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Master Thesis

Innovation in the Dutch agricultural sector:

Determinants on a firm-specific level

J.J.H. Simmelink

302934

Thesis supervisor: I. Colantone Ph.D.

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Abstract

The aim of this research is to show which determinants of innovation are important in the Dutch agricultural sector, on a firm-specific level. Historically the Dutch agricultural sector is relatively important for the Dutch economy, so in most studies -with respect to innovation- the benefit for the whole economy is taken as a starting point. The importance of innovation for economic progress in general is irrefutable, but is mostly explained on an aggregated level. This research however, focuses on the firm-specific level of analysis. Panel data from the Dutch FADN and in particular the data of the Innovatiemonitor survey, both collected by the Dutch Agricultural Economics Research Institute (LEI), made this research possible. Further, this research aims on providing a framework for important determinants of innovation and more importantly providing basic knowledge of innovation within the different subsectors of the Dutch agricultural sector. Differences between subsectors, profit, firm size, education and age of the farmer, legal forms of farms and connections with external sources of knowledge explain for differences in innovation in the Dutch agricultural sector. In principle there are difference between the most important determinants of product and process innovation; which is explained by the structural difference of these two types of innovation and their different requisites. The model of this research is also a useful prelude for additional, future, research due to the structural differences between the explaining determinants of both product and process innovation.

Key-words: agriculture, innovation, firm-specific level, Innovatiemonitor

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For the thesis and the research output an important matter should be considered:
The data used in the present work stem from the Dutch FADN system as collected by the Dutch Agricultural Economics Research Institute (LEI). The Centre of Economic Information (CEI) has provided access to these data. Results shown are and remain entirely the responsibility of the author, they neither represent LEI/CEI views nor constitute official statistics.

Chapter 1: Introduction

1.1 Introduction

The Dutch agricultural sector has changed rapidly throughout the last decades. Clear examples are the decline of the sector's share in the national economy, an overall decrease in the number of people that work in the agricultural sector, an increase in the overall labor productivity and a substantial scale increase of the 'average' farm size (Van Bruchem and Silvis, 2008). There are numerous examples that can be referred to, however the focus is for a large part on an aggregate level; ruling out the importance of these developments on a more firm-specific level. Also literature with respect to agriculture focuses in general on macro-economic problems or policy solutions to these problems. This is because, examples given: trade impact, subsidies and ensuring independent food supply are far more debated subjects than the role of the sector for a country itself. Although this may seem valid; is further research on a less aggregated level providing better understanding on the economic dynamicity of the agricultural sector and its innovation capabilities. The effectiveness and the success of the whole agricultural sector are frequently reported at an aggregated level, consequently ignoring "lower levels" of analysis. In principle does this lead to an abundant research field which is more or less unexplored. This research can be seen as a prelude for further studies in the field of firm specific innovation in the agricultural sector. It is not a research aim to provide a comprehensive overview, but more of a beginning towards more profound research. To illustrate the importance of the subject will the current policy regarding firm-specific innovation in the agricultural sector -in the Netherlands- be described briefly.

The governmental strategy towards the agricultural sector changed considerably in recent years. The focus has more and more shifted towards innovation on firm level and environmental sensible behaviour. For the first time in Dutch history there is in the budgetary plans[1] (in 2012) no explicit chapter for the agricultural sector. The implication is that innovation has, like other economic important sectors, become the most important policy focus point for the government. This is strengthened by the policy focus (innovation) of the Dutch government on agri(food) related business. For

[1] de Miljoenennota

some years now is the intention of the government to stimulate, fiscally, farmers with innovations or innovation plans. Minister Verhagen and the Secretary of State Bleker demand that in 2012 around 15% of the agricultural firms are innovative (Miljoenennota 2012). The problem here is to define innovativeness. According to the government this is if an agricultural entrepreneur is the first adopter of a new technology or belongs to the group of early adopters (Hekkert, 2011).

This goal towards forcing the agricultural sector into a highly innovative sector is quite drastic. According to the plans of Bleker all available funds, of the agricultural budget from the EU, should be -in time- invested in innovative firms. This implies a significant decrease in the income support for 'regular' farmers. Increasing the innovative ability of the sector by diverting the money from the EU to the highly innovative firms is rather difficult to implement. Amongst others because:

- There are many problems with measuring and quantifying innovation. A farmer can be innovative for his own firm, while using relative outdated technology for the sector as a whole.
- Agricultural policy has (very) limited influence on the innovation process. Van Bruchem and Silvis (2008) prove that the increase of the scale of the farms is determined by the increase of the cost of labor and the availability and implementation of new technology and both are considered to be independent of stimulation policies.
- For the smaller and financially less healthy firms it is not possible to innovate that easily. Their competitive abilities and future as a firm are 'hurt' by such 'harsh' policies

Not only are these arguments problematic for the suggested approach of Bleker, there is also a lack of solidarity in the proposal. The agricultural sector has many sub-sectors that vary with respect to innovative possibilities. Horticulturists are for example more able to implement innovative ideas than the 'classic' arable farmers. Demanding that these sub-sectors obtain the same 'innovation result' is not conform reality. Although there are considerable disadvantages with respect to the policy aim of the Ministry of Economic Affairs, is it expected that the agricultural sectors income will be largely dependent on his innovative abilities. It will be a more than considerable task to identify innovation in the agricultural sector. Surprisingly, as mentioned before there are almost no researches done in the Netherlands that try to identify the innovative ability (on a firm-specific level) of the agricultural sector. Diederen (2000), Van Galen en Bunte (2003) en Van Galen en Versteegen (2008) have provided good basic insights in innovation in the agricultural sector. In this thesis I will take the analysis a step further by focussing not only on the aggregate level but especially on the sub-sectoral and especially on farmer specific differences. The main question of this thesis will therefore be:

Which determinants are important for firm-specific innovation in the Dutch agricultural sector?

To be able to provide a satisfying answer on this question will chapter 2 give a general description of innovation. Innovation is a broad concept so it needs some further specification, also some types and categorizations of innovation will be listed. Chapter 3 provides a brief description of the agricultural sector in the Netherlands. First a short description regarding the history of this sector will be given. Further on some general facts and figures will be showed and the most important sub-sectors will be discussed briefly. The size of the economic importance determines which sub-sectors are included.

Given the theoretical framework describes chapter 4 which hypotheses are formulated to provide additional insight regarding the main question. Based upon the available data it is essential to use certain statistical methods and techniques to provide insight in the main question of the thesis; this is done in chapter 5. Chapter 6 describes the outcome of the relevant data and the applied statistical methods and techniques. Chapter 7 is the final chapter and contains a discussion of the results. Moreover it provides answers on the different hypotheses which are formulated for the purpose of finding satisfactory insight with regard to the main question. Also will these insights provide policy recommendations that can be used for the Dutch government to improve their policy toward innovation in the agricultural sector. Finally some limitations and future research possibilities will be put forward.

Chapter 2: Innovation and diffusion

2.1 Innovation in general

The past two decades there is particular attention for the relationship between innovation and economic development. Especially industrialized countries formulated policy objectives in order to promote innovation. These objectives are seen as an indispensable component of technological development and consequently stable economic growth in the long run.

Interestingly, the concept of governmental policies towards stimulation of innovative ideas is advocated since the 18^{th} century. In the early years of industrialization, this was made possible by the introduction of patents and the protection of intellectual property. Economists such as Adam Smith and John Stuart Mill promoted that inventions of individual persons should be protected. According to them this was the only possibility to keep the remuneration and rewards of the innovative idea for themselves. This was the solution, based upon the classical economic theory, for continued economic growth. (Wipo, 2008).

In the last hundred years the technological change in the agricultural sector was also a major factor (Sunding and Zilberman, 1999). Although institutional and governmental influences affected the agricultural sector significantly, is innovation the key element for progress (Cochrane, 1993). Policymakers therefore are since long interested in understanding the concept of innovation; which is difficult due to the diversity of economic literature available on this subject. The impact of innovation on the economy and consequently the impact on the competitiveness of individual firms a countries is broadly accepted. The 'founding father' of the modern innovation theory is Joseph Schumpeter. He was one of the first economists that combined in his theories economic growth with entrepreneurial activities. In his theories he describes that (economic) growth is a consequence of the continuous process of new innovations that replace existing innovations. This process is called 'creative destruction'. Basically the effect is that the technological level is continuously improving and consequently innovation is a necessity for economic progress. However in the process of creating value, there is also a loss in value, because the intrinsic value of the outdated innovation is partially lost. Luckily it is not a zero-sum-game and the benefit for the economy in general, in the long run, is positive. Along the way the importance of small business economics was accepted. Brock and Evans (1989) focus also on the importance of small firms for the growth of the economy and the innovation 'output' in a country, which essentially all has originate from the work of Alfred Marshall (1890) regarding advantages and disadvantages of small businesses. We have established that innovation is important for economic growth; however we have not defined the concept of innovation, which is essential to take as a starting point for the further analyses of this thesis.

There is a large variety of definitions of innovation. Kotler and Keller (2006) provide the following definition: '*innovation is any good, service or idea that is perceived by someone as new.'* It is no surprise that this is rather broad and does not provide much additional insight besides the fact that an innovation is 'subjective'. So it depends on the economic actor how the (possible) innovation is perceived. This definition is somewhat limited to use as a starting point for further analysis. King and Anderson (2002) provide a more narrowed description with respect to innovations: *"a new introduction for a specific social setting, aiming to realize specific advantages, in which the aim of the introduction and where the advantages of the newness are deliberate and 'profit driven'.* Important to realize is that the level of analysis of an innovation can vary. Innovations can be assessed on a firm-specific, sectoral or national level. This depends on the reference of the measurement of the innovation. The definition used by the World Intellectual Property Organization (WIPO) in 2008 is: *'the stream and implementation of new ideas, products and processes that are used to improve conditions of life and efficiency of production.'* Here we also see that the benefits of innovation are not solely profit, but it can also be an improvement in 'conditions of life'.

Further we need to realize that there is a significant difference between an invention and innovation. (Fagerberg, 2005). Invention is the first occurrence of an idea for a product or a process, while innovation is the attempt to carry out the invention in practice. Both concepts are closely linked, so distinguishing them can be hard.

Basically we can conclude three things on the above definitions:

1. Innovation is subjective and how it is perceived depends on the specific situation/person.
2. There are different levels of innovation analysis. It can vary between geographical areas. An innovation in country A, is maybe long outdated in country B. But it can also

vary between economic activities. A regular used product in one industry, maybe can make a significant difference (and is therefore innovation) in another industry. An example in the agricultural industry is the use of specific computer systems in horticulture, while for high-tech industries in e.g. Silicon Valley these systems would be almost archaic. In paragraph 2.3.3 will this be discussed more in-depth.

3. Innovation, in the long run, beneficial for economic growth in general but also for an individual firm. This can imply more direct profit, a reduction in costs of higher levels of efficiency which eventually will lead to higher profits.

2.2 Types of innovation

The broad definition(s) mentioned in the previous paragraph make it essential to categorize innovation according various criteria. The first categorization is made by the OECD[2]; product innovation, process innovation, organisational innovation and marketing innovation. First, product innovation; it is a strongly improved product or service or a completely new-to-the-market product. Take for example a new conveyer belt on a harvester that increases production by 10%. It is no requirement that it is physically touchable; also improvements of services can be product innovations.

The second type is a process innovation; which are implemented improvements or new elements in the production process, which lead to a more efficient production process.

Also organisational innovations can be distinguished. Basically this type of innovation is an implemented improvement of the strategy or the organisational structure of the company. The fourth category is marketing innovation. This is an implementation of new methods to improve selling conditions of a specific product. The properties of the good or the service are not altered, however the way a product is promoted, packed or priced is changed.

Important to realize is that there can also exist hybrid types. So a product innovation could also be a process innovation or a organisation innovation could also influence the marketing innovation. Consequently is thinking in rigid categories not desirable, innovation is a dynamic concept also with respect to its categorization.

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[2] < http://www.oecd.org/document/10/0,3746,en_2649_35845581_40898954_1_1_1_1,00.html>

2.3.1. Technological versus non-technological innovation

Van Galen and Verstegen (2008) emphasize the difference between these two sub-types of innovation. Product and process innovation can be categorized as technological innovation, while organisational and a marketing innovation are considered as non-technical innovations. The main difference between the two is that the non-technological innovation is more or less a 'social' innovation. Meaning: applicability on non-physical goods and services. Administrative and managerial innovations, e.g. Kaizen costing (Hilton, 2008) are examples of how innovations can be non-technological. Further examples are related to the way how people are monitored or how customer relations are managed. On the other hand there are the 'traditional' technological innovations. There are numerous examples that can be made such as making a new medicine (product innovation) or creating a more efficient production line by developing a new machine (process innovation). Important to realize is that the difference between technological and non-technological cannot be made that easily. Take the example of a new strategy of customer relationship management. It can have a non-technological component, because new methods of the division of customers between the salespersons are made. But it can also be technological, because a new computer programme needs to be developed in order to make the division possible. This is just a simple example to illustrate that making a difference is not that easy. Innovations (all types) need to be analyzed is several dimensions. Sunding and Zilberman (1999) make a distinction with respect to the goal of the innovation. Van Galen and Verstegen (2008) take the context of the innovation explicitly into account.

2.3.2 The impact of innovation

One of the most important contributions of Schumpeter is his classification of how radical an innovation is (Freeman and Soete, 1997). There are three important types according to Schumpeter (1934): incremental and radical innovations.

Incremental innovations are continuous improvements of already existing technologies or products. A good example is a synthetic fertilizer that is more easily to absorb for plants than its predecessors. Basically this type of innovation consists of 'building on the shoulders' of others. With respect to production processes an improvement of efficiency can be observed, such as increasing the capacity of the machinery.

This is in sharp contrast with radical innovations. These types of innovation completely change the 'economic reality'. These types of innovations are seldom observed, but

when they occur they provide numerous new possibilities an create new markets. In the agricultural sector a famous example is the creation of synthetic fertilizers. Before this innovation famers depended on the manure of their animals, while with synthetic fertilizers they could provide their crops an additional stimulation when the plant required it. Historically this has led to an enormous increase in production.
It is widely accepted that the cumulative impact of incremental innovations is in the long run just as great as radical innovations. (Fagerberg, 2005) However the radical innovations do change the market situation in such a way that in the short run a radical innovation is highly profitable for the innovator, while the incremental innovator does not earn the same 'monopoly' profits. Lundvall et al. 1992 point out that the social changes of a incremental innovation should not be confused with the potential benefit of the innovation. In most cases do radical innovations such as the airplane and the combustion engine require incremental innovations to be successful. Hence are the different types of innovation equally important for economic progress, although their initial impact is different. In modern agriculture there are hardly any recent radical innovations to mention. For this thesis the assumption will be that most innovations are incremental, especially on a firm-specific level.

