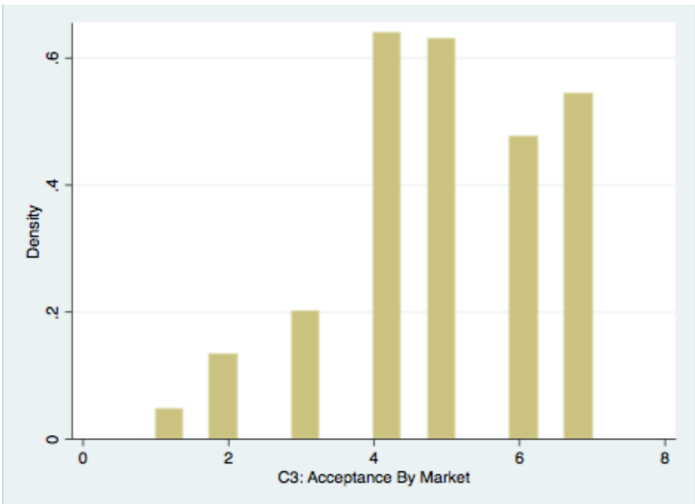

Figure 4. *Distribution of the variable 'C3: Acceptance By the Market'*

Finally, the average age of a firm in the sample is around 9 years, and it is seen that a firm with the highest age is 111 years old. A dummy variable was generated for this firm, which is Haglöfs AS. As is shown below in figure 3, this firm has a very high age compared to the other firms and the dummy for this is included in order to make sure that this firm does not falsely make 'age' statistically significant. In contrast to the dummy variable for large size, this dummy variable for age is statistically significant and is therefore included in the estimation of the models.

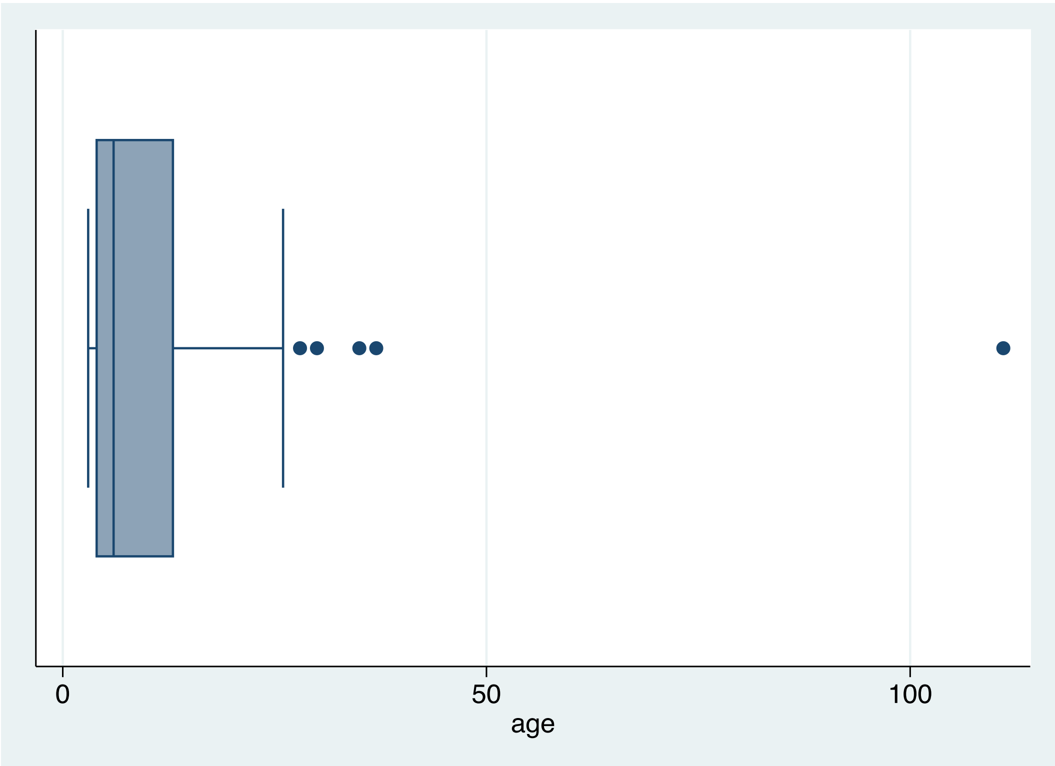

Figure 5. *Boxplot for the variable 'age'.*

6 – Results

This chapter presents the estimated results from both the Probit model and the Tobit model. First, the results regarding the probability of having product innovation are presented. This contains the estimated coefficients and average partial effects (APEs) from the Probit model. Next follows a section of the estimated results that describe how many product innovations a firm has, which are the estimated Tobit coefficients. The focus is on the three APEs of which one is comparable to the APE from the Probit model.

6.1 Results from the Probit model

Table 4 shows the outcome of the estimation with all the independent variables, where the dependent variable is product innovation. The least significant independent variable is removed from estimation, where after the model is estimated again. This process is iterated until all the remaining independent variables are statistically significant at a level of 10 percent. This results in a specified model of four significant variables, namely the variables 'R&D', 'export', 'C1: customer cooperation', and 'manufacturing' firms. Export is significant at a 10 percent level, whereas the remaining variables are significant at a level of 5 percent. Both R&D, export and customer cooperation show positive coefficients, whereas the manufacturing coefficient is negative. This means that firms having an R&D department or a firm who sell to the global market are more likely to have innovation than those who do not have one or two of these characteristics. On the other hand, a manufacturing firm is less likely to have product innovation than firms in services or the agricultural industry. Furthermore, customer cooperation shows a positive effect. This indicates that firms who find it successful to cooperate with customers are more likely to have innovation. It is also noted that neither of the two other variables concerning customer knowledge is statistically significant. For the variables 'age', 'size' and 'number of times a gazelle', which enter with both a linear and a squared term, a Wald-test of joint significance is performed before removing the variables from the estimation. The variables are removed if the hypothesis of joint significance is rejected at a level of 5 percent. All three variables show to be insignificant at a level of 5 percent, and are therefore rejected by the Wald- test of joint significance. Thus, the removal of the variables is in accordance with econometric suggestions. As is noted, neither of the variables reflecting firm size is significant. This result questions Schumpeter's hypothesis about firm size, and is further considered in the discussion chapter.