2.3.3 The context of an innovation

The context of a product is much debated subject in marketing literature (e.g. Kotler & Keller, 2006). Entrepreneurs should always consider if a product is new-to-the-market for the company, for a specific market segment or for the whole economic market (Burns and Stalker, 1961). This way of thinking also emerged in innovation literature, in which it is predominantly called contingency thinking. This theoretical approach emphasizes the importance to distinguish the importance of an innovation of a company within several types of environment. (De Weert-Nederhof et al., 2004). Consequently is it essential for innovation research to ask the question on what level the research is conducted. If the level of analysis is a national level, will this have considerable different outcomes than if the firm-specific level is researched. This research is conducted in a firm-specific context; hence will this have consequences for the interpretation of the innovation concept.

2.4 Motives for innovation

The goal of the Dutch government is, as mentioned, in the introduction to increase the productivity in the agricultural sector by enhancing innovation on the level of the firm. Basically this is an 'open door', because growth can only be realized by technological change / progress (Bruchem and Silves, 2008). The motives for innovation of central governments do not necessarily align with the motives of individual entrepreneurs. In general do entrepreneurs not directly care for the macro economic implications. The individual gains and the gain for the firm are usually more likely to be dominant in the decision whether or not to innovate. Basically there are two important motives.

2.4.1 Cost reductions

Chavas (2001) has proven that this progress is predominantly influenced by the effect of trying to cut on the expenses of the most expensive production factor. In a trade-off between labor and capital in the Netherlands will a farmer choose, in most cases for reducing the most expensive factor which is labor.

The consequence is that farmers tend to buy machines which will increase the productive capacity of the farm. Entrepreneurs tend to buy 'overcapacity', meaning that for an optimal / efficient use of the machine the company should grow. Given economic rational behavior will entrepreneurs continue to invest if the future expected profits are positive. This will lead to a fundamental overcapacity of the production factor capital in the agricultural sector. The incentive for entrepreneurs to innovate will increase (Van Galen, 2006). This can be explained by the fact that producing with newer techniques will give a comparative advantage compared to other incumbents.

The cost reductions can also play an imperative role within the concept of productivity enhancement. For individuals farmers it is (in most cases) beneficial to enhance productivity. When prices for the goods sold are low the motivation for an entrepreneur to innovate increases. For an individual farmer it is not possible to influence the price of a good, this is because of the large number of suppliers. In order to cope with the problem of low prices there is an incentive to increase the productivity and consequently reduce 'average costs of production'. For farmers this is the direct enhancement of productivity quite difficult, because increasing production implies an increase in the number of hectares cultivated, or an increase in the livestock owned. Because of the high costs this will incur, is it more sensible for the entrepreneur to

improve the used production method. If a farmer is successful he can compensate the low prices by a (relative) low(er) cost structure.
The consequence of the above explanations for technological progress in the Dutch agricultural sector, is that the supply grows faster than the demand (De Hoogh, 1985). This influences the entrepreneurial 'reward' for the farmer significantly, because the factor prices for land and cattle do not decrease accordingly. Cochrane (1959) indicates this as the 'conflict' between the individual and de collective interest. This conflict is close to a prisoner's dilemma, because although it is beneficial for the sector to limit supply, the individual farmer has an incentive to increase supply in order to receive additional income.

Van der Meer (1989) describes that there should be an optimal, equilibrium, price level for agricultural goods. However reaching this equilibrium is not likely. If prices are too low there is not enough money for farmers to implement innovations that is necessary to pay for the initial investment, but if prices are too high the sector will not innovate enough which hurts the economic growth potential in the long run. In both cases will there be, due to the 'shake out' of entrepreneurs, a movement towards the equilibrium level. The number of determinants that influence actual prices in agriculture is rather large and cannot be 'perfectly' controlled. External shocks, such as extreme weather conditions, influence prices in such a way that a sustainable equilibrium will not be reached. Silvis (2004) argues that the economic theories, in general, do not include the specific characteristics of the agricultural sector. Consequently the existing models of supply and demand do not fit actual reality.

2.4.2 Increasing and creating market share

In general in economic models is the most important aim for companies to become a monopoly and consequently receiving monopoly profits (Pepall, Richards, and Norman, 2008). The individual agricultural entrepreneur is in general not able to achieve a monopolistic situation. This is because there is a (very) large demand for goods / products and it is physically not possible to serve all consumers with just one supplier. Especially for the arable, dairy and meat farms this is the case. In horticulture and for flower growers this can be different, due to the patenting of specific varieties. However increasing market share is in general not the most important argument to innovate in the agricultural sector. The same holds for creating market share. The likelihood to create a new product variety and be able to reap the benefits of it completely self is not large due to amongst others capital restrictions.

2.5 The process of diffusion of an innovation

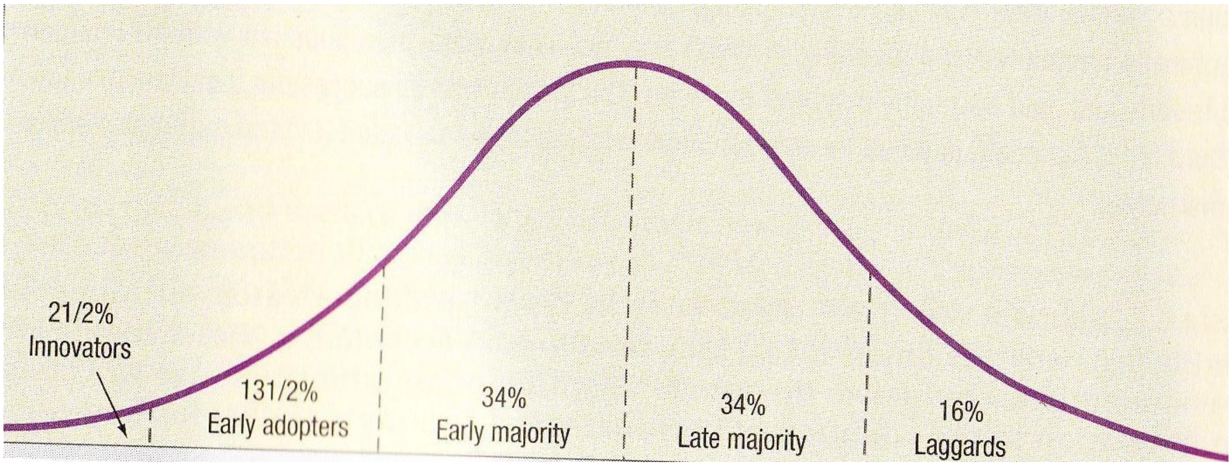
Basically innovation does not "just" emerge. The cases in which agricultural companies are able to invent, develop and commercialize their innovation is limited, compared to the more or less copying of already known innovation. The process of the creation of an innovation and the broad application of it, is called the diffusion process.
With respect to the diffusion of innovations there has been published an abundant amount of literature. Indirectly is the diffusion process also important for this thesis, which will be discussed in chapter 4. First it is essential to obtain basic insight in the diffusion process and the theoretical development of this concept over time.

The basic thought with respect to the diffusion of innovations are so called 'epidemic models'. Basically is technology expected to, in the long run, affect the whole population of prospects (Griliches, 1964). At the start of a diffusion process are there a given number of users of a new technology (Stoneman, 2002). Consequently do users and non-users mix and contact over time. The combination between the number of users, the higher probability of making contact with the technology, and the declining number of non-users lead to a S-shaped curve over time in which then number of users is a proportion of the total number of potential adopters. (Stoneman, 2002). The driving force between the diffusion of technology is the contact prospects have.
The simplicity of the reasoning that making contact was sufficient for people and companies to adopt a specific technology was also its largest pitfall. It is not per se the case that late adopters are late aware of the existence of the technology. Other factors such as economic constraints can also explain the relative late adoption. Although for this thesis the thought of 'infecting' colleagues can be a good starting point for analysis.

Everett Rogers provides in his famous book 'Diffusion of Innovations' an useful addition for the problem of solely indicating 'contact' as driving force behind the diffusion process. Rogers defines the diffusion process as the spread of a new idea from its source of invention or creation to its ultimate users and/or adapters (Rogers, 1962).

In principle, are adopter of innovations categorized in different categories; innovators, early adopters, early majority, late majority and laggards. This is shown in figure 1.

Figure 1: types of adopters based upon the theory of Everett Rogers (1962)



Source: Kotler and Keller, 2006 p. 659.

Adopters of a new technology consider in general five different steps (Rogers, 1962; Kotler and Keller, 2006):

- Awareness, first contact with the idea of the innovation. Basic information is lacking and possibilities and constraints are not known for the future adapter.
- Interest, the period in which information is gathered
- Evaluation, the prospect considers if the possible innovation has added value compared to other possibilities. Constraints are especially considered in this stage. Most innovations fail in this stage, due to a limited financial gain.
- Trial, if possible trying out the innovation for a limited time. Usually this stage is not applicable in the agricultural sector.
- Adaption; the final decision whether or not an innovation is implemented.

Every innovation that is implemented does follow more or less these steps. Compared to the epidemic model this largely increases the factors that play an influence with respect to the diffusion process. Further are variables within the organizations environment, the organization self and the direct social environment of the entrepreneur, factors that potentially influences the adoption of innovations (Kotler and Keller, 2006).

2.6 Conclusion

Innovation is the catalyst for economic progress and growth. Although some value is destroyed in the process of innovation (creative destruction) is the effect on the long run positive. A problem with innovation is that the concept is broad and there is a multitude of definitions available in the literature. As a starting point can the perception of newness of a good/service be perceived as innovation; however this definition is too broad in order to interpret easily in a research context. The definition used by the World Intellectual Property Organization (WIPO, 2008) is more appropriate: *'the stream and implementation of new ideas, products and processes that are used to improve conditions of life and efficiency of production.'* Three considerations are important. Innovation is subjective, there are different levels of innovation analysis and innovation is in the long run beneficial for the economy. Important is the difference between an invention and innovation; invention is creating an idea and innovation are the actual operations to carry the idea out in practise.

Innovation can be categorized in four main groups: product, process, organizational and marketing innovation. Important to realize is that hybrid innovations are likely. Many innovations can be categorized in more than one group at once. Further are there some additional considerations regarding innovation. It is possible to distinguish technological and non-technological innovations. There are different levels of impact of innovation; radical and incremental. Radical implies that the economic market is changed completely and a new market is created; a clear agricultural example is synthetic fertilizer. Incremental innovations are improvements of already existing technologies and do not change the market situation that radically. Innovations can also vary with respect to their context. Three major scales of analysis are considered: firm-specific, new-to-the-sector and new-to-the-market. This thesis will predominantly focus on the firm-specific level of innovation.

Consequently can companies have different motives for innovation. The most important are reducing costs, enhancing productivity and increasing / creating market share. Although companies can have clear motives for innovation they will not always be the first developers of that innovation. If they adopt an innovation on a later time than the first company they are part of the diffusion process. For this adaption process there are some important characteristics to distinguish. First should companies have contact with other companies or people. Second do they generally take five steps before adopting an innovation: awareness, interest, evaluation, trial and adaption.

Chapter 3: The agricultural sector in the Netherlands

3.1 The history of the agricultural sector

The total factor productivity of the Dutch agriculture increased at an annual average rate of approximately 3 per cent in the latter part of the 20^{th} century (Diederen, 2002). This is an impressive achievement and could not be accomplished without the 'right' economic ingredients. A brief description of the agricultural sector and its technological progress from the beginning of the 19^{th} century will show the origin of this impressive factor productivity growth. The focus is solely on the Dutch agricultural sector. The rationale behind this is that the development and the relative importance of the agricultural sector vary from country to country due to structural differences. There are three factors that explain these differences; climatological situation, difference in technological diffusion and governmental attitude (Van Zanden, 1985). Consequently does every country has its own development path, hence is the situation with respect to the Netherlands more or less unique. I do not have the intension to describe the whole history of the Dutch agricultural sector, because this would not fit the subject of this thesis. However to be able to understand observed differences in firm characteristics is it important to have (basic) insight in the history of the agricultural sector.

3.1.1 The development of the agricultural sector at a glance

The first steps towards a "modern" Dutch agricultural sector are made in the early 16^{th} century. In principle was the Netherlands divided into three important agricultural areas (Van Zanden, 1985):

I. The southern part consisting of modern Belgium, Limburg & Brabant and Zeeland. Due to the development of the Flemish cities was the degree of urbanization high, also overall levels of production output were high (De Vries, 1976). The regular arable activities, such as growing wheat and the growing of livestock for meat, wool and leather, were dominant in this area. This initial market situation lead to a relative intensified agricultural sector, leading to a -in comparison to the other areas in the Netherlands- a large(r) scale of production. The first innovations with respect to crop rotation and product specialization were observed in this area.

II. The eastern and northern part of the Netherlands. In this area was, because of the low population size, the agriculture relative extensive. Animal breeding was common and most arable activities were for own consumption or the immediate surroundings of the farm (same village. Caused by a low 'population pressure' has the agricultural sector in this area been backward with respect to scale and production output compared to the other regions (De Vries, 1980).

III. What we nowadays consider as Zuid- & Noord Holland is from the 16th century on the most important agricultural area in the Netherlands. Due to the close vicinity of large cities the agricultural sector thrived, as the Dutch prosperity skyrocketed in the 17th century. Irrigation and reclaiming land on the sea were the main drivers of continuous production increase and intensification. Stable sources of capital, from the merchants of the most important trade cities, lead to relative high investments in the agricultural sector.

These investments were made in order to improve production processes and techniques (Van der Wee and Van Cauwenberghe, 1978). Consequently was the 'beating heart' of the technological progress of the Dutch agricultural sector in the post-medieval time in the area of present Zuid & Noord Holland.

From the 17th century on has the agriculture in the coastal provinces developed towards market production by specialization, intensification and acquiring new fertile lands by reclaiming them on the sea. The opposite happened in the east and northern parts of the country. The loyalty towards subsistence production, caused by limited financial means, lead to inefficient growth and limited innovation with respect to cultivation techniques (De Vries, 1976). Around 1800 this resulted in a sharp contrast between the different agricultural areas (Van der Woude, 1972). In the coastal provinces arable activities became dominant, while in the other parts animal husbandry became the dominant focus. It has to be mentioned that soil composition and soil fertility do actually differ between the coastal and inland provinces, however the economic structure (e.g. lack of infrastructure) had more impact in that period of time. In general it can be concluded that the agricultural sector in the coastal provinces, especially in Zuid & Noord-Holland and Zeeland was well developed. The development in what we nowadays call Overijssel, Drenthe, Limburg and Gelderland was backward. Imperative to realize is that this analysis is highly generalized and local deviations were possible.

3.1.2 The progress in the era of industrialization

The regional differences with respect to the agricultural sector were rather large in the beginning of the 19th century. The following figure (figure 2) illustrates this:

Figure 2: Agricultural key figures in 1810 in the Netherlands

	Production*	Labor force**	Labor productivity*
Southern-Netherlands	115	345	438
East Netherlands	80	226	463
Holland & Zeeland	140	215	862
Average of the Netherlands	**114**	**226**	**665**

Source: Van Zanden, 1985
* Value of production in Dutch guilders (f) per hectare
** Labor force in the agricultural sector per 1000 hectares of cultivated land.

Under the influence of technological developments the allocation of land changed. In the inland provinces the allocation of pasture grounds increased at the expense of cropland. In the coastal provinces the opposite effect was observed. Primarily this was caused by the extraction of land from sea and lakes (Kocks and Van der Poel, 1980). Famous examples are the dry milling of polders like the Purmer, Wormer, Schermer and most renowned the Haarlemmermeer; increasing the arable surface considerably. These developments which predominantly took place in Holland and Zeeland caused also a spin-off effect of technological innovations used by farmers themselves. In other parts of the Netherlands the farmers were using less machinery and produced for long time on a smaller scale. This gives rise to the thought, that the agricultural sector nowadays is still predominantly concentrated in the west of the Netherlands. Due to some developments this is not entirely the case. From 1880 till 1910 was the agricultural sector one of structural changes. In the less developed areas specialization increased significantly, which lead to better means of existence and continued investments in that specific sub-sector. The main drivers behind this were the breakthrough of mechanization, a sharp increase in agricultural education and the regular use of synthetic fertilizers (Van Zanden, 1985). Especially this last breakthrough has led to increased opportunities for farmers in the east, north and south of the Netherlands. Basically they had the possibility to overcome the initial disadvantages of soil and concentration of people in their near vicinity. Because of this the agricultural sector converged with respect to adding value for the national and regional economies; while individual entrepreneurs where able to implement innovations and specialize accordingly. When this is put down in a table (figure 3), it is compelling to see that the average production per hectare has increased across all regions and converged considerably as compared to the situation described in figure 2. The labor productivity increased more or less with the same absolute numbers (Van der Poel, 1967). This proves that the 'backward' areas of old have found ways to cope with their disadvantage with respect to labor productivity (De Jonge, 1977).

Figure 3: Agricultural key figures in 1910 in the Netherlands

	Production*	Labor productivity*
Southern-Netherlands	233	729
East Netherlands	238	903
Holland & Zeeland	270	1208
Average of the Netherlands	**251**	**998**

Source: Van Zanden, 1985
* Value of production in Dutch guilders (f) per hectare
** Labor force in the agricultural sector per 1000 hectares of cultivated land.

The conclusion toward the 20th century is that the successful implementation of technology, the use of fertilizers and the continued specialization have led to the observed successes (Van Zanden, 1985).

This is in principle the prelude for the development towards a agricultural sector that is world renowned for its productivity and efficiency (Bieleman, 2000). Interesting to observe is the central position of education and science in the 20th century in the agricultural sector. The Dutch government invested relatively much money to develop a system in which individual farmers where able to reap the benefits from developing, alone or in groups, new varieties of crops. Especially the breeding of plants, flowers and groceries was and still is one of the strengths of Dutch agriculturalists (Bieleman, 2000). Surprisingly most of these activities are done in the areas that were in the 18th century relatively underdeveloped. On the other hand we see an impressive increase in production in the arable area (Minderhoud, 1952). Predominantly this is made possible by the (continuous) improvement of machinery and the implementations of product and process innovation.

3.2 Modern agriculture

As mentioned in the previous paragraph is the improvement of machinery and the development of growing techniques important for the agricultural sector in the Netherlands. Interesting is to compare this statement with actual macro-statistics (figure 4) regarding the Dutch agricultural sector.

Figure 4: Key indicators of the agricultural sector

	1950*	1960	1970	1980	1990	2000	2005	2009
Share in % of GDP	13,1	10,2	5,8	3,2	3,7	2,4	1,9	1,5
Number of jobs (x 1000 people)**	581	499	339	284	294	282	236	218
Production volume (index: 1960=100)	71	100	148	225	274	317	321	n.a.
Cultivated area (in hectares x 1000)	2337	2317	2143	2020	2006	1956	1921	n.a.

Source: CBS Landbouwtelling, LEI-landbouwcijfers & van Bruchem and Silvis (2008)
***** The data in this year are partially based on 1948
** This includes the entrepreneur self, (active) participating family members and hired personnel.

The share in overall GDP declines rapidly throughout the years. The same pattern can be observed with the number of jobs in the sector. Although declining more slowly has the cultivated area become smaller. In contrary, has the production volume increased significantly. The role of intensification and innovation is clearly visible. Van Bruchem and Silvis (2008) also note that the increase in overall welfare is an explanation of the increased production volumes. Due to the higher levels of income are consumers more able to buy food in large quantities, thereby causing increasing price levels. Consequently additional profits created (financial) room for further development in increasing levels of production. The comparative advantage regarding the economic structure of the Dutch agricultural sector and the accumulated knowledge in the previous centuries proved to be a prelude for further development.

The "European influence" is also one that should not be underestimated. The opening of the internal trade boundaries created more possibilities for farmers to export their goods. The increase of the size of the internal market and vis-à-vis better access to other markets proved to be positive stimuli to produce (more) efficiently. In the broad

sense, this has led to an export dependency. Around 75% of the production of the agricultural sector is exported (Van Leeuwen, 2006). Especially with respect to vegetables and flowers are high export ratios achieved.
The Dutch agricultural sector distinguish himself by continuously improving productivity by implementing new technology and developing new product varieties and applications by using communitarian restructuring rules to their advantage. (Van den Brink, 1990). Mainly the entrepreneurs in the horticulture and flower sector proved to be innovative and still these sectors are renowned for their continuous progress. This also holds for the arable farmers that focus on seed potatoes.

EU regulations however posed some problems for the agricultural sector. The increased regulations with regard to soil and water quality lead to production restrictions, especially for pig and cattle farms the legislation with respect to the emission of phosphates the consequences negative. Also the arable sector encountered restrictions in the use of pesticides and fertilizers. All in all this hurts production directly, although for firm-specific innovations this could be a catalyst.

For this thesis will it be interesting whether or not the historical success of the agricultural sector is carried forward; in the sense that specialization and technological implementations are caused by firm-specific innovations.

Further it should be noted that the agricultural sector nowadays is a clear example of a supplier dominated sector (Pavitt, 1984). This implies that the sector is mainly depending on the supply of innovations by industries that are further up in the supply chain, such as seed breeding companies or the petrochemical industry. In general is the agricultural sector divided between numerous small firms that produce homogeneous outputs that are used by food processing firms (Diederen, 2002). The technological progress is therefore partially determined by the setup of the supply chain where the individual farmer is in. In principle do these chains vary between sub-sectors.

3.3 Sub-sectors of the agricultural sector

In the previous chapters is the history of the agricultural sector in the Netherlands briefly discussed. The allocation of the land was discussed along with further specializing towards a specific agricultural activity. Nowadays almost every farmer has one main economic activity, apart from incidentally secondary means of income. This part will focus on the different and most important main activities. Further are there structural differences with respect to land use; capital and/or labor intensity, but most importantly regarding the principle economic activity.

The following paragraphs will describe the most important sub-sectors of the Dutch agricultural sector. Every sector will be briefly discussed and where possible key statistics will be provided. Further, are likely innovation methods discussed briefly; because, this is an important "overture" towards the results part of this thesis. Data from the CBS (Central Statistics Office) and the LEI (Agricultural Economic Institute) published in the Land- & tuinbouwcijfers[3] 2011 and in editions from previous years play an important role. The typology with respect to the different sub-sector is only partially based upon the Standard Output (SO)-measure.[4] This is a measure used by the EU to make agricultural statistics comparable between countries. The problem by using this classification solely is that the characteristics of certain sub-sectors are too aggregated or too specific. Some of the Dutch sectors, such as the flower horticulture are significantly larger than in other EU-countries, hence is this not a specific category. It is necessary in order to provide sufficient insight in the Dutch agriculture, to deviate partially from the SO-measure. However the main groups of the SO-system are being used and will provide the basic framework of analysis. For quantifying purposes the NSO-codes are put down in the reference of every sub-sector. NSO is a specific typology that is used in the Netherlands to classify each (agricultural) sector in a certain sub-group. Up to the publications of the Land- en tuinbouwcijfers of 2010 the NEG-typology was used. Hence are there possibly some measure differences, this will be, if relevant, clearly stated.

3.4 Arable farming

Arable farming is the totality of economic and agricultural activities involving the process of adapting the natural environment for the production and using of plants and biomass. The actual growing and nurturing of the plant falls also under this concept.

[3] Figures explicitly gathered for the agricultural sector.

[4] The first harmonization attempt was the Commission Decision 85/337/EEC on 7 June 1985, at that time the SGM (standard gross margin) was used.

The main purposes of arable farming are providing input for food, fuel, (animal) feed, fibres and mineral reclamation. Arable farming together with keeping livestock are seen as the archetypes of agriculture. This is reflected in the number of arable farms:

Figure 5: Number of firms in the arable sector

Year	2000	2005	2007	2008	2009	2010
Number of firms	14799	13060	12144	11857	11660	11962

Source: Land- en tuinbouwcijfers 2011, 2006;
NSO: 1500, 1601, 1602, 1603 & 1604

The number of farms is not evenly distributed across the Netherlands. In paragraph 3.1 a description is provided with respect to the history of the Dutch agricultural sector, hence is there a difference between the allocations of land on a regional level. This difference is mainly caused by the soil specification and the availability of minerals in the soil. In the Netherlands the number of arable farms varies significantly across provinces:

Figure 6: Number of arable farms in 2010, relative differences per province

Province	Total number of farms	Total number of arable farms	Percentage (in %)
Flevoland	1868	1453	78,0
Zeeland	3210	2499	77,9
Limburg	4739	2457	51,8
Groningen	3309	1551	46,9
Friesland	5690	740	13,0
Utrecht	2866	212	7,4%

Source: Land- en tuinbouwcijfers 2011

Based upon the previous figure it makes sense that for other subsectors the distribution of farms is also rather unevenly distributed. In principle this distribution has no direct effect on the innovation capabilities of the farms. For arable farms are direct connections to colleagues, which is likely if there is a high intensity of firms in a province, of limited importance for innovation (Diederen, 2002). Another factor that can influence innovation are the crops that are grown, and consequently the possible product innovation that result from this.

Figure 7: Important crops for arable farmers in the Netherlands in 2010

Crop type	Area in 2010 (x 1000 hectares)	Added value in 2010 (€ x mln)
Silage maize***	228,8	542
Grain*	218,8	266
Potatoes**	158,3	1277
Sugar beets	70,6	243
Onions	28,9	n.a.
Grass seeds	12,7	n.a
Chicory	4,7	14
Legumes	3,6	n.a.

Source: CBS Landbouwtelling, Land- en tuinbouwcijfers 2011

* includes corn for consumption, barley, winter/summer wheat, rye and oats

** Potatoes do contain seed potatoes, potatoes for consumption and for starch extraction

*** including hectares farmed by livestock farmers for the sole purpose of providing maize for their livestock

Interestingly are several of the most important crops grown by Dutch arable farmers of low financial value. Silage maize, grain and grass seeds are in general low-priced commodities. The average price of a kilogram of wheat, with average specifications, fluctuated around 10 eurocents in 2009 and peaked with 20 eurocents in 2011 (Landbouwcijfers, 2011). Simple math will lead to the conclusion that with an average of around 9 tons per hectare the financial profit, and hence the available funds for innovation, are (very) small. Basically the added value of arable farms is quite low. The implication for innovation is, that it -in general- innovation will aim on reducing costs and improving productivity. Further are innovation investments expected to be limited, so only (small) incremental innovations will be made by arable farmers. The costs of buying or renting additional land are also limiting for innovation, because these costs are in Netherlands high. At the moment up to 72.000 euro's a hectare[5] or around 1200 euro's for renting a hectare for a year. This constraint of expanding the principle mean of production (land) and the low returns on products lead to an expected low level of innovation in the arable sector.

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[5] The highest average price for 'regular' arable land in 2010 is paid in the IJsselmeerpolders: € 72.228.

3.5.1 Horticulture: in general

Horticulture is a type of intensive cultivation in which on a commercial basis various vegetables, flowers, plants, bulbs and seeds are grown. The Netherlands is especially world-renowned for its export of bulbs, flowers and qualitative vegetables. In 2007 the overall value of exported horticulture products exceeded 15 billion euro's. The added value of this sub sector is hitherto one of the largest of the Dutch agricultural sector. According to the NSO-typology there are two major distinctions: horticulture in greenhouses and outdoor horticulture. This differentiation has important implications for the use of land, the choice of commercial products and consequently the type(s) of innovation that can be expected.

3.5.2.1 Greenhouse horticulture: vegetables

Greenhouse horticulture is frequently named 'horticulture under glass' and is relatively capital intensive. Two types can be distinguished: temperature regulated greenhouses and non-temperature regulated greenhouses. The main difference is the structural regulation of temperature and is determined by the characteristics of the vegetable the individual horticulturist grows. The following vegetables have an area of production of at least 100 hectares in 2010: tomatoes, cucumbers, strawberries, paprika and eggplants. The small scale of these types of horticulture is partially determined by the construction costs of new greenhouses. The setup costs are around one million euro's per hectare. The allocation of land is usually not that large, so the allocated land is used intensively. For example: horticulturists who grow tomatoes as only economic activity in 2010 have 4,52 hectares under glass, while this for cucumbers is 2,41 hectares. In comparison to the arable sector this average size is rather small.
The high start-up costs have led to relative low number of firms, which is shown in following figure:

Figure 8: Number of greenhouse vegetable horticulturists in the Netherlands in 2010

Year	2000	2005	2007	2008	2009	2010
Number of firms	2511	1803	1549	1418	1303	1257

Source: Land- en tuinbouwcijfers 2011, 2010;
NSO: 2111

A sharp decline of the number of vegetable horticulturists can be observed. This is mainly because of structural low prices for the products and increasing competition from greenhouse horticulturists in the eastern and southern part of the European Union. The rationale behind this is that, in general, the costs of production are lower in more Mediterranean countries. Obviously the consumption of energy is lower and behind the former 'Iron Curtain' are the labour costs considerably lower. Both lead to relative lower production costs and consequently competition disadvantages for Dutch vegetable horticulturists. Probably this influenced the innovation behaviour of vegetable horticulturist. With competitors across Europe who have -on average- lower costs of production it is essential for the continuation of the firm to innovate. Especially in terms of product specialities, cultivation novelties and optimization the growing process can horticulturists distinguish themselves. Innovation is consequently an absolute necessity for this type of entrepreneurs. In recent history there are numerous examples of innovation, such as the 'snack tomato' which is a small sized tomato with the unique tomato look and flavour, but has a snack size. Further the efficient use of the heat of the earth for reducing energy costs and the use of bacterial substrates to fasten the speed of growing and increasing the yield of a single plant.

3.5.2.2 Greenhouse horticulture: flowers and plants

The Dutch flower industry is one of the most famous of the world. Two sectors can be distinguished; growing flowers which are grown in greenhouses and flowers growing in the open air. The latter group will be discussed in the next paragraph. The Dutch flower horticulturists are especially renowned for growing high-quality roses, orchids, chrysanthemums, lilies and gerberas. All across the globe are the Dutch flowers sold to numerous customers. The fame of this industry is established by the continuous development of new flower and plant varieties, in which this industry successfully succeeded. This success resulted in more flower & plant horticulturists than vegetable horticulturists.