Table 4. *Estimated Probit coefficients.*

Dependent Variable Product Innovation	EST. 1	EST. 2	EST. 3	EST. 4	EST. 5	EST. 6	EST. 7	EST. 8	EST. 9	EST. 10
R&D	1.635*** (0.487)	1.636*** (0.487)	1.636*** (0.487)	1.653*** (0.478)	1.649*** (0.478)	1.640*** (0.477)	1.650*** (0.476)	1.663*** (0.477)	1.650*** (0.471)	1.580*** (0.463)
Export	0.306* (0.186)	0.307* (0.185)	0.307* (0.185)	0.311* (0.182)	0.314* (0.183)	0.321* (0.183)	0.331* (0.181)	0.328* (0.181)	0.346* (0.180)	0.345* (0.178)
C1: Customer Cooperation	0.197*** (0.064)	0.198*** (0.062)	0.198*** (0.062)	0.193*** (0.062)	0.202*** (0.053)	0.200*** (0.053)	0.199*** (0.052)	0.200*** (0.053)	0.200*** (0.053)	0.202*** (0.053)
C2: Customer Importance	0.017 (0.079)	0.020 (0.064)	0.020 (0.064)	0.016 (0.403)						
C3: Acceptance by Market	0.007 (0.080)									
Firm Size	-0.008 (0.007)	-0.008 (0.007)	-0.008 (0.007)	-0.007 (0.006)	-0.007 (0.006)	-0.007 (0.006)	-0.007 (0.006)	-0.005 (0.005)	-0.005 (0.005)	
Firm Size Squared	0.00002 (0.00002)	0.00002 (0.00002)	0.00002 (0.00002)	0.00002 (0.00002)	0.00002 (0.00002)	0.00002 (0.00002)	0.00002 (0.00002)	0.00001 (0.00001)	0.00001 (0.00001)	
Micro Size	-0.080 (0.022)	-0.079 (0.219)	-0.080 (0.218)	-0.113 (0.215)	-0.117 (0.215)	-0.126 (0.213)	-0.124 (0.213)			
Capital	0.088 (0.215)	0.088 (0.215)	0.092 (0.211)	0.010 (0.210)	0.097 (0.210)	0.084 (0.207)				
Agriculture	0.130 (0.397)	0.130 (0.397)	0.133 (0.396)	0.137 (0.392)	0.140 (0.391)					
Manufacturing	-0.354* (0.195)	-0.355* (0.195)	-0.353* (0.194)	-0.381** (0.193)	-0.380** (0.193)	-0.393** (0.189)	-0.409** (0.185)	-0.404** (0.185)	-0.408** (0.185)	-0.428** (0.183)
Age	-0.024 (0.020)	-0.025 (0.020)	-0.025 (0.020)	-0.020 (0.019)	-0.020 (0.019)	-0.020 (0.019)	-0.019 (0.019)	-0.018 (0.018)		
Age Squared	0.00042 (0.0004)	0.00042 (0.0004)	0.00042 (0.0004)	0.0003 (0.0004)	0.0003 (0.0004)	0.0003 (0.0004)	0.0003 (0.0004)	0.0003 (0.0004)		
#Gazelle	0.127 (0.233)	0.126 (0.233)	0.129 (0.231)							
#Gazelle Squared	-0.005 (0.036)	-0.005 (0.036)	-0.005 (0.036)							
CEO	-0.033 (0.295)	-0.032 (0.295)								
D.Haglöfs	Omitted									
Constant	-0.856 (0.569)	-0.847 (0.558)	-0.874* (0.500)	-0.650 (0.403)	-0.601* (0.356)	-0.582* (0.352)	-0.565 (0.349)	-0.673** (0.296)	-0.798*** (0.263)	-0.862*** (0.256)
Log-Likelihood	-161.2831	-161.28665	-161.29265	-162.33673	-162.37038	-162.43411	-162.5172	-162.68864	-163.29028	-163.88495
Observations	279	280	280	280	280	280	280	280	280	280
LR chi2	60.76	61.92	61.91	59.82	59.76	59.63	59.46	59.12	57.92	56.73
Prob>Chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.1585	0.1611	0.1610	0.1556	0.1554	0.1551	0.1547	0.1538	0.1506	0.1475

Note: Wald-tests of nonlinear restrictions: Number of times a Gazelle:(P>2.07)=0.3557, Age:(P>1.02)=0.6005, Firm Size:(P>1.11)=0.5737.
Standard errors are given in parentheses. Test statistics is indicated with ***. **. * and represents the 1%,- 5% - and 10% level .

Next, APEs are computed for the four significant variables. These are presented in table 5. From this it is shown that having an R&D department increases the probability of having innovation by 31.6 percent, compared to those firms who do not. This seems reasonable as R&D departments are incorporated into firms in order to develop new products and to research on the firms' existing products. Additionally, a firm who has export is 11.3 percent more likely to innovate than firms who do not export. An intuitive argument for this positive result could be that exporting firms meet competition from the global market, and are thus threatened by more competition than non-exporting firms. Consequently, all else equal, an exporting firm should be more likely to have innovation than a comparable non-exporting firm. Furthermore, a firm operating in the manufacturing industry has 15.1 percent lower probability of having innovation than a firm operating in either the agricultural or the service industries. One might think that firms in the manufacturing industry are more likely to have process innovations than product innovations, as manufacturing firms often relies on more traditional industry characteristics. In contrast, a service sector firm might more easily produce changes in existing products. Therefore, product change and developments may be more difficult and less present in the manufacturing industry, compared to the two other industries. The estimated APE of customer cooperation is positive, indicating that more successful cooperation with customers is related to a higher probability of having product innovation. If it is further assumed that all respondents have the same perception of the scale used in the survey question, this means that firms who assess their 'customer cooperation success' one measurement unit higher have 6.8 percent higher probability of having innovation. This is in accordance with expectations, as it is implied that firms who finds it 'successfully to innovate' with customers, already have innovations.

Table 5. *Average Partial Effect of Probit Estimates.*

Dependent Variable: Product Innovation	**Estimated APE**
R&D	0.316
Export	0.113
C1: Customer Cooperation	0.068
Manufacturing	-0.151
Observations	280

6.2 Results from the Tobit model

The probability of having product innovation, as studied in the Probit model, is also implicitly given in the Tobit model. Table 6 presents the estimated $\hat{\beta}$-coefficients of the model. Again, this model uses the generated/transformed variable with low number of product innovations as dependent variable. This transformation implies that the number of innovations a firm makes is at the lowest possible value for firms who have more than 10 innovations. This also means that the absolute magnitude of the $\hat{\beta}$-coefficients can be seen as a lower bound for the true underlying population coefficients. Similarly to the Probit model, for each estimation of the model the least significant variable is removed and this process is iterated until all remaining explanatory variables are significant at a level of 10 percent. As seen from table 6, the variables ‘export’, ‘customer cooperation’ and ‘manufacturing’ are similarly significant and with the same signs as in the Probit model. The variable R&D is dropped from the fitted model, which implies that having a R&D department does not show to have an effect on innovation performance. However, in the Tobit model there are more significant variables at a level of 10 percent than in the Probit model. It is shown that the dummy variables for respectively Haglöfs and capital localization are statistically significant.

Table 6. *Estimated Tobit Coefficients.*

Dependent Variable Number of Product Innovations	EST. 1	EST. 2	EST. 3	EST. 4	EST. 5	EST. 6	EST. 7	EST. 8	EST. 9	EST. 10
Capital	5.206***	5.228***	5.232***	5.200***	5.098***	5.020***	5.097***	5.203***	5.060***	4.745***
	(1.474)	(1.458)	(1.457)	(1.455)	(1.448)	(1.443)	(1.434)	(1.428)	(1.429)	(1.417)
Export	2.169*	2.163*	2.143*	2.157*	2.166*	2.233*	2.358*	2.301*	2.490*	2.660**
	(1.311)	(1.310)	(1.299)	(1.298)	(1.300)	(1.290)	(1.271)	(1.270)	(1.269)	(1.267)
D. Haglöfs	27.179*	27.114*	27.045*	27.243*	27.566*	28.365*	29.259*	30.063*	34.021**	44.201***
	(16.328)	(16.317)	(16.309)	(16.300)	(16.314)	(16.271)	(16.176)	(16.164)	(16.114)	(8.998)
C1: Customer Cooperation	1.422***	1.426***	1.413***	1.398***	1.393***	1.392***	1.428***	1.258***	1.151***	1.169***
	(0.479)	(0.477)	(0.465)	(0.463)	(0.464)	(0.463)	(0.459)	(0.389)	(0.384)	(0.385)
C2: Customer Importance	-0.324	-0.326	-0.367	-0.352	-0.315	-0.310	-0.326			
	(0.583)	(0.583)	(0.473)	(0.471)	(0.468)	(0.465)	(0.463)			
C3: Acceptance by Market	-0.071	-0.070								
	(0.591)	(0.591)								
Agriculture	-0.299									
	(3.010)									
Manufacturing	-1.986	-1.960	-1.950	-1.922	-1.948	-2.083	-2.123	-2.144	-2.441*	-2.520*
	(1.507)	(1.485)	(1.482)	(1.480)	(1.482)	(1.407)	(1.466)	(1.469)	(1.467)	(1.471)
Age	-0.259*	-0.259*	-0.259*	-0.259*	-0.251*	-0.257*	-0.255*	-0.247*	-0.182	
	(0.133)	(0.133)	(0.133)	(0.133)	(0.133)	(0.132)	(0.132)	(0.132)	(0.127)	
Age Squared	0.003*	0.003*	0.003*	0.003*	0.003	0.003*	0.003*	0.003	0.002	
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	
# Gazelle	2.002	1.986	1.995	2.012	1.900	1.895	2.010	2.108		
	(1.641)	(1.633)	(1.631)	(1.630)	(1.623)	(1.601)	(1.607)	(1.604)		
# Gazelle Squared	-0.190	-0.188	-0.189	-0.189	-0.174	-0.184	-0.194	-0.208		
	(0.252)	(0.251)	(0.250)	(0.250)	(0.250)	(0.249)	(0.248)	(0.248)		
Firm Size	-0.035	-0.035	-0.035	-0.025	-0.025					
	(0.044)	(0.044)	(0.442)	(0.036)	(0.036)					
Firm Size Squared	0.00007	0.00007	0.00008	0.00006	0.00006					
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)					
Micro Size	-0.606	-0.589	-0.605							
	(1.554)	(1.545)	(1.540)							
CEO	1.237	1.256	1.271	1.253						
	(2.079)	(2.070)	(2.067)	(2.067)						
R&D	1.403	1.424	1.430	1.455	1.410	1.161				
	(1.938)	(1.927)	(1.927)	(1.926)	(1.927)	(1.891)				
Constant	-8.001*	-8.040**	-8.143**	-8.659**	-7.598**	-7.781**	-7.945**	-8.939***	-6.066***	-7.451***
	(4.076)	(4.058)	(3.966)	(3.747)	(3.310)	(3.285)	(3.269)	(2.967)	(2.254)	(2.049)
Sigma	8.779	8.780	8.781	8.781	8.794	8.797	8.782	8.798	8.851	8.896
	(0.523)	(0.523)	(0.523)	(0.523)	(0.524)	(0.524)	(0.522)	(0.523)	(0.527)	(0.530)
Log-Likelihood	-632.977	-632.982	-632.989	-633.066	-633.251	-633.497	-633.687	-633.933	-633.839	-632.872
Observations	280	280	280	280	280	280	280	280	280	280
LR chi2	70.59	70.58	70.57	70.41	70.04	69.55	69.17	68.68	64.87	62.80
Prob>Chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0528	0.0528	0.0528	0.0528	0.0528	0.0520	0.0518	0.0514	0.0485	0.0470