Figure 9: Number of greenhouse flower horticulturists in the Netherlands in 2010

Year	2000	2005	2007	2008	2009	2010
Number of firms	4962	3830	3299	3099	2849	2494

Source: Land- en tuinbouwcijfers 2011, 2010;
NSO: 2121 & 2122

The same pattern as for the vegetable counterparts is observable; a sharp decline of firms. In principle are the arguments the same, provided that the competition outside the European Union has increased significantly. With respect to flowers are growers in Africa causing lower selling prices for Dutch flower horticulturists. The innovation of this sector is mainly with respect to continuously improving and developing varieties of flowers. New flowers that have specific new, unique, colour characteristics or are immune for certain illnesses are the 'holy grails' for individual horticulturists. Innovations with respect to optimization of the growing conditions for flowers & plants are also widespread.

3.5.3 Outdoor horticulture

In contrast with the horticulture under glass, is outdoor horticulture in the open air. The consequence is that products with specific climatological requirements such as tomatoes and paprika are not part of the crop rotation of Dutch outdoor horticulturists. In principle there are three main groups of outdoor horticulturalists: growers of field vegetables (such as lettuce, broccoli, beans and spinach), tree & plant nurseries and flower (bulb) growers. The total number outdoor horticulturist is surprisingly higher than the number of greenhouse horticulturists (vegetables and flowers combined). S

Figure 10: Number of outdoor horticulturists in the Netherlands in 2010

Year	2000	2005	2007	2008	2009	2010
Number of firms	6197	5199	4909	4786	4650	4465

Source: Land- en tuinbouwcijfers 2011, 2010;
NSO: 2210, 2221 & 2320

However the aggregated group is too diverse to estimate innovation behaviour, so a further description is necessary.

The group of field vegetables growers is rather difficult to define, mainly because regular arable farmers frequently have some field vegetables in their crop rotation schedule. Consequently they are not explicit growers of field vegetables, but have some characteristics of it. Crops such as butterbeans and Brussels sprouts are ideal for a diversification strategy for an arable farmer. In this research we explicitly speak of main business activity, so the number of vegetable growers is (very) limited in comparison with the actual number of cultivated hectares of outdoor vegetables. The innovation of this group is largely depending on the use of efficient machinery and being able to achieve high quality products. Both product and process innovation are observable, with a focus on product innovations.

Tree and plant growing are often singular economic activities of firms, because it requires specific investments before this cultivation can become profitable. It takes at least three years to reap benefits from a nursery, because the products need to be of sufficient size and quality before they can be sold. This results in a specific industry. Across the Netherlands there are in 2010 in total 2534 nurseries (56,8 % of all outdoor horticulturists). Most of them are located in the provinces Noord-Brabant, Gelderland and Limburg. The soil in these parts of the Netherlands is sandy, which is required for most shrubs, bushes, trees and plants to grow optimally. The average size of a nursery varies between 1,96 hectares for shrub and climber growers and 6,59 hectares for fruit tree nurseries. On average this is small compared to arable farms. Consequently will innovation processes focus on the intensification of the economic activity and trying to achieve higher production, because the available land should be allocated efficiently.
Dutch growers of flower(bulbs) are highly successful and known around the world. FloraHolland, a large farmers cooperative specialized in selling, buying and trading flowers is a company with a turnover in 2010 of 4,13 billion euros (NCR, November 2011). This is an outstanding performance, considering that next to the greenhouse flower horticulturists there are only 1265 farms that have flowers in the open air as main business activity. The most common flowers are tulips, daffodil, lilies and hyacinths. Most of these types are sold as a bulb, instead of the flower. The bulb can be used by consumers to grow flowers themselves or by companies to create a more value adding activity. The daily fresh flower market is not common for outside horticulturist. The 23.347 hectares which are allocated for growing flowers are mostly for selling the bulb. Only 2543 hectares, roughly 10%, is used for selling the actual flower. Innovation in this sub-sector is expected to be high, because (inter)national competition is high and growers have to satisfy consumers’ needs for new varieties.

3.6 Fruit farms

The fruit sector in the Netherlands traditionally focusses on growing apples and pears; 90,9% of all the fruit farms grow these types of fruits (2010). The total number of fruit farms is rather limited as is shown in the following figure:

Figure 11: Number of fruit farms in the Netherlands

Year	2000	2005	2007	2008	2009	2010
Number of firms	2336	1857	1778	1701	1682	1698

Source: Land- en tuinbouwcijfers 2011, 2007
NSO: 3610
***vineyard companies (NSO: 3500) are excluded, due to limited size (47 companies in 2010)**

Around 51% of all fruit farms can be found in the provinces of Gelderland and Zeeland. This geographic clustering is because the soil quality in parts of these provinces is ideal for this type of cultivation. Traditionally there is high level of knowledge available in these areas, due to spill-over effect of the accumulated experiences of the fruit farmers. This can also be observed by the available knowledge of institutions. The cooperative Rijnvallei (situated in Gelderland) is in the group of Cropsolutions (a platform of farmers' cooperatives for exchanging knowledge) the leading institute for sharing knowledge and agricultural cultivation advices. This specific knowledge is important, because the change in cultivated fruit varieties is not large (as can be seen in the following figure). It should however be noted that the change in varieties is rigid, because before a new orchard is up-and-running it takes usually at least three years. The reported changes such as the decrease in Jonagold apples from 28,6% to 17,5% 'market share' is therefore, relatively, in five years quite large. Consequently is this an indication of a presence of innovation. Changing to new varieties is a type of product innovation. Innovation with respect to techniques of cultivation is also likely, because the process of harvesting, processing and storing the fruit needs continuously improving. Recent developments with respect to oxygen free warehousing methods are slowly but surely implemented by more and more fruit farmers.

Figure 12: Most common apple and pear varieties (in % of total area) in the Netherlands

	Elstar Apple	Jonagold Apple	Golden Delicious Apple	Goudreinette Apple	Conference Pear	Doyenne du Comice Pear
2005	45,2	28,6	6,0	6,0	73,4	14,9
2010	41,4	17,5	5,4	5,5	73,6	12,1

Source: Land- en tuinbouwcijfers 2011, 2007

3.7.1 Livestock: in general

Together with arable farming is raising livestock stereotype for the agricultural sector. The economic importance of livestock and the (in)direct related activities contribute for around 1,25 % of Dutch GDP (where the direct agricultural contribution is around 0,5% of the GDP and 0,75% is from the processing of the output of the farmers.

In principle there are two categories of livestock; grazing animals and housed animals. The main difference is that if animals are likely to live most of their life inside a stable or cowshed are 'housed', while if animals can frequently go outside such as dairy cows they are called grazing animals. To clearly maintain this difference will paragraph 3.7.2 till 3.7.4 describe the different 'grazing' types. Paragraph 3.8 will describe housed animals and the relevant subdivisions.

3.7.2 Dairy farms

Traditionally dairy farms are wide-spread in the Netherlands and an important agricultural activity. The fact that the largest Dutch cooperative, Friesland Campina, with a turnover of almost 9 billion euro's in 2010 is a dairy cooperative illustrates this economic importance. In absolute numbers are the dairy farmers the largest 'group' in the Dutch agricultural sector. Of the total number of farmers left in the Netherlands is in 2010 around 25% a dairy farmer. The provinces Friesland, Overijssel, Gelderland and Noord-Brabant contribute for almost 64% of the total Dutch dairy farms. So regional clustering is observable. Most likely this is caused by the fact that the land was in the early days of Dutch agricultural too difficult to cultivate with traditional arable methods. Consequently was the allocation towards grassland the most sensible economic move.

Figure 13: Number of dairy farms in the Netherlands

Year	2000	2005	2007	2008	2009	2010
Number of firms	23280	19713	18208	18007	17815	17519

Source: Land- en tuinbouwcijfers 2011, 2010
NSO: 4500

The number of firms is decreasing over time; however the number of dairy cows shrinks only slightly. This observation implies a significant up scaling of the different dairy farms.

Figure 14: Number of dairy cows in the Netherlands

Year	2000	2005	2007	2008	2009	2010
Number of dairy cows (x 1000)	1504	1433	1413	1466	1489	1479

Source: Land- en tuinbouwcijfers 2011

In the period from 2000 till 2010 we see a decline of dairy farms of 24,8% while the number of dairy cows in the same period decreases with 1,7%. This can be explained by the monetary certainties caused by quotas of the European Union. The dairy sector is one of the most regulated sub-sectors of the agricultural sector. Although milk quota will be abolished with the next revision of the European Market Regulations in 2015, is the certainty for a stable milk price for farmers nowadays assured. This certainty does imply that dairy farmers can more easily 'calculate' whether or not they should innovate or increase the number of animals they keep. In other agricultural subsectors is the price certainty, apart from fixed contracts, much more limited. Innovation will therefore be much more focusing on working more efficient, decrease costs and increase quality. Mainly because producing more or expanding production capacity involves buying additional rights of production. These costs should be considered before production increasing innovations are introduced, so other motives of innovation are expected.

3.7.3 Cattle farms

In contrast with dairy farms, where cows are 'producing' the output, is the product output of cattle farms the cow itself. In principle do cattle farms sell young-stock and other fatting calves, for meat. Most cattle farms are located in Gelderland, Noord-Brabant and Overijssel.

Figure 15: Number of cattle farms in the Netherlands

Year	2000	2005	2007	2008	2009	2010
Number of firms	11069	9471	9507	9167	8869	8967

Source: Land- en tuinbouwcijfers 2011, 2006
NSO: 4611 & 4612

Again we see a pattern of a decreasing number of farms in this subsector. Interestingly has the number of cattle grown recent years. Especially fatting calves are increasing in numbers, while young-stock has decreased in absolute terms. This is caused by the shorter period of time that is required before the fatting calves can be sold; this higher turnaround increases the earning capacity. So choosing for fatting calves is a sensible economic decision, with in general low production conversion costs.

Figure 16: Cattle in the Netherlands

Year	2000	2005	2007	2008	2009	2010
Fatting calves (x 1000)	783	829	860	899	894	928
Young-stock (x1000)	284	230	216	221	216	207
Total (x 1000)	1067	1059	1076	1120	1119	1134

Source: Land- en tuinbouwcijfers 2011

The shift from young-stock towards fatting calves could be a driver for innovation. In a transition process can farmers be more lenient toward changing already existing production methods and processing methods. Further is product innovation with respect to the output (the calves) expected to be limited. Most of the innovation will be in the actual production process, e.g. feed compositions, application of natural growth accelerators and other production optimization innovations.

3.7.4 Sheep, goat and horse farms

The remaining three groups of important grazing animals are sheep, goats and horses. In the Netherlands are these types not dominant with respect to the principle source of income for a farmer. This can be illustrated by the number of sheep per farm:

Figure 17: Number of farms with sheep in various categories in the Netherlands

	1-20 sheep	20-50 sheep	50-100 sheep	>100 sheep
2000	5039	4839	3955	3741
2005	3762	3521	3243	3834
2007	3672	3172	3146	3823
2008	3866	3366	3106	3229
2009	3793	3258	2803	2979
2010	3541	3496	2962	2872

Source: Land- en tuinbouwcijfers 2011, 2009

According to the actual market prices of wool, lambs and sheep was it in 2010 not possible for farms with less than 85 sheep to earn enough money (compared to a minimum wage level). In general is the group that have less sheep considered is keeping sheep for their hobby or for the purpose of earning additional money in the winter period. Arable farmers have in general not much work to do in the winter, because growing seasons are usually from March until October (except for winter wheat). So in the intermediate period is keeping sheep interesting to earn additional income. In contrary is keeping goats more of a unique economic activity; however the number of goats in the Netherlands is not even one/third of the total number of sheep. 353.000 goats are kept by 3719 firms (2010). The economic importance and weight of this sub-sector is limited, this is mainly because the value of the goat products are low compared to cattle and sheep output.

The last sub group of grazing animals are horse farmers. Up to approximately the 1960's was the horse the most important 'tool' for a farmer. The necessary horsepower for ploughing, sowing and travelling were indispensable for farmers. In recent years has the role of the horse changed considerably. Where farmers in the old days bred their own horses for own utilization, are there now farmers that keep horses for private persons in order to earn money. Some do this on a large scale and have large horse stocks. However it is difficult to identify this group and distinguish the farmers from "civilians" that keep horses (non-)commercially.

Figure 18: Number of farms with horses in various categories in the Netherlands

	1 horse	2 horses	3 horses	4 horses	5 horses	> 5 horses
2000	4714	2985	1555	893	546	2153
2005	3539	2593	1532	870	588	2561
2007	2992	2327	1398	914	559	2580
2008	2832	2234	1421	861	565	2917
2009	2810	2147	1349	923	579	2901
2010	2369	1842	1311	813	570	2823

Source: Land- en tuinbouwcijfers 2011, 2009

Innovation of sheep, goat and horse farms are difficult to interpret, hence will the focus of this thesis be on the aggregation of dairy, cattle and 'other' grazing animals. This provides better insight in the innovation behaviour of this subgroup, as can be read in chapter 5, then making a further distinction.

3.8.1 Poultry

In the previous paragraphs the "grazing" animals category is enumerated on, in this and the next paragraph will the "housed" animal category be discussed. There are in general two different sub-categories: poultry farms and pig farms. The economic profitability of this sub-category as a whole is low, although there are structural differences between the two types. For some years have both poultry as pig farmers been confronted with low prices and consequently are the numbers of farmers plummeted.

The sub-category poultry farms can be divided into two main groups: laying-hens and broilers. In principle are laying-hens kept for the eggs and broilers for meat, the production methods of these two differ considerably. However because of the limited number of farms that earn at least two third of their income with poultry is chosen for an aggregation of these two types. Also the category 'other poultry' is included in this statistic. Various animals such as turkeys, peacocks and geese are also grown commercially, however in that small numbers that they are included in the overall number of poultry farms.

Figure 19: Number of poultry farms in the Netherlands

Year	**2000**	**2005**	**2007**	**2008**	**2009**	**2010**
Number of firms	2274	1772	1790	1678	1629	1656

Source: Land- en tuinbouwcijfers 2011, 2006
NSO: 5211, 5221 & 5231

Clearly is the number of poultry farms rather small in the Netherlands, however it should be noted that there are farms that have "some" poultry. In 2010, 2431 farms kept to some extent (less than 2/3 of the farms main income earned by poultry) commercially poultry. The overall number of poultry has not declined that much over time, because in 2000 there were 104.015.000 animals kept by farmers. In 2010 this was 101.248.000 animals. In 2003 the number of animals plummeted to 79.235.000, caused amongst others by veterinary diseases such as the bird flu and the imposed destruction of animals in specific areas. All in all the profitability of keeping poultry commercially is marginally. In 2010 the profitability of an investment of 100 euro's was 0,96 for broilers, and exactly 1,0 for laying hens. Based upon these observations will the expected innovation of this subsector be quite low.