Note: Wald-tests of nonlinear restrictions: Firm Size: (P>0.24)=0.7839, Number of times a Gazelle:(P>1.90)=0.1512, Age: (P>1.03)=0.3580.
Standard errors are given in parentheses. Test statistics is indicated with ***. **. * and represents the 1%,- 5% - and 10% level .

As is seen from table 6, the dummy variables for respectively capital localization, export and the firm Haglöfs, have positive coefficients. This is also the case for customer cooperation, whereas it is negative for the dummy variable for manufacturing industry. Similar to the Probit model, neither firm size nor micro size is statistically significant in the Tobit model.

This finding is in contrast to expectations as firm size is suggested to in some way affect the innovative performance of the firms. However, this might be due to the relatively small size of the sample and/or too little variation in size within the sample. Further, the same yields the three variables of customer knowledge, in which only customer cooperation is statistically significant. The positive coefficient for this variable is in accordance with expectations, whereas the effects of the importance of customers and how cooperation affects the acceptance of the product by the market are not statistically significant. This result is interesting, as it would be expected that all the three variables show a positive effect. This may be due to the difficulties for the respondents in separating the questions. As mentioned in the data chapter, one may argue to take the average of these three variables together and use this as an overall level of customer knowledge. However, it does not make interpretation of the results any easier, and furthermore it may not give 'correct' results. In table A.4 in Appendix 3, estimation results when including the average of the three variables of customer knowledge is presented. The result is that it is statistically significant with a positive coefficient. As it is shown above, only customer cooperation is statistically significant when the variables are included separately. This suggests that the statistical significance of the average variable, 'customer knowledge', stems solely from the statistical significance of the variable for customer cooperation, C1. Further, because of difficulties in actually knowing how to interpret a variable for 'customer knowledge' at an overall level, the further used coefficient is the one given in table 6.

Furthermore, it is an interesting result that the age of the firms does not affect the innovation level. As is mentioned in the data chapter, the qualitative effect of age on innovation is ambiguous. Age is the final variable that is omitted from the model. These results are shown in table A.5 in Appendix 3, and it is found that age becomes statistically significant without the dummy variable for Haglöfs. This result seems to suggest that the firm Haglöfs (alone) is making the age variable statistically significant. This suggests that without making a dummy variable for Haglöfs, the results are misleading and will lead to false conclusions. Similarly with firm size, the lack of a significant effect may be due to a small number of observations and little variation in the data.

Next, the estimated coefficients, $\hat{\beta}$, and the estimated standard deviation, $\hat{\sigma}$, are used to calculate the APEs. The APEs for the five significant explanatory variables are presented in table 7. First, the APE that measures the probability of having product innovation is comparable to the results of the APEs of the Probit. The following holds for the variables that are statistically significant in both models: The absolute value of the marginal probability is lower in the Tobit model compared to the Probit model for export, customer cooperation and manufacturing.

Table 7. *Average Partial Effects for Tobit Estimates.*

Dependent Variable: Number of Product Innovations	**P(y>0|x)** Estimated APE	**E(y|x)** Estimated APE	**E (y|x, y>0)** Estimated APE
Export	0.11	1.294	0.969
C1: Customer Cooperation	0.048	0.546	0.416
Capital	0.200	2.477	1.823
Manufacturing	-0.104	-1.111	-0.857
DHäglöfs	0.533	39.951	36.433
Sigma	8.896		
Observations	280		

As mentioned, the APEs of main interest in the Tobit model are the two remaining ones, which determines the marginal number of innovations a firm makes on average. First, a firm who has export makes on average approximately 1.3 innovations more than a corresponding firm with no export. Similarly, given that the firms who export have innovations, this average marginal number of innovation is now lower, approximately 1. As mentioned in the Probit results, this may be due to the higher competition at the export market compared to the domestic market, all else equal. However, if one assumes that the goal is to make innovations, this difference between these two APEs suggests that already innovative firms should be more or just as encouraged to export than non-innovative firms. As expected, a firm located in the capital area is on average making 2.5 more innovations than firms outside this region. Additionally, given that the firm does have innovation, its number of innovations made increases by less, namely by 1.82 innovations, compared to a firm not located in the capital area. This finding should not be interpreted that being located in the capital increases a firm's number of innovations, but rather that being located in a geographically concentrated area has a positive effect on innovation. Again, if the goal for Norway is to promote innovation, this difference between these two average partial effects suggests that one should induce firms to locate in areas with high geographical concentration, and this holds especially for those firms who are not innovative in advance.

Moreover, a manufacturing firm makes on average just above 1 innovation less than firms in each of the other industries. This may be due to the more traditional industry characteristics in the manufacturing companies. Given that the manufacturing firm has innovation, the magnitude of this effect is a little lower, relative to firms in each of the other industries, with a negative APE value of 0.85. This implies that being a service or agricultural firm, the expected number of innovations is higher, but there is no statistically significant difference between these two industries.

Furthermore, the oldest company in the sample, Haglöfs, which is highly innovative with more than 50 product innovations (and therefore set to the value 50 in the estimation), is expected to on average make approximately 40 innovations more than the other firms. This high average partial effect is to be expected, when the average number of product innovations in the entire sample, in comparison, is approximately 2.8. When conditioning on a firm having innovation, the average partial effect of the dummy variable for Haglöfs is of course lower, but still relatively high with a value of approximately 36.4. As mentioned, including a dummy variable for Haglöfs was done in order to avoid a situation where the age variable was falsely statistically significant. Therefore, interpretation of the APEs for Haglöfs is not of special interest. However, this positive statistically significant effect of the dummy variable for Haglöfs may indicate that there, in fact, is a positive relationship between age and innovation. To explore this, one would need a data set with a larger sample size and especially one with a larger number of old firms.

Finally, one should be cautious with interpretation of the APE of the customer cooperation variable. The APEs for this variable are initially qualitatively interpreted: The higher a firm values its cooperation with customers, the more innovations is it expected to make. This holds both with and without a firm already being innovative. If one additionally assumes that the respondents have the same perception of the ranking scale, the estimated APEs can be seen as the approximate additional number of innovations a firm makes when evaluating customer cooperation to be one unit better. For instance, a firm ranking its customer cooperation 4 makes approximately 0.5 innovations more than a corresponding firm who ranks its customer cooperation 3. When conditioning on being innovative, this effect is slightly smaller, namely approximately 0.4.

7 – Discussion

In this chapter, the estimated results are discussed and compared to other empirical findings. First, a comparison to the theory around the Schumpeterian hypothesis about firm size is made, and then follows a subsection of comparisons with other studies regarding customer cooperation. A subsection on the findings of being located in the capital area is also made, and the section ends with a discussion around policy implications and the future of innovation.

7.1 Comparison to other results

7.1.1. *The Schumpeterian hypothesis*

An interesting finding in the previous chapter is that none of the specifications of firm size is statistically significant in any of the models. Acs and Audretsch are two of the main contributors to the literature of small-sized firms and innovative activity. In their study, Audretsch and Acs (1991) investigate innovation at the firm level in small sized firms, in a sample of 1695 firms. Over half of these firms had fewer than 500 employees, which is considered to be small-sized firms according to the U.S. Small Business Administration. Additionally, they include firms with 50.000 employees in their sample. This is in accordance with their suggestion of including both small and large firms in studies of firm size. They approach innovation in two ways; on the one hand, innovation is measured as the inputs of R&D, and on the other hand, innovation is measured by patented developments. Their study involves solely innovative firms, which may not give the same results as if non-innovative firms were also included. The finding is a different relationship between firm size and innovation between high- and low-technological industries. This supports the argument of Scherer (1984) that innovative activity of firms is constrained by their technological environment. In contrast to the study by Audretsch and Acs (1991), this thesis uses relatively small sized firms, even so-called micro firms. Additionally, since the firms in the studied sample are not sampled due to their innovative behavior, but to their high economic growth, this thesis includes both innovative and non-innovative firms. Thus, the results are suggested to give a more complete picture of the innovative behavior of the studied firms, compared to if only innovative firms had been included. Furthermore, this thesis includes a more direct measure of innovation, namely the number of innovations, instead of patents or R&D inputs, which is used by Audretsch and Acs (1991).

In addition, Acs and Audretsch (1987a) have also investigated if there are differences or similarities in the determinants of innovation in small and large firms. Their study also measures innovation as the number of innovations made (in 1982), and estimates regression models on the small and large-sized firms. The result is a support for the hypothesis that large firms have more innovative activity than small firms. Additionally, they find that determinants of innovation seem to be similar in large and small firms. Finally, Acs and Audretsch (1987a) finds that R&D is more important for large firms compared to small firms. This result is of interest in this thesis as it is shown that R&D is not statistically significant in the Tobit model. Because this thesis contains observations on small-sized firms, and R&D is not statistically significant, this supports the findings of Acs and Audretsch (1987a). Seeing this result together with the result that customer cooperation has a positive effect on innovative activity, it may suggest that for small-sized firms customer cooperation is more important than R&D. The reason for this might be that small-sized firms have a higher risk of innovation than large-sized firms, and that they therefore decide to cooperate with customers in the innovation process. Furthermore, large-sized firms may have more financial capital devoted to innovations than small-sized firms, as it was argued in chapter 2. Although the firms in the studied sample here have high economic growth, and it is now seen that some of these firms are innovative, it is not known how much financial capital these firms spend on innovation. This is beyond the scope of this thesis, but for future research it would be interesting to study the relationship between firms' economic growth and their spending on innovation.

Cohen et al. (1987) test the Schumpeterian hypothesis that it is the large firms who contribute most to investment in R&D. They control for differences in industries and they find that there is little support for the Schumpeterian hypothesis. However, their measure of innovation is not adequate, as they use R&D investment as a measure of innovative activity. In contrast, the study is performed on 2494 business units in the U.S, such that the studied sample is of relatively large size compared to the small gazelle sample used in this thesis. Besides the fact that they have a relatively large number of observations, their result of firm size having no effect on the output of innovations is similar to the findings in this thesis. The facts that there are studies that support the findings in this thesis suggest some possibilities. First, it may imply that there really is no relationship between the direct size of the firm and their innovative activity. Second, there could also be country specific differences that are not taken into consideration in this thesis and other earlier studies, which in turn suggests that further research is needed. Furthermore, the fact that customer cooperation seems to influence innovative activity positively suggests that it is not the firm size specifically, but the firms' ability to include customers in its innovation process, that influences the firms innovative activity. This can for example be due to the specific customer demands (in terms of products that matches their preferences) in a rapidly changing world.

It is pointed out in Audretsch and Acs (1991) that there are two reasons for why some studies find positive relationship on firm size whereas others have not. First, the difference lies in the various measures if innovation that is used in empirical studies (patent or R&D expenditures). Secondly, the studies of firm size and innovation have used size distributions in which only large firms are included. The use of only large firms in studies of firm size can give misleading results, and comparison to small sized firms is difficult. Making generalizations of this kind may be dangerous and the reliability can be questioned.

Can the non-significant result of firm size on innovation be expected to actually be true? The non-significant result may be due to the relatively small sample size in this thesis, as the estimation only uses 280 observations. As is seen in the subsections above, the other empirical papers have much more observations. Additionally, there is a possibility that it may be due to the low degree of variation within the observations on firm size. Specifically, there are not many of the relatively large firms. Therefore, it would be interesting to make a similar study of a larger sample, including more observations on firms with a higher number of employees. Furthermore, the non-significant result may stem from the fact that the firm size variable is specified as a mixture of the number of employees and the number of man-year. The overall result suggest that Schumpeter's hypothesis around firm size still requires empirical studies in order to prove him right or wrong with regards to the views of the so-called Schumpeter Mark II.

7.1.2. *Customer knowledge*

In the paper of customer cooperation on firms innovative activity, Sánchez-González and Herrera (2014) study 4713 Spanish firms of the years 2004-2007, in which 656 of these firms cooperated with customers. The study contained comparisons of firms who cooperated with customers with a control group of firms who did not cooperate with customers. The study takes both innovative input (the early stages of innovation) and output (the obtained economic returns from the innovation) into consideration and finds that customer cooperation is increasing the innovative activity of a firm. Especially customer cooperation is beneficial in the emergence of radical innovations, in which knowledge expansion is of importance, as it involves developing skills that the firm not necessarily (already) has internally. Another result of this paper is that earlier experience with R&D increases the probability of cooperating with customers. This could indicate that R&D and customer cooperation are complements in firms' creation of innovations. In this thesis, however, it is found that having an R&D department does not any statistically effect on innovation, whereas customer cooperation has. This in turn suggests that R&D and customer cooperation are substitutes in firms' creation of innovation. Consequently, there is a conflict between the findings of Sánchez-González and Herrera (2014) and this thesis.

Furthermore, the findings of this thesis confirm the findings of Sánchez-González and Herrera (2014) in the way that cooperation with customers here is positively related to innovation. However, not all of the firms studied in this thesis cooperate with customers, which is in contrast to Sánchez-González and Herrera (2014). Using the same argument as above regarding the relationship between innovation and firm size, a study that excludes non-cooperative firms may give altered results. With regards to the innovative output, Sánchez-González and Herrera (2014) find that the economic returns are influenced by customer cooperation. This seems plausible as firms reduce their risk of getting the innovation accepted by the market, which again may result in higher sales. Despite that this thesis does not study the relationship between the economic returns and innovative activity, it still implicitly conditions on firms having high economic growth. As mentioned above, a direction for future research can be to study this possible relationship.

Chu, Tian, and Wang (2014) study the relationship between supplier and customer on the innovation of the supplier through knowledge spillovers. They find spillovers of knowledge from the customers to have a positive effect on innovation of the suppliers. This is supported by the findings in this thesis. Furthermore, they find that the cooperation and knowledge spillovers have a positive impact on the market performance of the firm's product. This finding is in contrast to this thesis, in which no statistically significant relationship is found between innovation and the variables concerning importance of the customers and acceptance of the product by the market, respectively. In general, the fact that only one of the three variables regarding customer knowledge is statistically significant makes the overall importance of firms' customer knowledge doubtful, and one may question whether this result is true or due to respondents' difficulties in the ranking and separation of the different categories. The non-significant coefficient regarding customer importance and acceptance by the market is an interesting finding. It may suggest that the process of cooperation with customers not really affects the innovative output. In summary, the result suggests that cooperation with customers is of interest to the firms in the development of the innovation, whereas this is not necessarily the case for getting market acceptance.