3.8.2 Pig farms

The second 'group' of housed animals are the pig farms. Originally this is an important sector for Dutch agriculture, mainly because the Netherlands had a good infrastructure for processing and commercializing pig meat. The fact that the slaughter cooperative Vion has a turnover of around the 9 billion euros and began its activities in the pig slaughter industry shows the size and economic possibilities of this activity.

There are two main economic activities regarding pig farming; fatting pigs and breeding sows. The first category consists of pigs that are bred and fed for the meat industry. Breeding sows are the female pigs that are being kept by farmers to breed as much as possible offspring. Farmers of this second category do not solely sell their young piglets to the meat industry.

Both pig farmer categories are aggregated in the following figure:

Figure 20: Number of pig farms in the Netherlands

Year	2000	2005	2007	2008	2009	2010
Number of firms	7667	5582	5224	5028	4733	4514

Source: Land- en tuinbouwcijfers 2011, 2006
NSO: 5111, 5121 & 5131

The overall number of pig farms has decreased significantly; with 41,1%. At the one hand this is caused by a low profitability of this sector; on average, from 2005 until 2010, 0,9033: implying a negative return on investment. In the long term this is for farmers financially unsustainable. This low profitability has many causes, but two are important. First the outbreak of different contagious animal diseases: because of this numerous pigs were killed for public health purposes. Farmers who suffered this setback were compensated by the government, but many of them decided to stop their activities completely. This was stimulated and made possible by, for quitting farmers, advantageous regulations such as the 'ruime voor ruimte' initiative of the Dutch government. The rationale behind this was to reduce the number of pig farms, because of a negative public opinion regarding an intensive pig farming industry in the Netherlands. Further it was a good possibility to regulate and reduce certain manure emissions, such as phosphate and methane. That is also an overture for the second main reason for the overall decline of this subsector. The strict EU-regulations regarding particulates and the emission of manure has led to high investments in proper stables. These high investments where rather difficult to make and consequently many pig farmers gave up their business. Given the decline in the number of pig farms and the low profitability is the expected innovation rather low. Although farmers need to meet to the strict regulations, and in that context have to innovate are financial constraints causing low innovation levels.

3.9 Hybrid types

In principle do farms belong to a specific NSO-code if at least 2/3 of the total income is earned with a specific economic agricultural activity. If for example an arable farmer has 100 hectares and grows 2 hectares of lettuce (outdoor vegetable), it still belongs to the arable category. It makes sense that several farms do not meet the threshold of 2/3. It implies that the firm is a so called hybrid type, implying that there are two main sources of income. Important to realize is that these two types are both NSO-subtypes. When a farmer has an additional source of income such as a caravan storage this is not covered by the hybrid type.

In practice there are two possible combinations: a livestock / livestock combination and a livestock / arable combination. Below it is observable, that in recent years the number of hybrid firms has significantly decreased. The livestock / livestock combination has in the course of ten years decreased with approximately 65%.

Figure 21: Number of livestock / livestock farms in the Netherlands

Year	2000	2005	2007	2008	2009	2010
Number of firms	3069	1876	1576	1365	1194	1072

Source: Land- en tuinbouwcijfers 2011, 2006
NSO: 7300 & 7400

Also the livestock / arable combination decreased sharply with roughly 42%:

Figure 22: Number of livestock / arable farms in the Netherlands

Year	2000	2005	2007	2008	2009	2010
Number of firms	3185	2294	2104	2052	1933	1859

Source: Land- en tuinbouwcijfers 2011, 2006
NSO: 8300 & 8400

Innovation of this type is difficult to estimate, mainly because it depends on the focus of the individual farmer. As can be observed more and more hybrid farmers choose for a specialization towards one economic activity. This implies that the focus of the company shifts. Consequently is the innovation behaviour proportional with this behaviour.

3.10 Conclusion

This chapter provided a short overview of the history of the Dutch agricultural sector.
The 16th century can be seen as the starting point towards the modern agricultural sector as we now it nowadays. The Netherlands could traditionally be divided in four areas in which the agricultural activities where considerably different from each other. Due to the, amongst others, Industrial Revolution have these regional differences been reduced considerably. Further has the Dutch agricultural sector developed itself toward an innovative and successful industry, mainly because a good infrastructure of (agricultural) education and the continuous progress of product and process improvements. This has led to a further specialization of activities and a higher desire for implementing technological advancements on a firm-specific level. Nowadays has the agricultural sector to deal with harsh EU regulations, and with diminishing economic importance in the overall Dutch economy.
Another issue that is addressed in this chapter is the classification of the different (most important) agricultural subsectors in the Netherlands. Based upon the NSO and NEG classifications an overview has been provided regarding the number of farms in each subsector. A farm belongs to a certain subsector if 2/3 of farms income is earned in a specific subsector.

Arable farmers are most often stereotype for the agricultural sector. They occupy themselves with growing plants on acres. Silage maize, grain, potatoes and sugar beets are the most important crops for arable farmers in the Netherlands. Further a strong provincial difference between the numbers of arable farms as a percentage of the total number of farms is observed. Innovation in the arable sector is expected to be rather low.

The second subsector consists of horticulturists. This group can be divided into two main groups: greenhouse horticulturists and outdoor horticulturists. The differences between the two groups are large. First can the greenhouse horticulturists be distinguished into vegetable and flower horticulturists. Both grow their products in a greenhouse. Implying that they large investments before they can produce the desired product. As a consequence is the surface covered by a greenhouse rather small compared to regular arable activities, hence is this an 'intensive' agricultural activity. Both the flower and the vegetable horticulturist are expected to be innovative as this an important requirement for their success as entrepreneur in a sector which is dominated by internal and external competition. The second main group consist of outdoor horticulturists. They grow vegetables, trees & shrubs and flowers in the open air as main products. Innovation is also considered to be high in this sector, because of competition and the possibility of creating an own profitable market share by developing a unique variety.

Fruit farms are the third subsector. Apples and pears are the most important products of fruit farmers. The (small) changes in the varieties of grown fruits give insight in possible innovation. Further is innovation observable in the preservation and warehousing of the fruit.

The fourth and the fifth subgroup consist of different types of livestock. The distinction between grazing animals and housed animals is first addressed. The primary difference between both is to what extent animals are able to go outside. If animals spend no or almost no time of their life in the open air, they are considered to be housed animals.
The 'grazing animals' category' can be divided into different sub-groups. First the dairy farmers, those are the largest group of famers. They occupy themselves with keeping cows for the production of milk. These farmers have quotas with reasonably fixed prices, hence they are able to estimate quite precise their costs and revenues. Further is the production of every dairy farmer maximized (limited) by these quotas.

Consequently will dairy farmers innovate in order to achieve costs advantages. The second subgroup is: cattle farmers. They commercialize the meat of cattle and in recent years has the size of the animals stock grown, while the number of farmers declined. Given the limited capital intensity, is innovation observed regarding improving productivity. Sheep, goats and horses make up the third subgroup. Due to the fact that many farmers have some of these animals on their farm, and the farmers who earn 2/3 of their income with these animals are small in numbers, is an insight with respect to innovation difficult

The housed animals consist of poultry and pig farmers. This first subgroup denotes mainly the laying-hen and broiler farmers. Recent years have been economic difficult for this group, so innovation is almost non-existent in this group. Finally, pig farmers; which is a relative large group of famers. The last couple of years has this subgroup been harassed by low economic profitability and stringent regulations. To be able to meet to these regulations have some farmers ended their businesses, while others were able to meet these strict standards. These farmers are likely to be innovative, hence are the pig farmers considered to be relatively innovative.

Finally as a subgroup the 'hybrid' type of farms. These farms do not have one main agricultural activity where at least 2/3 of the farmer's income is earned with (apart from secondary sources of income). It is difficult to describe innovation behaviour of these farms, because of their structural heterogeneity.

All in all a different pattern with respect to innovation can be expected across the different subsectors. In chapter 4 this observation will be used for developing a hypothesis with respect to the innovation behaviour of agricultural firms and to what extent they belong to a certain subgroup.

Chapter 4: Innovation and agriculture: towards hypotheses

As mentioned in the introduction is the main research goal of this thesis to find out the nature and the extent of innovation in de agricultural sector in the Netherlands on a firm-specific level. The implication of this goal is that it is necessary to find explanations why some agricultural firms do innovate and why some do not. In principle are there many possible influences on the innovation behaviour of a firm. Consequently are choices regarding the research focus essential, given the restrictions of the available data (chapter 5). To achieve a good insight in the different explanatory factors, will the most important exogenous factors of innovation be defined. Based upon this; hypotheses will be made. These can serve as support for the answering of the main question of this thesis. Every paragraph of this chapter will describe an important 'source' of firm-specific innovation. First are some concepts and underlying fundamentals of innovation clarified and defined, further are several examples of innovation in the agricultural sector provided. Both in order to provide a good starting point for the conceptualization of the different hypotheses and as a beginning towards a robust research.

4.1.1 'Creating' versus 'adopting'

Innovation is in many cases the output from a combination of curiosity, extensive research, trial and error and resourcefulness within the context of being entrepreneurial (Diederen, 1996). Not only having a good idea is sufficient, the entrepreneur should also be able to make the idea commercial feasible for himself or other market participants. As mentioned earlier will this thesis primarily focus on the innovation within an individual farm, more or less ruling out the possible influence of innovative spin-offs from institutional organisations. Although this may seem at odds with the practice of innovation in a wide range of other economic sector is it the best approach for the agricultural sector. Due to the earlier mentioned large number of small farms, with almost no market share, is it interesting to see whether or not these firms behave innovative by adopting (new) technology or developing this on their own. Implicitly is the impact of research done by institutions and research centres included in the (possible) adoption process. It is difficult to distinguish if an entrepreneur is being innovative or if he is implementing an already existing technology. Consequently there is little stimulation for entrepreneurial and innovation behaviour for a number of

farms due to the lack of financial means and the proper economic scale to reap the benefits from the innovation. The implication of this is that the innovation progress in the agricultural entrepreneurs can be described as 'of the shelf' innovators (Griliches, 1957). This is because the commercial suppliers of e.g. seeds and fertilizers provide in new technologies that can be applied by individual farmers. Although applicable for the whole sector is it also of importance on a firm-specific level. It is also important to take different innovation contexts into account. It can be the case that for farmer A an innovation is new, while farmer B is already applying the innovation successfully for some years. However both farmers do not know that others use the same innovation. Are both innovators? According to Fagerberg (2005) this is a matter of convention. Schumpeter (1934) indicates that the first adaptor should be seen as the innovator and the other adaptor is an imitator. However the pitfall of this reasoning is that the imitator is for himself also an innovator, because he introduces a product/process into a new context. It can be argued that there is qualitative difference between commercializing something for the first time and copying it and introducing it in a different context (Fagerberg, 2005). The latter does not rule out the possibility of innovation. It can be pointed out that there are many significant incremental innovations made in the process of diffusion. The introduction in a new environment usually leads to new adaptations and applications, which are incremental innovations
Again we see the importance of the scale of analyses. This thesis takes not the innovation for the market as a whole as a starting point, but for the individual farmer. Consequently this is considered as the firm-specific level of analysis.

4.1.2 Examples of innovation on a firm specific level

In order to have a clear image about how innovation is perceived by the different farmers, who are part of the dataset, is it convenient to provide some clear examples of product and process innovation on a firm specific level. This is solely to provide a basic understanding on how innovation is interpreted by most of the respondents. A further distinction by subsector is made in the next paragraph. In principle is process innovation expected to be more widespread compared to product innovation because of less economic investments required for this type of innovation in the agricultural sector (Van Galen and Bunte, 2003). Process innovations can be new more efficient crop rotation schedules, improved monitoring systems for finding the optimal moment for sowing or crop dusting. The use and development of better administrative processes and/or systems are also process innovations. Some farmers also perceive the use of new selling contracts or a change in the use of these contracts as process innovation. A good example with respect to cultivation is the no-tillage farming technique used on areas with high lutum percentages in the soil. This technique is used for quite some years in areas with loess and silt soils. Some farmers have tried (successfully) no-tillage on another soil type. For several years this was seen as impossible, which proved false. Product innovations in the agricultural sector are commonly new varieties of output. This can arrange from new varieties of flowers, vegetables or potatoes. For example are new disk coulters on sowing machines also considered to be innovations of this type. In general are the costs involved in this type of innovation rather high, on average is this type of innovation probably less widespread compared to process innovation.

The list of possible innovations can be inexhaustible. Due to the construction of this research is it essential to realize that innovation is self-reported. The individual perception of a farmer with respect to innovation can cause sub-optimal research results. Although this can be the case is expected and for the purpose of the research assumed, that most interpretations are more or less homogeneous. The data led to no preliminary excluded reported innovations.

4.2 Profitability and innovation

The first hypothesis can be based on the profit of the specific firm. Profit can lead towards less financial constraints for an entrepreneur. This can lead to more available money to invest in new -innovative- initiatives. In principle this is too simplistic economic thinking; farmers are only possible to spend money if they make a profit. The possibility to loan money from banks or attract equity from investors is always a possibility. Both institutions analyse the earning capacity of the relevant firm in order to provide the loan or the equity. So making a loss should not necessarily imply that the firm cannot innovate. However negative profits (losses) are more or less a constraint for innovation, but making a loss can also be an entrepreneurial trigger for individuals to explore other business possibilities in order to make a profit. This can also be of positive effect on innovation. The effect of financial profit on innovation, which is in the literature much debated on, can be ambiguous and varies by entrepreneur. Due to the frequent complex funding in the agricultural sector, because of the high prices per hectare, is a strict approach towards a hypothesis difficult to justify. The consequence is that for this research a more psychological approach has been chosen. Making profit can result in less risk taking behaviour, because entrepreneurs want to 'stay' in the happy mood state based upon the achieved profits (Kahneman and Tversky, 1979). Entrepreneurial behaviour tends on the short run to be aiming for not making a loss, instead of improving business conditions for a better perspective in the long-run. This has a negative influence on risk assessments of innovations. Entrepreneurs tend to over rationalize risk and uncertainty, while underestimating possible benefits and profits (Tversky and Kahneman, 1992). The observed behaviour can lead to lower levels of innovations, due to the association of innovation and risk. Given the motives in chapter 3 it is likely that agricultural entrepreneurs will be more inclined to innovate with losses in their company in order to reduce the financial losses. This may feel at odds with regular entrepreneurial theory, where entrepreneurial activity is seen on the long rung (e.g. Schumpeter, 1934), however due to high levels of debt or dependent of capital of external investors are farmers in principle more short term orientated (Landbouwcijfers, 2011).

Hypothesis I:

Agricultural firms that make a profit are expected to innovate less than firms who do not.

It should be noted that this hypothesis discusses the explicit situation of making a profit from a more psychological point of view (e.g. Baron, 2008; Isen, Means, Patrick and Nowicki, 1981; Wright and Bower, 1992; Einhorn and Hogarth, 1981).