Ultimately, the findings in this thesis may suggest that the future for innovation is not directly about the size of the firms, but about their creation of networks and cooperation with customers in the innovation process. However, the validity of this result is questionable in some ways. First, this suggestion relies on the fact that all respondents have the same understanding of 'success' with customer cooperation. Second, measuring innovation seems to be difficult, and the results rely on the respondents knowing the firms' actual levels of innovative activity, and having the same conceptual understanding of what is meant by innovation. Finally, as the studied sample consists of high growth Norwegian firms, there is a possibility that these findings differ from non-gazelles and/or from firms in other countries, and that they therefore is only applicable to a small part of the firms in Norway.

7.1.3. *Other findings*

The positive coefficient of the capital variable is in accordance with the findings of knowledge spillovers (Audretsch & Feldman, 2004). It indicates that such spillovers may occur between firms localized in areas with high geographical concentration. The argument for this is that they happen between firms, because of their (relatively) close geographical connections. In addition, one may argue that there is a greater possibility of innovation in the capital area as there is a higher influence of people working and living there, and therefore knowledge transactions of a higher level compared to a firm located in a smaller city or at the countryside.

7.2 Policy implications and future innovation

Despite that these results do not predict the future of innovation, the results provide information about innovative characteristics of gazelle firms that may be considered for policy implications in the future. It is interesting that there is no finding of a relationship between firm size and innovation. The reasons why this may be the case is already mentioned above. It cannot be confirmed that the size of the gazelles is important for innovative activity.

However, for the future of innovative promotions and activity in Norway, it may indicate that there is no credible evidence to lead the focus of the policy makers towards (especially) large firms. This may suggest that small firms should, just as well as large firms, be considered for the focus of innovation. Besides this, one should keep in mind that, despite a low modal value of number of employees, many of the firms in the considered sample does actually have innovation. For this particular reason, one may suggest that future innovative promotions should continue, or at least be kept in the same level as of today. With regards to the theory of Schumpeter, it is suggested that the large sized firms are able to innovate because of their financial capital. A firm's possibility of getting external funding, e.g. through loans from banks, to promote its innovation should not depend on its number of employees. It would be interesting to have further studies that estimate the effects of firm size on innovation in high growth firms with larger samples and more variation in firm size.

It is suggested that the authorities should encourage firms to find ways of involving customers more in the innovation process in order to increase innovative activity. Maybe the future innovative activity of firms will to a larger extent be characterized by cooperation with customers, lead users and other institutions, such as universities. Reasons for this are both in order to reduce risk for the firms but also for customers to get more specialized products, which may be beneficial for both parts. Specifically, as long as the total and marginal costs of the firms are relatively unaffected and the prices of the produced products do not increase too much, this should increase social welfare.

Moreover, the fact that R&D does not seem to have an impact on innovation in the gazelle firms may suggest that public funding to R&D for innovation may not be of importance. This, together with the fact that cooperation with customers seems to affect innovative activity in a positive way, suggests that policy makers should give firms financial incentives to include customers in the innovation process, rather than to have a R&D department. Even though the results indicate that having a R&D department does not influence innovative activity, intuition and the results from the Probit model suggest that having such a department should affect the probability of having innovation. Therefore, entirely excluding public subsidization of R&D spending is not recommended. On the other hand, balancing R&D and customer cooperation is challenging for the policy makers, as another argument may be that public financial resources spent on R&D instead should be used on other economic factors for economic growth, for example obtaining a larger workforce or better production technologies in order to reduce firms costs. Notice that this final point of production technologies concerns process innovation, but it is assumed that public subsidies are devoted to innovation at an overall level.

The result that firms being located around the capital area have more innovations than other firms, all else equal, is of importance for planning future innovative aspects in Norway. This result may at an overall level suggest that having more firms located around each other may provide higher knowledge spillovers and maybe more competition, thus the incentives of innovation are larger compared to firms who are located far away from each other. However, this is not be interpreted as if the policy makers should advice firms to start up or move to the capital area. If the policy makers have a goal of creating more innovation, they may give firms incentives of start up or move localizations to areas of high geographical concentration. An example of how this can be done is to give regional corporate taxation reduction. However, since this is likely to increase the population density in these city areas at the expense of the country sides, such a policy may have adverse effects. It is therefore a complex issue, and the policy makers should take all these different factors into account when designing policies aiming at promoting innovation.

Furthermore, the results of the three different industries show that the services and agricultural sectors are more innovative than those within manufacturing. This may suggest that the focus of the policy makers should be to promote innovative activity in especially services and perhaps also agricultural industries.

It may also be discussed whether all innovations are equally beneficial for the society. For example, for the firm Haglöfs, a new product within equipment of hiking may not necessarily have the same impact as a development of a new product within the manufacturing firms that involves engineering and product designs, or a process innovation that for all future production lowers the production costs. Innovation is still difficult due to its various forms and stages, and because of the challenges in relation to designing policies that induce more innovation. Also, the rapid changes in the world may increase innovative demand. It should again be emphasized that innovation is only one source to economic growth. Further, the profit-maximizing behavior of the firms does not imply that their main goal is to innovate. The characteristics of the firms studied in the sample indicate that innovation is not essential for being successful in terms of having high economic growth. If the goal of society is to create economic value, then the political focus should not necessarily be to promote innovation, but only in the cases where more innovation yields a net benefit for the society.

Finally, these policy implications rely heavily on the validity of the estimated results. These, in turn, rely on the specifications of the variables, and on the fact that the studied sample is relatively small, and that the degree of variation within the variables is limited. Therefore, this discussion around the different policies is only suggested to be a starting point of future innovative promoting activities.

8 – Summary and conclusion

This thesis has studied innovation in small-sized high-growth firms in Norway. The studied firms' innovative activity took place in the year of 2011 and the behavior of 280 firms was studied. The study used a direct measure of product innovation, namely the number of product innovations made, which was in contrast to many other studies on this topic. Furthermore, the relationship between firm size and innovative activity, much studied by e.g. Schumpeter, was illustrated using a theoretical model developed by d'Aspremont and Jacquemin (1988). The studied innovative activity of the firms covered their probability of having product innovation and also their expected number of innovations, both with and without a condition of a firm already being innovative. For the former, a Probit model was used to estimate the probability of a firm having innovation. Regarding the latter, since many of the firms did not have innovation, a Tobit corner solution model that took this probability mass at zero into account was estimated. From this it was found that the effect of firm size had no statistically significant effect on innovation in any of the models, whereas cooperation with customers was found to have a statistically significant positive effect on innovation in both models. Further, both i) the importance of customers to the firms, and ii) the market acceptance of products developed together with their customers, did not have any statistically significant effects on innovation.

As it is pointed out in this thesis, there are many difficulties with the empirical study of innovation. First of all, measuring innovation is difficult. Moreover, with regards to the measure of innovation, the variable that determines how many product innovations a firm makes is originally specified with both single numbers of innovations made and as grouped categories. This questions the validity of the estimated results, as the specification of the variable is compensated by a variable that assigns each observation with its lowest possible number of product innovations. Further, a potential problem for the used data is that the respondents may not have the same understanding of product innovation and in what way a product or service is considered to be new. Additionally, the validity of the variables that concerns customer knowledge is questioned, since the content of the questions might be difficult to separate due to the relatively vague formulation of the questions. Also, it is difficult to know if the respondents understand and interpret the questions in the same way.

The results of this thesis may have implications for Norwegian policy makers. First, if policy makers want to promote innovative activity, there should be no differences between the "treatment" of respectively small and large firms. In addition, authorities should provide firms with incentives to include customers in their innovation process. Finally, giving firms incentive to open a R&D department is likely to increase the share of innovative firms, but not to increase the total number of innovations. Consequently, whether or not the authorities should promote firms' investments in R&D departments depends on the authorities' overall innovative objectives. Also, the authorities should have a focus on promoting innovation in firms located in geographically concentrated areas, i.e. firms in large cities. Finally, if there is a goal to develop and make more innovations, the attention should be directed mainly to the service industry, and perhaps also the agricultural industry.

It must be emphasized that the study concerns only a sample of gazelle firms in Norway, and it may not necessarily give the same results if non-gazelles had been included in the study. Furthermore, only a small size of the asked sample responded to the survey. There might be differences in the groups of those who did respond and those who did not. A precise study requires precise data, and in order to better obtain this, one could give the firms economic incentives to respond and doing so truthfully, which a common practice in economic experiments. As of today, a large share of Norway's income stems from the oil industry. In the future, alternative income resources are needed. Innovations made today may help Norway meet this need. Therefore, it is crucial to have a good understanding of the determinants of firms' innovative behavior. Consequently, further studies on innovative activity are of interest and importance.

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Appendices

Appendix 1.

Derivations of the second order conditions of the model from section 2.2.1.

Second order condition in duopoly case:

$$\frac{\partial^2 \pi_i(x)}{\partial x_i^2} = -b\frac{\partial Q}{\partial x_i}\frac{\partial q_i(x)}{\partial x_i} + [a - bQ(x)]\frac{\partial}{\partial x_i}\left(\frac{\partial q_i(x)}{\partial x_i}\right) - b\left[\frac{\partial q_i(x)}{\partial x_i}\frac{\partial Q}{\partial x_i} + q_i(x)\frac{\partial}{\partial x_i}\left(\frac{\partial Q}{\partial x_i}\right)\right]$$
$$- \left[-\frac{\partial q_i(x)}{\partial x_i} + [A - x_i]\frac{\partial}{\partial x_i}\left(\frac{\partial q_i(x)}{\partial x_i}\right)\right] + \frac{\partial q_i(x)}{\partial x_i} - \gamma$$

Since $\frac{\partial}{\partial x_i}\left(\frac{\partial q_i(x)}{\partial x_i}\right) = \frac{\partial}{\partial x_i}\left(\frac{\partial Q}{\partial x_i}\right) = 0$, it follows that

$$\frac{\partial^2 \pi_i(x)}{\partial x_i^2} = -b\frac{\partial Q}{\partial x_i}\frac{\partial q_i(x)}{\partial x_i} - b\frac{\partial q_i(x)}{\partial x_i}\frac{\partial Q}{\partial x_i} + \frac{\partial q_i(x)}{\partial x_i} + \frac{\partial q_i(x)}{\partial x_i} - \gamma$$
$$= -2b\frac{\partial Q}{\partial x_i}\frac{\partial q_i(x)}{\partial x_i} + 2\frac{\partial q_i(x)}{\partial x_i} - \gamma = -2\frac{\partial q_i(x)}{\partial x_i}\left[b\frac{\partial Q}{\partial x_i} - 1\right] - \gamma$$
$$= -2\frac{2}{3b}\left[b\frac{1}{3b} - 1\right] - \gamma = \frac{8}{9b} - \gamma < 0 \Leftrightarrow \gamma > \frac{8}{9b}$$

Second order condition in monopoly case:

$$\frac{\partial^2 \pi(x)}{\partial x^2} = \frac{1}{2b} - \gamma < 0 \Leftrightarrow \gamma > \frac{1}{2b}$$

Appendix 2.

Table A.1. *Distribution of the variable 'firm size'.*

# Employees	Frequency	Percent
0.5	1	0.36
1	17	6.07
1.5	2	0.71
2	18	6.43
3	20	7.14
3.2	1	0.36
4	22	7.86
4.5	2	0.71
5	19	6.79
5.5	1	0.36
6	17	6.07
7	18	6.43
7.5	1	0.36
8	16	5.71
8.5	1	0.36
9	13	4.64
10	5	1.79
11	6	2.14
12	5	1.79
13	3	1.07
14	5	1.79
15	9	3.21
16	5	1.79
17	6	2.14
18	3	1.07
19	3	1.07
20	3	1.07
21	1	0.36
22	3	1.07
23	3	1.07
24	5	1.79
25	7	2.50
26	1	0.36
27	2	0.71
28	3	1.07
29	2	0.71
30	2	0.71
32	2	0.71
33	2	0.71
36	1	0.36
39	1	0.36
40	2	0.71
42	1	0.36
44	1	0.36
48	1	0.36

49	1	0.36
50	2	0.71
52	1	0.36
56	1	0.36
59	1	0.36
60	1	0.36
64	1	0.36
65	1	0.36
75	1	0.36
79	1	0.36
87	1	0.36
116	1	0.36
148	1	0.36
160	1	0.36
218	1	0.36
280	1	0.36
511	1	0.36
Total	280	100.00

Appendix 3.

Table A.2. *Estimated Tobit coefficients for the values of high*

Dependent Variable Number of Product Innovations	EST. 1	EST. 2	EST. 3	EST. 4	EST. 5	EST. 6	EST. 7	EST. 8	EST. 9	EST. 10
Capital	10.270***	10.339***	10.350***	10.288***	10.416***	10.254***	10.017***	10.206***	9.923***	9.267***
	(2.858)	(2.826)	(2.826)	(2.878)	(2.808)	(2.797)	(2.782)	(2.771)	(2.770)	(2.750)
Export	3.575	3.558	3.501	3.530	3.821	3.874	3.888	3.785	4.150*	4.522*
	(2.545)	(2.543)	(2.522)	(2.520)	(2.478)	(2.463)	(2.468)	(2.466)		(2.459)
D. Haglöfs	54.265*	54.063*	53.862*	54.257*	56.495*	57.638*	58.252*	59.692*	66.965**	90.187***
	(31.579)	(31.561)	(31.546)	(31.528)	(31.293)	(31.265)	(31.314)	(31.283)	(31.155)	(17.410)
C1: Customer Cooperation	2.701***	2.712***	2.676***	2.648***	2.720***	2.702***	2.689***	2.385***	2.181***	2.212***
	(0.929)	(0.927)	(0.903)	(0.899)	(0.891)	'(0.891)	(0.893)	(0.756)	(4.376)	(0.748)
C2: Customer Importance	-0.570	-0.578	-0.694	-0.665	-0.691	-0.666	-0.583			
	(1.134)	-1.133	(0.918)	(0.915)	(0.912)	(0.905)	(0.900)			
C3: Acceptance by Market	-0.201	-0.200								
	(1.148)	(1.149)								
Agriculture	-0.941									
	(5.853)									
Manufacturing	-3.934	-3.855	-3.826	-3.771	-3.906	-4.122	-4.174	-4.213	-4.757*	-4.927*
	(2.928)	(2.887)	(2.882)	(2.878)	(2.865)	(2.848)	(2.853)	(2.857)	(2.853)	(2.862)
Age	-0.526**	-0.527**	-0.526**	-0.527**	-0.525**	-0.536**	-0.517**	-0.503*	-0.282	
	(0.259)	(0.259)	(0.259)	(0.258)	(0.258)	(0.258)	(0.257)	(0.256)	(0.247)	
Age Squared	0.007*	0.007*	0.007*	0.007*	0.007*	0.007*	0.007*	0.006*	0.005	
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	
# Gazelle	3.936	3.885	3.911	3.943	4.174	4.131	3.868	4.045		
	(3.181)	(3.165)	(3.162)	(3.161)	(3.135)	(3.133)	(3.118)	(3.112)		
# Gazelle Squared	-0.387	-0.379	-0.384	-0.382	-0.408	-0.423	-0.388	-0.413		
	(0.489)	(0.486)	(0.485)	(0.485)	(0.483)	(0.482)	(0.481)	(0.480)		
Firm Size	-0.072	-0.072	-0.074	-0.054	-0.045					
	(0.087)	(0.087)	(0.086)	(0.070)	(0.069)					
Firm Size Squared	0.0001	0.0001	0.0002	0.0001	0.0001					
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)					
Micro Size	-1.188	-1.135	-1.180							
	(3.020)	(3.003)	(2.992)							
CEO	2.936	2.999	3.042	3.008	2.887	2.838				
	(4.040)	(4.024)	(0.450)	(4.018)	(4.001)	(4.000)				
R&D	2.431	2.496	2.514	2.559						
	(3.752)	(3.732)	(3.731)	(3.729)						
Constant	-16.290**	-16.412**	-16.706**	-17.713**	-18.030**	-18.309**	-15.880*	-17.655***	-12.175***	-15.037***
	(7.910)	(7.877)	(7.699)	(7.272)	(7.242)	(7.222)	(6.351)	(5.762)	(4.376)	(03.982)
Sigma	16.972	16.975	16.978	16.979	16.946	16.961	16.995	17.023	17.109	17.211
	(1.002)	(1.002)	(1.003)	(1.003)	(0.999)	(1.000)	(1.001)	(1.003)	(1.009)	(1.012)
Log-Likelihood	-733.176	-733.189	-733.204	-733.282	-733.519	-733.735	-733.988	-734.197	-735.930	-737.144
Observations	280	280	280	280	280	280	280	280	280	280
LR chi2	71.30	71.27	71.24	71.09	70.61	70.18	69.68	69.26	65.70	63.37
Prob>Chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0464	0.0464	0.0463	0.0462	0.0459	0.0456	0.0453	0.0450	0.0428	0.0412