4.3 Firm size and innovation

There are, apart from differences on subsector level, differences between firms with respect to size. The size of a firm can be expressed in an endless number of variables. Frequent determinants of firm size are turnover, number of employees and value of assets. In the agricultural sector there are some specific determinants that play a role: number of animals, size in hectares, output of commodities (such as milk output or tonnage per hectare). Basic economic theory describes that, if the same technology is unlimited accessible for firms, decreasing returns of scale will be observed. Consequently all firms are of the same size, determined by the minimum point of the long-run average cost schedule. Further is entry or exit determined by a change in demand or a change in factor prices (Brock and Evans, 1989). This 'textbook' description is at odds with the agricultural sector. The stylized description of this model of industry is in this sector not possible, due to the fact that the same technology is not unlimited accessible. This is caused by companies down or upstream who only give licenses to certain farmers to use innovations. The licensed use of specific flower bulb varieties is a good example of this phenomenon. The determinant behind this is entrepreneurial ability, which is the ability of an entrepreneur to improve his own firm continuously. By doing so he is creating additional options to realize cost benefits or additional added value. This entrepreneurial ability is discussed more deeply in the next paragraph. Schumpeter's statement that large(r) firms are innovating more than smaller firms has been disputed extensively (e.g. Acs and Audretsch, 1988). Interesting is that Acs and Audretsch (1988) describe the systematic differences of small-firm and large-firm innovations across industries. Due to the fact that the agricultural sector is rather unique with respect to its characteristics is it interesting to investigate whether firm size influences innovation in the agricultural sector.

Hypothesis II:
Small agricultural firms are more likely to innovate than large firms.

This hypothesis is endorsed by the fact that, in agriculture, most firms do not have a substantial market share. Hence are intermediate levels of market concentration which induce innovations not relevant (Brouwer and Kleinknecht, 1998). The fact that an average farmer has a negligible share of the market does imply that considerations of large firms to obtain a 'monopoly market share' are not applicable (Schumpeter, 1934). The incentive of small firms to innovate in order to gain additional benefits is more likely to be large; implying that small(er) firms are more likely to be innovative.

4.4 The legal form of the farm

An important question for farms is whether or not the continuity of their firm is guaranteed. In most cases this is indicated by the presence of a business successor and the legal form of the farm. Usually the successor is a son/daughter or a (young) close relative. If such a successor is present it is likely that the farmer is thinking about the future of the firm, which will increase the likelihood of innovation because of pursuing continuous progress for the farm. This progress is necessary to keep a profitable farm for in the future. The problem regarding business succession is in the agricultural sector relatively high, because the most frequent types of legal enterprises are the husband/wife partnership, parent/child partnership, limited partnership and regular partnership. These types of legal enterprise are dependent of the direct input and contribution of the partners. Based upon Dutch laws is a partnership dissolved if one of the partners dies (article 7A:1683 sub 4 BW). This problem is non-existent for a private company or a limited liability company; however in the agricultural sector these legal types are scarce and mostly only used by large, risk taking, farms (see paragraph 5.2.1). The presence of a business successor is therefore required for a (possible) continuation of the farm. If a farmer is aware that his farm will be sold on a short term, he will not be eager to invest in risky innovation projects. The main argument is that taking the risk is not worthwhile, because he cannot properly reap the benefits of the innovation. Farmers with a successor, regardless in what form, do not have that problem, because their successor is able to profit from the innovation, so the reluctance towards innovation will be lower. In most family partnerships the expected business successor is already participating (with capital, or -most likely- with labour) in the farm. The same as for the family partnership[6] holds for a regular partnership[7]. It should be noted that the explanation above focuses mainly on business succession.

Hypothesis III:

If a farm has a type of partnership as legal structure it is more likely to innovate, compared to a limited liability company.

[6] In Dutch: maatschap

[7] In Dutch: vennootschap onder firma

4.5.1 Characteristics of the farmer: age

It is shown in a research on the age distribution of farm owners in the agricultural sector that the presence of young entrepreneurs is very low (Sotte, 2003). In a research done by the European Parliament (2000) there is clear evidence that the presence of young people in the agricultural sector is declining all across Europe. There are differences across the countries, so countries in the Southern and Eastern part of the EU show a faster (in relative terms) development towards older aged agricultural entrepreneurs. This can be explained by the fact that these countries are agriculturally more 'backward' than there North European counterparts. The Netherlands is in this research mentioned as a country with a semi-structural problem; because the employment migration towards the services industry has occurred in the middle of the 20th century. However only 41,7% of farm owners is younger than 50 years (Landbouwcijfers, 2011). This is mostly caused by several subjective conditions such as the fiscal disadvantages for a young farmer to cooperate in the farm with the parents, the difficulties with respect to taking over the business on a young age (severe conditions of loans, lacking financial assets and limited experience) and a relative high value of assets to take over. This high value of assets is caused by the imperfections of the land market. The land market is also used by speculative and institutional investors. The consequence of this is that the purchasing costs and the renting of land are beyond what can be justified by the actual profitableness (Sotte, 2003). Also the agricultural activity and the expected profitability of this activity are not justifying the value of the land. All in all is investing in the land market as a farmer, which is necessary to be a young agricultural entrepreneur, is from an economic point of view not easily done.

Based upon the assumption that innovative entrepreneurs are risk seeking / less risk averse (Henrekson and Johansson, 2008), is it plausible to assume that young farmers are more innovative than older farmers. It makes sense that young farmers who do succeed in owning an agricultural company are entrepreneurial minded, because of the mentioned constraints of becoming a farmer.

In literature (e.g. Jones, 2010) is also evidence found for an increased innovation output of elderly people. The focus of this research was 'inventors' and not 'entrepreneurs'. Because of this structural difference is the hypothesis formulated as followed:

Hypothesis IV:

Older agricultural entrepreneurs are less innovative than younger agricultural entrepreneurs.

4.5.2 Characteristics of the farmer: educational attainment

Potentially there can be numerous characteristics of entrepreneurs which can influence the attitude towards innovation. Parker (2009) describes internal and external motives which (can) influence attitudes towards entrepreneurship and innovation. In general is it rather difficult to combine traits, individual characteristics and a personal attitude with the likelihood of innovation of a farmer. Mostly this is caused by a majority of other (external) factors that can play a role in the decision process. Further are this more psychology driven questions, so the role of these factors will also be partially discussed in the hypothesis I. Although individual characteristics are difficult to quantify is educational attainment interesting to examine more closely. Education provides the necessary skillset to assess potential risks and opportunities. Consequently is expected that having a high education attainment is positive on levels of innovations. Even in the case if educational attainment is not directly increasing the likelihood of innovation, is the high educational attainment an indication of a certain ambition, endurance and social background (Parker, 2009).

Hypothesis V:

Agricultural entrepreneurs with a high educational attainment are more likely to innovate.

4.6 Connection with 'sources of knowledge'

If individual farmers are engaged in frequent contacts with colleagues, advisors, representatives of commercial companies, knowledge sources and other potential providers of information, they are expected to be relatively well informed.

In principle is having information regarding e.g. the market situation a comparative advantage for the entrepreneur. This information can be allocated to improve his business position compared to other farmers. Also is an information asymmetry advantageous in the case of intended innovation. If a farmer has better insight in the opportunities and threats of a specific innovation, he can make a more sensible decision whether or not to continue the process towards an innovation. In general can innovations be done more from an informed point of view, this eliminates the possible ignorant and informational incompetent innovations.

Hypothesis VI:

Agricultural firms that have few connections with external sources of knowledge are less likely to innovate.

Chapter 5: Data and methods

5.1.1 The (panel)dataset: in general

The Dutch Agricultural Economics Research Institute (LEI) collects annually a wide range of information and firm specific data of the (Dutch) agricultural sector. One of datasets in which key statistics are gathered is the 'Bedrijven Informatienet' (BIN). This dataset consists annually out of a panel of 1500 agricultural firms. The panel is a statistical representation of the most important subsectors of the Dutch agricultural sector. In principle is around the 93% of the output of agricultural products represented (Poppe, 2004). Besides, is this panel semi-rotating, so the composition of the panel is in transition (see: paragraph 5.3). This rotation is partially to counter the possible learning effect of participating farmers regarding the questions of the enquiry.
The LEI institute is responsible for the data collection and farmers are participating voluntarily. In order to provide data, with an as low as possible administrative burden for farmers, has the database been connected with other databases such as the CBS[8] and NRS[9]. The 'Innovatiemonitor' is an additional research enquiry and is conducted amongst approximately 800 to 1100 farmers who are participants in the 'Bedrijven Informatienet'. The response rate is usually between 80% and 85% (Van Galen, 2009). Due the connection with the BIN can innovation data be connected with general data such as financial performance and other firm-specific information. The data with respect to the Innovatiemonitor and the farm specific key statistics were made accessible by the LEI-institute for the purpose of this research for the years 2004 till 2009. In principle are the data gathered at approximately the same point of time in every year, so there should not be any inter temporal deviations. Hence, does this dataset function as the starting point of this research.

5.1.2 The (panel)dataset: a sub selection

The dataset of the Innovatiemonitor in combination with key statistics from the Bedrijven Informatienet are the most important sources for this thesis. Due to the focus on innovation and the determinants that influence it, was it necessary to create a unique set of observations for the purpose of this research. Farms, identified with a

[8] Centraal bureau van de Statistiek (In English: The Dutch Bureau of Statistics)
[9] Nationaal Rundvee syndicaat (In English: National Cattle Syndicate)

unique BIN-number, are the object of analysis. This BIN-number is unique for every farm participating in the Bedrijven Informatienet and consists of a number varying from four till seven numbers. The time units in this research are 2004, 2005, 2006, 2007, 2008 and 2009. The delta of the time unit (denoted by Δ) is one (1) year.

As described in paragraph 5.1 are the most important sub-sectors represented in the dataset. Based upon the NSO-typology was it possible to determine the nine most important sub-sectors. This determination is for a large part in accordance with chapter 3; however due to statistical underrepresentation and/or economic importance are some (sub)sectors divided. Every farm is classified in one group, based upon their main economic activity in accordance with the classification requirements. Farms which change their economic activity in the period in which they are respondents for the Innovatiemonitor are considered to be hybrid types. This is to minimize the statistic nuisance of these firms; however it should be noted that these cases are limited to approximately 30 cases. The following figure describes the classification used in this research. Note that in figure 31 are the frequencies of each subsector reported.

Figure 23: Classification of subsectors

Typology	NSO-type
Arable	1500, 1601, 1602, 1603, 1604
Greenhouse horticulture: vegetables	2111
Greenhouse horticulture: flowers & plants	2010, 2011, 2122, 2131, 2121, 2331
Outdoor horticulture	2210, 2221, 2310, 2320, 3699
Fruit	3610
Dairy	4500
Other (grazing) animals	4611, 4612, 4810, 4830, 4841, 4843, 5301, 5231
Poultry	5211, 5221, 5231
Pig	5111, 5121, 5131
Hybrid	7300, 7400, 8300, 8400, 6100

5.2.1 Variables regarding the hypotheses

The main purpose of this study is to look which determinants are important for firm-specific innovation. Innovation is split into two types: product innovation and process innovation. Farmers have annually reported whether or not they innovated and if so, which type of innovation they implemented. In the dataset both types of innovation are binary variables. A '0' indicates no innovation and a '1' indicates innovation.
Product innovation is denoted as '*ProductInno'* and process innovation as '*ProcessInno'*, which are in principle the dependent variables in the model.

The first hypothesis requires insight in the profit of the farm. The problem with the terminology 'profit' is that it is hard to define. In the BIN there are different profit types to choose between. The choice for this research is a concept of profit which includes the revenue of the farm minus the costs of production and running the businesses. Furthermore is there a standardized deduction of the capital and labor input of the entrepreneur. If a farm has multiple work units (arbeidsjaareenheden) the cost of labour is adjusted accordingly. So by the calculation of this type of profit there is a reasonable compensation for the entrepreneurial activity of the farmer. The advantage of using this measure is that it gives insight in the 'real' profit of the farmer in accordance with his actual worked hours. However for innovation investment decisions this is presumably not always the measure which is entrepreneur in the agricultural sector makes his calculations. Farmers tend to minimize their compensation for their input of labor/capital. In 2007 about 40% of the farmers were living below the subsistence (Schut, 2007). However the providers of debt and equity are usually pricing-in reasonable compensations in their decision whether or not they agree to invest or provide a loan. Especially in the case of product innovation are the capital requirements rather large; so for innovation investment decisions are these institutions important for the actual innovation implementation. The variable *'profit'* also includes the income out of activities outside the farm of the entrepreneur. The rationale behind this is that this additional income can increase the likelihood of innovation, because of possible larger capital availability. These observations justify the use of the calculated profit based upon standardized deductions for capital and labor.

For hypothesis II is it necessary to use a measure that describes how large a farm is. The difficulty with this variable is that largeness is relative for the subsector; because of the structural differences between them. To avoid a bias towards variables that only focus on profit levels or size are two variables included. The *surface area in hectares* is used to take into account the absolute size of the farm. Especially for subsectors, with lower intensive production characteristics, such as arable and dairy is this a good proxy. How larger a farm of that type is, the more it is capable to finance (larger) innovation projects. Relatively this is also the case for the other sectors; a large greenhouse horticulturist in terms of hectares has an advantageous position compared to another that is only half the size. However the size of this firm (in hectares) is much lower than its arable counterparts, due to the costs incurred of building an additional hectare of greenhouse. The variable '*number of farmers in legal form*' is also used to control for size. The number of farmers is an indicator of earning capacity. Only when a farm is (marginally) profitable are family members legally part of the farm. If earnings are too low, it will come more profitable for those family members to earn more money outside the farm. Because there is no corrections in this variable for actual active participation should conclusion with respect to this be done rather carefully.

The third hypothesis relates to the legal form of a farm. In the agricultural sector the importance of partnership, within the family of with other partners is rather large. Limited liability companies[10] play only a marginal role in the agricultural sector; however they are included in the dataset. In order to research the difference of innovation behaviour across the different legal forms are multiple variables created. The four most important legal forms are coded as binary variables. Hence are sole proprietorship, family partnership, partnership and the limited liability company coded as variables; these four types contain all the observations. Obviously joint stock limited companies[11] are not present in the dataset.

The difficulty regarding the fourth hypothesis is to define 'old' and 'young'. These are relative concepts and differ from person to person. Further do partnerships have multiple partners with different ages, so making a statement regarding age and

[10] In Dutch: Besloten Vennootschap
[11] In Dutch: Naamloze Vennootschap

innovation is not that easy. In order to provide the most satisfying solution to this problem the choice has been made to take the variable *age of oldest entrepreneur* as estimator to what extent age makes a difference in innovation behaviour. This variable gives insight in the age of the oldest farmer who is formally part of the legal company type. A problem with this estimator is that in family partnerships parents often remain active in the partnership, because of the high costs for the child to take over the farm. In order to relieve the financial burden of buying the complete farm, they remain legally active by providing capital for the farm. However their influence on the actual day-to-day business is (very) limited. Although the chosen variable does not mitigate this clear problem, does it provide a far better insight than the age of the respondent of the BIN or the Innovatiemonitor. In principle is this problem not present for the farms that have sole proprietorship as their legal form. Due to the fact that there is a rather large number of (family) partnerships in the dataset (see figure 26), is the estimator of the oldest entrepreneur for the comparability and the estimation of the effect recommended. This is a continuous variable and changes accordingly over time. For the validity of the model, is the age of the entrepreneur linked to the specific year in which it is observed. In the case of missing values is the age increased or decreased accordingly with the change in the panel year of that specific firm.