Note: Wald-tests of nonlinear restrictions: Firm Size: (P>0.21)=0.8079, Number of times a Gazelle:(P>1.73)=0.1793, Age: (P>1.21)=0.2995.
Standard errors are given in parentheses. Test statistics is indicated with ***. **. * and represents the 1%,- 5% - and 10% level .

Table A.3. *Estimated Average Partial Effect for the values of high*

Dependent Variable: Number of Product Innovations	P(y>0|x) Estimated APE	E(y|x) Estimated APE	E (y|x, y>0) Estimated APE
Export	0.098	2.087	1.584
C1: Customer Cooperation	0.047	0.0985	0.759
Capital	0.202	4.631	3.436
Manufacturing	-0.104	-2.062	-1.614
DHäglöfs	0.556	81.420	74.491
Sigma	17.211		
Observations	280		

Table A.4. *Estimated Tobit coefficients with average of 'customer knowledge'*

Dependent Variable Number of Product Innovations	EST 1	EST 2	EST 3	EST 4	EST 5	EST 6	EST 7	EST 8
Capital	5.201**	5.185**	5.245**	5.159**	4.956**	4.898**	4.617**	4.766**
	(1.490)	(1.488)	(1.470)	(1.460)	(1.458)	(1.453)	(1.444)	(1.433)
Export	2.216*	2.224*	2.208*	2.215*	2.355*	2.410*	2.561*	2.804**
	(1.319)	(1.318)	(1.317)	(1.318)	(1.316)	(1.306)	(1.305)	(1.283)
Customer Knowledge'	1.004**	1.002**	1.005**	1.027**	0.903**	0.903**	0.966**	0.983**
	(0.477)	(0.467)	(0.477)	(0.476)	(0.467)	(0.467)	(0.466)	(0.465)
D. Haglöfs	30.154*	30.237*	30.087*	30.284*	33.352**	33.668**	43.419***	44.991***
	(16.427)	(16.423)	(16.418)	(16.429)	(16.396)	(16.377)	(9.120)	(9.070)
Agriculture	-0.852	-0.761						
	(3.038)	(3.018)						
Manufacturing	-2.267	-2.239	-2.179	-2.194	-2.475*	-2.552*	-2.615*	-2.727*
	(1.514)	(1.510)	(1.492)	(1.493)	(1.491)	(1.482)	(1.486)	(1.478)
Age	-0.228*	-0.229*	-0.230*	-0.224*	-0.174	-0.180		
	(0.138)	(0.134)	(0.134)	(0.133)	(0.130)	(0.129)		
Age Squared	0.003	0.003	0.003	0.003	0.002	0.002		
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)		
# Gazelle	1.944	1.951	1.907	1.818				
	(1.657)	(1.657)	(1.648)	(1.640)				
# Gazelle Squared	-0.191	-0.189	-0.182	-0.171				
	(0.255)	(0.255)	(0.254)	(0253)				
Firm Size	-0.031	-0.025	-0.025	-0.025	-0.015			
	(0.044)	(0.036)	(0.036)	(0.036)	(0.035)			
Firm Size Squared	0.00007	0.00006	0.00006	0.00006	0.00004			
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)			
Micro Size	-0.417							
	(1.556)							
CEO	0.930	0.930	0.977					
	(2.082)	(2.082)	(2.076)					
R&D	1.930	1.950	2.006	1.966	2.455	2.281	2.117	
	(1.948)	(1.947)	(1.936)	(1.935)	(1.925)	(1.881)	(1.884)	
Constant	-8.235**	-8.587**	-8.649**	-7.798**	-5.202*	-5.313*	-6.898***	-6.817***
	(4.117)	(3.905)	(3.900)	(3.453)	(2.733)	(2.714)	(2.477)	(2.466)
Sigma	8.879	8.878	8.882	8.890	8.938	8.939	8.981	8.961
	(0.530)	(0.530)	(0.530)	(0.530)	(0.534)	(0.534)	(0.537)	(0.535)
Log-Likelihood	-635.972	-636.008	-636.040	-636-151	-637.615	-637.720	-638.695	-639.332
Observations	280	280	280	280	280	280	280	280
LR chi2	64.60	64.53	64.47	64.24	61.32	61.11	59.16	57.88
Prob>Chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0483	0.0483	0.0482	0.0481	0.0459	0.0457	0.0443	0.0433

Note: Wald-tests of nonlinear restrictions: Number of times a Gazelle:(P>1.47)=0.2326, Firm Size: (P>0.10)=0.9014, Age: (P>0.97)=0.3793.
Standard errors are given in parentheses. Test statistics is indicated with ***. **. * and represents the 1%,- 5% - and 10% level .