Educational attainment of the oldest farmer is the next variable that is essential regarding answering whether or not the fifth hypotheses are right. Based upon the threshold which is used in numerous other researches, are people who have obtained a degree of a university or of another type of higher education (e.g. in the Netherlands a diploma of the HBO) high educated. For this research the variable *education high* is constructed. This includes all the farmers who are 'highly educated'. In the initial database there is also a distinction between diplomas of regular attainments and agricultural attainments. Because this is not in the scope of this research is this distinction neglected.

Hypothesis VI questions the connections with external sources of knowledge. External can be defined as everything not within the own firm and between the participants of the same legal form. All other types of connection are considered to be external. A source of knowledge is a vague description, this differs between people. To make no assumption regarding the quality of the source is the variable *'connected wesok' (with* *external sources of knowledge)* constructed. This is a composition of different questions and is expected to be present, if the respondent has answered yes to the question if his farm is participating in an intensive collaboration with another farm, is part of a study group, is active in a growers association, is part of a best practice group or is active in a sectoral interest group than the variable '*connected wesok'* will be valued with a '1'. If none of the above questions is answered with yes, than the value is '0'.

Finally we control for the impact of the subsector in which a farm is active. In principle this is done to control for structural differences between subsectors.

5.2.2 Differences of innovation across subsectors

In chapter 3 a description is provided regarding the most important subsectors in the Dutch agricultural sector. Clearly there is a large difference in the setup of the subsectors and the different levels of innovation. The most striking differences are with respect to the cultivated area, allocated means of production and the type of production. In principle is the contrast between arable farms and greenhouse horticulture one of the largest. As described are arable activities done in the open air and is the land the primary mean of production. For greenhouse horticulturists is the greenhouse itself the most important production input. The fact that for the arable farmer the bigger the cultivated area the better, e.g. economies of scale, while for a greenhouse horticulturists the 'quality' of the greenhouse is much more important. Because of the high costs of building a greenhouse a horticulturist can achieve more benefits by optimizing his greenhouse instead of building or acquiring random additional hectares of greenhouse. Dairy farmers are somewhere in the middle, a larger surface area is desirable (extensive) but a higher quality stable can be beneficial for the company (intensive). The contrast between intensification and expansion will also influence innovation behaviour. It is expected that agricultural firms that can be indicated as 'intensive' with regard to their means of production are more innovative. The question that rises is what intensive agricultural firms are. A clear definition is difficult to provide, because of the firm-specific differences relating the intensity of cultivating crops or keeping animals. In this case are all types of greenhouse horticulture, outdoor horticulture and fruit farms considered to be firms that have intensive production characteristics. Surely it should be acknowledged that this is a highly stylized statement and is not applicable for all type of farms in the selected intensive subsectors. Vis-à-vis can relative extensive producing outdoor horticulturists be distinguished, compared to ntensive producing cattle farmers. However the subsector is in itself a broad concept. To be able to provide insight in the extent of both types of innovation in the Dutch agricultural sector and on farms itself, it is essential to distinguish between subsectors and by doing so choices have to be made regarding production characteristics and the allocation of subsectors to these characteristics for this research. The intensity of production is closely related to the capital intensity of the production process. As described in chapter 3 are there in the agricultural sector differences between the capital and labor intensity across subsectors. Based upon chapter 2 is the lowering of production costs an important motive for innovation. In general is the production factor 'labor' in the Netherlands, when required in large numbers, more expensive than the production factor 'capital'. So it is expected, that labor intensive production methods are likely to be innovation 'targets' (Frank, 2006). A clear example is that fruit farmers can save many euros if they are able to substitute the dozens of fruit pickers needed in harvest time (partially) by machinery. The cost advantages of these types of innovation are expected to be higher than to achieve (marginal) progress by capital driven innovation, e.g. improving the effectiveness of the sorting machines. The outdoor horticulture, the greenhouse horticulture and the fruit farms are considered to be labor intensive. It should be pointed out that capital in this case is not defined as the costs of an additional hectare of land, because this is part of the production factor 'land'. Capital is in this research considered to be analogues to the neoclassical definition of Marshall and others and imply human-made goods which are used for the production of other goods.

These variables and choices regarding the hypotheses leads to the overview of variables as showed in figure 24 (see next page).

Figure 24: Overview of variables

Explanatory influence	Name of the variable	Variable type
Innovation: -process	Process innovation	Binary
-product	Product innovation	Binary
Subsectors	Arable,	Binary
	Greenhouse horticulture: vegetables,	Binary
	Greenhouse horticulture: flowers & plants	Binary
	Outdoor horticulture	Binary
	Fruit	Binary
	Dairy	Binary
	Other (grazing) animals	Binary
	Poultry	Binary
	Pig	Binary
	Hybrid	Binary
Economic performance	Profit	Continuous
Size	Surface area (in hectares)	Continuous
	Number of farmers in legal form	Continuous
Age	Age of oldest farmer	Continuous
Legal form	Sole proprietorship	Binary
	Family partnership	Binary
	Partnership	Binary
	Limited liability company	Binary
Educational attainment	Education: high	Binary
Connection to external sources of knowledge	Connected wesok	Binary

5.3 Methodology

Given the dataset, the adjustments in order to make the dataset useable for this research and the selection and construction of the dataset, has made it possible to apply specific methodological and statistical tests in order to find answers on the main question and hypotheses of this research. Before this can be done, is a further explanation regarding the panel data required. A panel dataset contains repeated observations over the same units, collected over a number of periods (Verbeek, 2011). In this case different firm and innovation characteristics are observed. To avoid panel biases and to minimize conditioning behaviour is the panel rotating (see figure 25). This figure describes in which pattern the farms have participated in the panel. A pattern of 0 0 0 1 1 1 indicates that the farm did not participate in the first three years of the study, but did in the last three years. Consequently is a 0 0 0 0 0 1 pattern an indication that the farm only participated in the last year of the survey.

Figure 25: Panel setup of the Innovatiemonitor

Panel setup of Innovatiemonitor		
Starting year: 2004, Final year: 2009		Delta (year)= 1 year
Number of periods (T): 6 periods		0 =no participation 1= participation
Identification: BINnumber		N=1337
Frequency	**Percent**	**Pattern**
377	**28,2**	**1 1 1 1 1 1**
104	**7,78**	**0 0 0 0 0 1**
104	**7,78**	**0 0 0 1 1 1**
92	**6,88**	**0 1 1 1 1 1**
74	**5,53**	**0 0 1 1 1 1**
65	**4,86**	**1 0 0 0 0 0**
51	**3,81**	**1 1 1 0 0 0**
48	**3,59**	**1 1 0 0 0 0**
46	**3,44**	**0 0 0 0 1 1**
376	**28,12**	**Other**
1337	**100,00**	

The availability of data of individual firms over a certain number of years allows for a better understanding and more realistic estimations regarding innovation behaviour then single regressions or single-time series would.

Based upon the panel data and the binary structure of the dependent variable is the use of a logistic regression preferable. A logistic regression, also called a logit model, is useful to predict the probability of a possible occurrence of an event (which is in this case product innovation or process innovation) by fitting data to a logistic function.

With the help of different independent variables, which can be continuous or binary, can the impact of that specific variable on the dependent variable be calculated. So in a nutshell is a logistic regression a multiple regression with an outcome variable that is a categorical dichotomy and predictor variables that are continuous or categorical. (Field, 2005)
Using the variables mentioned in paragraph 5.2 can the regression be noted for process innovation as formula I, for product innovation as formula II. In which is the beta the gradient of the straight line followed by the value of predictor variable. Further is u the residual term and the β_0 is the intercept. However it should be noted that the interpretation of the intercept in the case of logit model should be done with reluctance. Hence is the intercept largely neglected in the interpretation of the model.

Formula I:

$$ProcessInno = \beta_0 + \beta_1 arable + \beta_2 greenhousehorticulture.vegetables + \beta_3 greenhousehorticulture.flowers + \beta_4 outdoor.horticulture + \beta_5 fruit + \beta_6 dairy + \beta_7 other.grazing.animals + \beta_8 poultry + \beta_9 pig + \beta_{10} hybrid + \beta_{11p} profit + \beta_{12} numberoffarmsinlegalform + B_{13} surface.area + \beta_{14} age.of.oldest.farmer + \beta_{15} Sole.proprietorship + B_{16} Family.partnership + \beta_{17} Partnership + \beta_{18} Limited.liability.comp + \beta_{19}\ Education.high + \beta_{20} Connected\ wesok + u$$

Formula II:

$$ProductInno = \beta_0 + \beta_1 arable + \beta_2 greenhousehorticulture.vegetables + \beta_3 greenhousehorticulture.flowers + \beta_4 outdoor.horticulture + \beta_5 fruit + \beta_6 dairy + \beta_7 other.grazing.animals + \beta_8 poultry + \beta_9 pig + \beta_{10} hybrid + \beta_{11p} profit + \beta_{12} numberoffarmsinlegalform + B_{13} surface.area + \beta_{14} age.of.oldest.farmer + \beta_{15} Sole.proprietorship + B_{16} Family.partnership + \beta_{17} Partnership + \beta_{18} Limited.liability.comp + \beta_{19}\ Education.high + \beta_{20} Connected\ wesok + u$$

To analyse whether or not the model is applicable and has sufficient explanatory capabilities will there be a check on the log-likelihood and on the chi-square distribution. Basically the Wald-statistic tells whether or not the b-coefficient for that predictor is significantly different from zero. If this is the case it can be assumed that the predictor is contributing significantly to the prediction of the outcome (Field, 2005).

The usage of panel data has several advantages and disadvantages which should be considered in the application of statistical measures and tests (Verbeek, 2011). Based upon the characteristics of this research is the logit model also applicable in this panel.

This implies that the following formula (Verbeek, 2011) holds:

$$y_{it} = \alpha_i + x_{it}'\beta + \varepsilon_{it},$$

Where is assumed that $\varepsilon_{it} \sim IID(0, \sigma_\varepsilon^2)$, independent of all x_{it}'s. This is mitigated in a regression by including a dummy variable for each individual and consequently omitting the overall intercept. This is implied by the fact that x_{it} is strictly exogenous. The consistency of the 'within estimator' for β requires an within (transformed) regressor that is uncorrelated with the error term. This is implied by:

$$E\{x_{it}\varepsilon_{is}\} = 0 \text{ for all } s, t,$$

Essentially the fixed effects model concentrates on differences within individuals and any time-invariant variable is eliminated by the within transformation. In principle is the impact subsumed by the fixed effects.

The approach of the random effects differs from the fixed effects model, because it simply treats α_i as part of the error term. This lead to the following formula:

$$y_{it} = \mu + x_{it}'\beta + \alpha_i + \varepsilon_{it},$$

In which we assume that $\varepsilon_{it} \sim IID(0, \sigma_\varepsilon^2)$, $\alpha_i \sim IID(0, \sigma_\alpha^2)$, independent of all x_{it}'s. With the random effects model is the intercept term μ included, because α_i is considered to have a mean of zero. This leads to the application of a standard linear model, where the error term has a non-zero covariance. Consequently is a feasible GLS possible.

When both models are considered the following difference can be observed. The fixed effects approach model assumes:

$$E\{y_{it} \mid x_{it}, \alpha_i\} = \alpha_i + x_{it}'\beta,$$

While the random effects model assumes:

$$E\{y_{it} \mid x_{it}\} = x_{it}'\beta.$$

So the β coefficients are the same, only if:

$$E\{\alpha_i \mid x_{it}\} = 0.$$

The statistical measure to check which of the models should be used is the Hausman test. In chapter 6 will this measure explicitly be used to explain why this innovation model requires random effects.

5.4 A further specification of variables

Based upon the variables described in paragraph 5.2 and the methodology it is required to make some additional assumptions. The sectoral variables need to have a specific 'control group', the some holds for the legal structure. The other hypotheses can be answered based upon a binary variable (see figure 25), hence is a specific choice for a control variable not required.

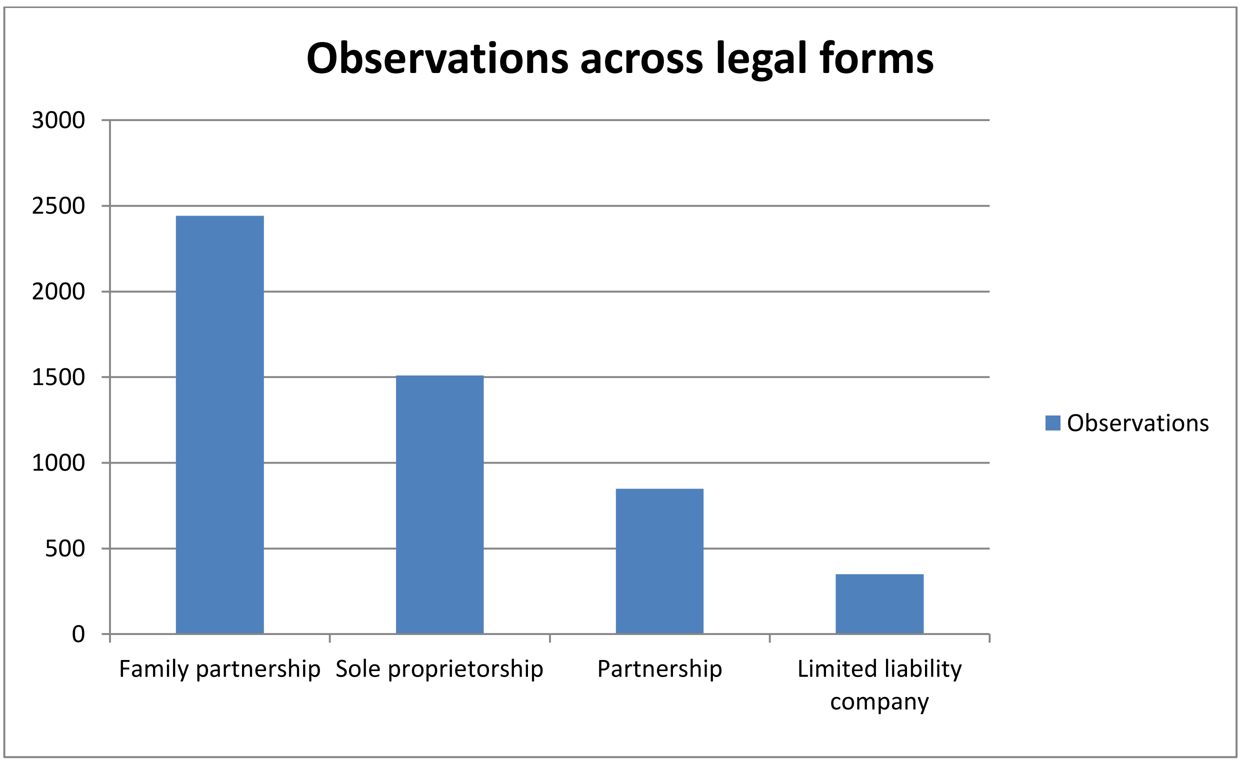
5.4.1 The sectoral choice

In principle are not all sectors included in the final model. This is because leaving out a variable creates a possibility to compare the expected outcome of another sector compared to the one left out. For this research is the variable that is left out the hybrid sub sector. This is mostly because of the structural characteristics of this sector. As mentioned before does that type of farm not have at least 2/3 source of income out of one main activity. Because of this distribution is the average level of innovation considered to be relatively low. These farms have a limited focus strategy and can therefor reap fewer benefits from an innovation towards a specific product / process. The relative success of other, more specialized agricultural sectors, are compared to this hybrid type. In paragraph 6.1.2 will additional insight be provided with respect to the overall absolute and relative levels of innovation of the subsectors.