Table A.5. *Estimated Tobit coefficients without dummy variable for Haglöfs*

Dependent Variable **Number of Product Innovations**	**EST. 1**	**EST. 2**	**EST. 3**	**EST. 4**	**EST. 5**	**EST. 6**	**EST. 7**	**EST. 8**	**EST. 9**
Capital	5.486***	5.493***	5.494***	5.461***	5.352***	5.160***	5.110***	5.236***	5.410***
	(1.485)	(1.468)	(1.468)	(1.466)	(1.459)	(1.463)	(1.458)	(1.455)	(1.445)
Export	2.033	2.031	2.021	2.037	2.045	2.177*	2.213*	2.135	2.396*
	(1.327)	(1.325)	(1.315)	(1.314)	(1.316)	(1.319)	(1.309)	(1.310)	(1.290)
C1: Customer Cooperation	1.489***	1.490***	1.484***	1.468***	1.463***	1.372***	1.373***	1.154***	1.200***
	(0.484)	(0.483)	(0.470)	(0.468)	(0.469)	(0.468)	(0.468)	(0.393)	(0.390)
C2: Customer Importance	-0.405	-0.406	-0.426	-0.410	-0.370	-0.418	-0.411		
	(0.590)	(0.589)	(0.478)	(0.476)	(0.473)	(0.474)	(0.471)		
C3: Acceptance by Market	-0.035	-0.035							
	(0.600)	(0.599)							
Agriculture	-0.094								
	(3.051)								
Manufacturing	-1.843	-1.835	-1.831	-1.797	-1.824	-2.151	-2.236	-2.261	-2.373
	(1.524)	(1.503)	(1.501)	(1.498)	(1.500)	(1.503)	(1.494)	(1.499)	(1.493)
Age	-0.351***	-0.351***	-0.351***	-0.353***	-0.345***	-0.297**	-0.303**	-0.295**	-0.291**
	(0.123)	(0.123)	(0.123)	(0.123)	(0.123)	(0.120)	(0.119)	(0.119)	(0.119)
Age Squared	0.006***	0.006***	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
# Gazelle	2.120	2.115	2.120	2.139	2.019				
	(1.661)	(1.653)	(1.651)	(1.650)	(1.643)				
# Gazelle Squared	-0.193	-0.192	-0.193	-0.192	-0.176				
	(0.256)	(0.254)	(0.254)	(0.254)	(0.253)				
Firm Size	-0.041	-0.041	-0.041	-0.030	-0.030	-0.018			
	(0.045)	(0.045)	(0.045)	(0.037)	(0.037)	(0.036)			
Firm Size Squared	0.00009	0.00009	0.00009	0.00007	0.00007	0.00004			
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)			
Micro Size	-0.689	-0.685	-0.692						
	(1.576)	(1.567)	(1.561)						
CEO	1.376	1.382	1.389	1.369					
	(2.106)	(2.097)	(2.093)	(2.094)					
R&D	1.778	1.784	1.787	1.817	1.773	2.424	2.222	2.351	
	(1.952)	(1.942)	(1.941)	(1.951)	(1.942)	(1.932)	(1.890)	(1.890)	
Constant	-7.929*	-7.941*	-7.992**	-8.583**	-7.422**	-4.477*	-4.661*	-5.759**	-5.839**
	(4.129)	(4.111)	(4.016)	(3.794)	(3.350)	(2.620)	(2.594)	(2.293)	(2.288)
Sigma	8.892	8.892	8.891	8.893	8.908	8.986	8.986	9.014	9.002
	(0.528)	(0.528)	(0.528)	(0.529)	(0.529)	(0.535)	(0.535)	(0.536)	(0.535)
Log-Likelihood	-634.341	-634.341	-634.343	-634.441	-634.656	-636.736	-636.867	-637.247	-638.027
Observations	280	280	280	280	280	280	280	280	280
LR chi2	67.87	67.86	67.86	67.66	67.24	63.07	62.81	62.05	60.49
Prob>Chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0508	0.0508	0.0508	0.0506	0.0503	0.0472	0.0470	0.0464	0.0453

Note: Wald-tests of nonlinear restrictions: Number of times a Gazelle:(P>2.09)=0.1260, Firm Size: (P>0.13)=0.8785.
Standard errors are given in parentheses. Test statistics is indicated with ***. **. * and represents the 1%,- 5% - and 10% level .

Table A.6. *Estimated Tobit Coefficients for dummy variable of Large Sized Firms*

Dependent Variable Number of Product Innovations	EST. 1	EST. 2	EST. 3	EST. 4	EST. 5	EST. 6	EST. 7	EST. 8	EST. 9	EST. 10	EST. 11
Capital	5.261***	5.283***	5.287***	5.286***	5.176***	5.074***	5.020***	5.097***	5.203***	5.060***	4.745***
	(1.480)	(1.463)	(1.463)	(1.463)	(1.453)	(1.445)	(1.443)	(1.434)	(1.428)	(1.429)	(1.417)
Export	2.174*	2.169*	2.149*	2.154*	2.257*	2.267*	2.233*	2.358*	2.301*	2.490*	2.660**
	(1.312)	(1.311)	(1.300)	(1.230)	(1.290)	(1.291)	(1.290)	(1.271)	(1.270)	(0.127)	(1.267)
D. Haglöfs	27.015*	26.952*	26.883	26.917*	27.413*	27.721*	28.365*	29.259*	30.063*	34.021**	44.201***
	(16.334)	(16.323)	(16.314)	(16.312)	(16.287)	(16.301)	(16.271)	(16.176)	(16.164)	(16.114)	(8.998)
C1: Customer Cooperation	1.420***	1.423***	1.410***	1.406***	1.408***	1.403***	1.392***	1.428***	1.258***	1.151***	1.169***
	(0.479)	(0.478)	(0.465)	(0.464)	(0.463)	(0.464)	(0.463)	(0.459)	(0.389)	(0.384)	(0.385)
C2: Customer Importance	-0.323	-0.325	-0.365	-0.361	-0.376	-0.340	-0.310	-0.326			
	(0.584)	(0.583)	(0.473)	(0.472)	(0.471)	(0.467)	(0.465)	(0.463)			
C3: Acceptance by Market	0.070	-0.069									
	(0.591)	(0.591)									
Agriculture	-0.291										
	(3.011)										
Manufacturing	-1.984	-1.960	-1.950	-1.942	-2.024	-2.048	-2.083	-2.123	-2.144	-2.441*	-2.520*
	(1.507)	(1.485)	(1.483)	(1.481)	(1.470)	(1.471)	(1.470)	(1.466)	(1.469)	(1.467)	(1.471)
Age	-0.256*	-0.256*	-0.255*	-0.255*	-0.260*	-0.254*	-0.257*	-0.255*	-0.247*	-0.182	
	(0.133)	(0.133)	(0.133)	(0.133)	(0.133)	(0.133)	(0.132)	(0.132)	(0.132)	(0.127)	
Age Squared	0.003*	0.003*	0.003*	0.003*	0.003*	0.003*	0.003*	0.003*	0.003	0.002	
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	
# Gazelle	2.022	2.006	2.015	2.023	1.974	1.863	1.895	2.010	2.108		
	(1.641)	(1.633)	(1.631)	(1.630)	(1.629)	(1.621)	(1.621)	(1.607)	(1.604)		
# Gazelle Squared	-0.197	-0.194	-0.196	-0.197	-0.193	-0.178	-0.184	-0.194	-0.208		
	(0.253)	(0.251)	(0.251)	(0.251)	(0.250)	(0.249)	(0.249)	(0.248)	(0.248)		
Firm Size	-0.013	-0.013	-0.013	-0.007							
	(0.067)	(0.067)	(0.067)	(0.048)							
Firm Size Squared	0.00005	0.00005	0.00005	0.00004							
	(0.0001)	(0.0001)	(0.0001)	(0.0001)							
Micro Size	-0.230	-0.213	-0.228								
	(1.769)	(1.760)	(1.756)								
Large Size (>100)	-3.944	-3.951	-3.957	-4.508	-2.617	-2.586					
	(8.885)	(8.888)	(8.894)	(7.815)	(4.270)	(4.259)					
CEO	1.193	1.212	1.227	1.216	1.237						
	(2.085)	(2.076)	(2.073)	(2.072)	2.066)						
R&D	1.450	1.470	1.477	1.490	1.331	1.289	1.161				
	(1.942)	(1.931)	(1.931)	(1.928)	(1.902)	(1.903)	(1.891)				
Constant	-8.496**	-8.535**	8.637**	-8.855**	-8.750**	-7.694**	-7.781**	-7.945**	-8.939***	-6.066***	-7.451***
	(4.230)	(4.213)	(4.123)	(3.766)	(3.732)	(3.285)	(3.285)	(3.269)	(2.967)	(2.254)	(2.049)
Sigma	8.779	8.780	8.780	8.780	8.781	8.793	8.797	8.782	8.798	8.851	8.896
	(0.523)	(0.523)	(0.523)	(0.523)	(0.523)	(0.524)	(0.524)	(0.522)	(0.523)	(0.527)	(0.530)
Log-Likelihood	-632.878	-632.883	-632.890	-632.898	-633.130	-633.310	-633.497	-633.687	-633.933	-633.839	-632.872
Observations	280	280	280	280	280	280	280	280	280	280	280
LR chi2	70.79	70.78	70.77	70.75	70.29	69.93	69.55	69.17	68.68	64.87	62.80
Prob>Chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.0530	0.0530	0.0529	0.0529	0.0526	0.0523	0.0520	0.0518	0.0514	0.0485	0.0470

Note: Wald-tests of nonlinear restrictions: Firm Size: (P>0.23)=0.7942, Number of times a Gazelle:(P>1.90)=0.1512,Age:(P>1.03)=0.3580.
Standard errors are given in parentheses. Test statistics is indicated with ***. **. * and represents the 1%,- 5% - and 10% level .