5.4.2 The legal structure: preliminary description

The fourth hypothesis states that partnerships tend to be more innovative compared to other legal forms. Legal forms are, in this dataset, distinguished in four groups. To provide additional insight which is required to answer this hypothesis, it is important to outline some of the characteristics of the outcome regarding legal forms. In figure 26 is shown how the distribution within the dataset is. Family partnerships do clearly consist of the majority in this research. This is no surprise, given the fact that most farms tend to have a familial characteristic.

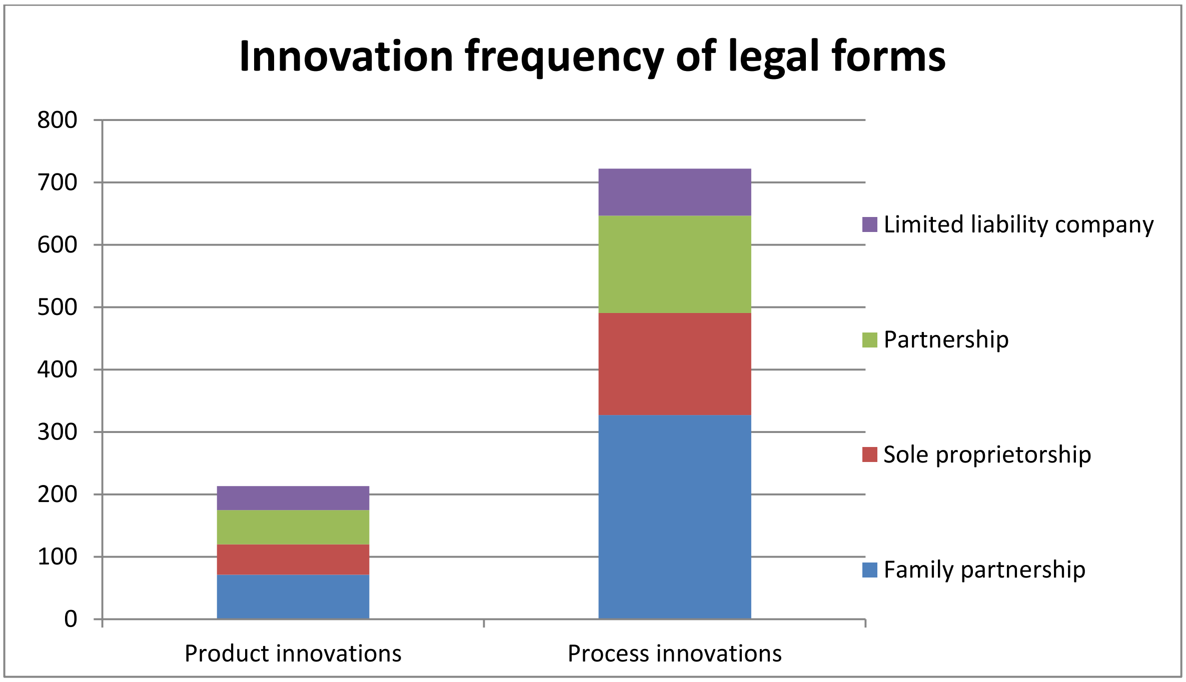
Figure 26: Observations across legal forms



Furthermore is it important to realize that the low number of limited liability companies is in accordance with the reality. A very low number of this type of legal form is active in the agricultural sector (Landbouwcijfers, 2011).

It is based upon innovation (within this dataset) by legal structure striking to see that regarding product and process innovation a disproportional number of innovations are done by this limited liability companies (see figure 27).

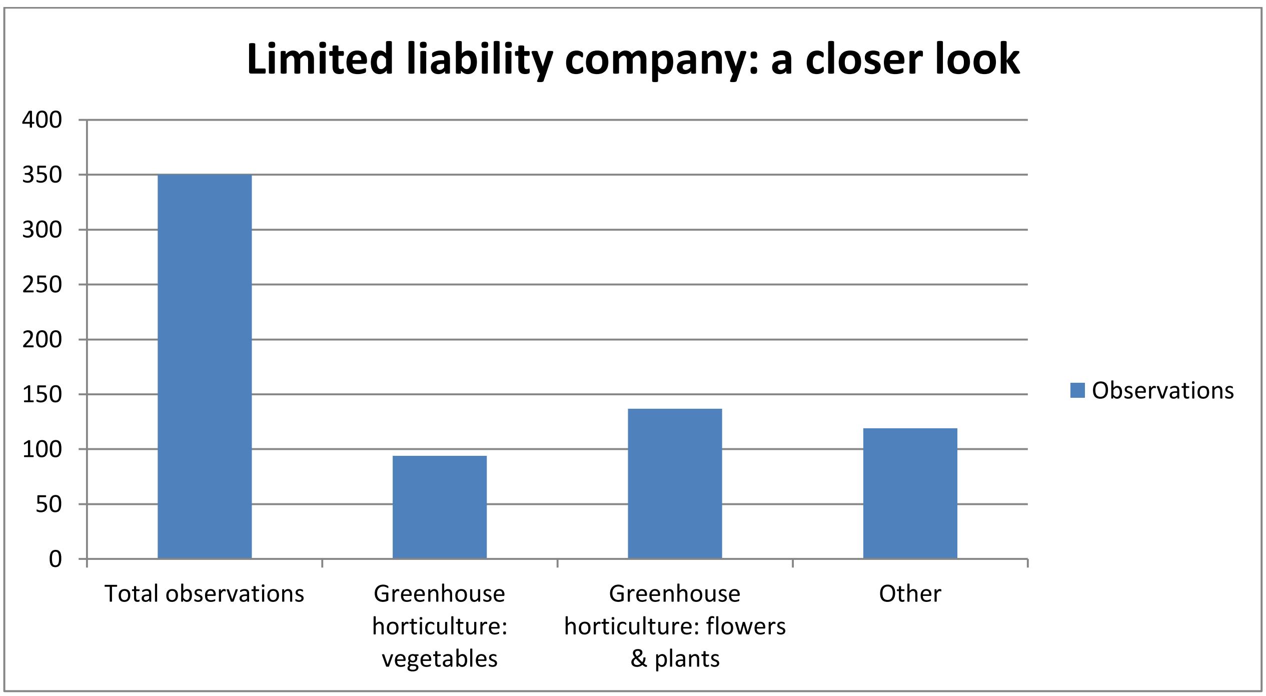
Figure 27: Innovation frequency of legal forms



This relative overrepresentation gives rise to the thought that possibly limited liability companies are used by innovative entrepreneurs to minimize risk. The other legal structures make the owner liable for possible debts and/or insolvability. The limited liability company does not have this characteristic so can be used by high risk innovators to reduce the possible effects of a failure.

As is shown in figure 27 do limited liability companies consists of 6,7% of the total observed legal structures in this dataset. However the weight in both types of innovation is larger. In 17,84% of the cases of product innovation is it done by a limited liability company, compared to 10,39% with process innovations. This is a notable difference and should be subject to further interpretation. As described in figure 27 is it possible to observe the high representation of these two subsectors in the total of this legal form. Although these two subsectors are important it gives an erroneous insight in the importance of innovation of this type. In Dutch Law is a limited liability company often created to diversify entrepreneurial activities and making sure the entrepreneur is not liable with his private wealth and property for eventual debts out of the company. This is not the case with the other three legal types in this research. Given this fact, combined with the overrepresentation in the greenhouse subsectors has led to the conclusion that the limited liability company should not be part of the final model. Although important for the agricultural sector, is this legal form not necessarily a driver for innovation but more of a consequence. If farmers are innovative and try to lessen liability, they will institute a limited liability company. So defining innovation as risk taking behaviour is partially explaining the high occurrence of innovation in limited liability companies.

Figure 28: Limited liability company, a closer look



In the final model is the limited liability company used as a control group to test the impact on innovation of the other types of legal forms against.

Chapter 6: Results

6.1.1 Descriptive outcomes: in general

Before the model and outcomes with respect to innovation are described is it essential to grasp the magnitude of process and product innovation in this dataset. Further are some other important descriptives of variables showed; basically to function as a prelude towards the (final) model of this research. In paragraph 5.3 is shown that there are in total 1337 panel respondents. As described is the pattern of participation not equal across the dataset. The dataset consists out of 5156 unique observations. This implies, because this research covers six years, that the average of participation is 3,86 years per farm. For the interpretation of the results, this is important to bear in mind. It can be the case that farms do multiple innovations in the years in which they are observed. This being said, first the frequency of product innovation within this dataset:

Figure 29: Description of product innovation

Product Innovation	Frequency	Percentage in %
Yes	213	4,1
No	4942	95,9
Total	5155	100

As can be observed there is 1 missing value for product innovation. The total number of observations is 5155, while the actual dataset consists out of 5156 observations. Further is the number of actual product innovations rather limited. Only 4,1% of all the observed cases has implemented a product innovation in a year. Further is 11,3% of the participating firms an implementer of some type of product innovation throughout the years in which it is observed. Striking is the relative low occurrence of product innovation compared to process innovations. In figure 30 can a substantial higher number of observations be observed. Although there are more missing values (5153 instead of the nominal 5156 observations), is the frequency more than tripled compared to product innovation.

Figure 30: Description of process innovation

Process Innovation	Frequency	Percentage in %
Yes	724	14,05
No	4429	85,95
Total	5153	100

Based upon these outcomes seems process innovations be more frequently implemented than product innovation, however it does not explain the determinants influencing both types of innovation. On the other hand, it confirms the importance of distinguishing both types from each other. From this point in the research, the distinction between the types of innovation is emphasized by the colour used in the figures. Outcomes regarding product innovation are reported in blue, while process innovation is reported in green.

6.1.2 Descriptive outcomes: differences of subsectors

The difference of subsectors in the agricultural sector has been emphasized in chapter 3. The dataset makes a distinction between the different subsectors.

Figure 31: Frequencies of the subsectors

Subsector	Frequency	Percentage in %
Arable	634	12,3
Greenhouse horticulture: vegetables	561	10,9
Greenhouse horticulture: flowers & plants	710	13,8
Outdoor horticulture	239	4,6
Fruit	117	2,3
Dairy	1356	26,3
Other (grazing) animals	306	5,9
Poultry	342	6,6
Pig	608	11,8
Hybrid	283	5,5
Total	**5156**	**100**

In accordance with the actual magnitude of the dairy subsector, is this group also the largest in this dataset. Relatively are the greenhouse horticulture subsectors overrepresented regarding the frequency of observations (24,7% in total). Although the number of firms is not that high in the Netherlands, their economic importance is rather large.

When the different subsectors are analysed with respect to the occurred innovations it is important to look more closely towards to absolute number of innovations, the percentage of process innovations per subsector; but also the number of innovations compared to the total of observations in the whole dataset of that specific subsector.

Figure 32: Product innovation per subsector

Subsector	Frequency of product innovation	Percentage of the total number of product innovation	Percentage of total observations in subsector
Arable	12	5,6	1,9
Greenhouse horticulture: vegetables	26	12,2	4,6
Greenhouse horticulture: flowers & plants	95	44,6	13,4
Outdoor horticulture	11	5,2	4,6
Fruit	11	5,2	9,4
Dairy	16	7,5	1,2
Other (grazing) animals	8	3,8	2,6
Poultry	13	6,1	3,8
Pig	13	6,1	2,1
Hybrid	8	3,8	2,8
Total	213	100	-

From the 213 product innovations have 95 taken place in the greenhouse horticulture: flower & plants. This is 44,6% of the total number of product innovations. Also the greenhouse horticulture: vegetables subsector is relatively important. With 26 innovation cases, consisting 12,2% of the total number of product innovation. So, 56,8% of the total product innovations are done by greenhouse horticulture firms. Although this seems that these subsectors are important with respect to product innovations it ignores the number of innovations compared to the overall number of respondents. Given this figure, described in the last column of the table it is observable That 13,4% of the observations in the greenhouse horticulture: flowers & plants are product innovations. While only 4,6% of the total observations for the vegetable greenhouse horticulturists are product innovators. Especially the fruit farmers distinguish themselves within this measure. Approximately 9,4% of the observations in the fruit sector are innovations. On the other hand is product innovation in the dairy sector rather non-existent; only 1,2% has innovated. Also the arable sector has this pattern, 1,9% has implemented a product innovation.

The other subsectors are closely distributed and vary between the 2% and 4%. Relatively this is a difference in the margin and is difficult to elaborate on, but it is of importance towards the final model and the modelling process.

When looking more closely to process innovation per subsector, see figure 33, is the first striking difference the larger magnitude of this type of innovation. That is also observable in the percentages of the total observations in the subsector.
Again the both types of greenhouse horticulture are of importance. In total is 36,1% of the observed process innovation (261 in absolute numbers) done in these two subsectors. In contrast to product innovation a large part (19,1%) of the process innovation is implemented by dairy farms. However when this is compared to the total number of observations in the whole dataset, this is only 10,2% of all dairy firms. So a little more than 10 per cent of the dairy related observations has implemented some sort of process innovation. Compared to other sectors such as arable (13,4%), outdoor horticulture (17,6%) and poultry (12,9%), this is rather limited.

Figure 33: Process innovation per subsector

Subsector	Frequency of process innovation	Percentage of the total number of process innovation	Percentage of total observations in subsector
Arable	85	11,7	13,4
Greenhouse horticulture: vegetables	144	19,9	25,7
Greenhouse horticulture: flowers &plants	117	16,2	16,5
Outdoor horticulture	42	5,8	17,6
Fruit	9	1,2	7,7
Dairy	138	19,1	10,2
Other (grazing) animals	37	5,1	12,1
Poultry	44	6,1	12,9
Pig	64	8,8	10,5
Hybrid	44	6,1	15,5
Total	724	100	-

Although the total number of process innovations in the dairy sector is large, it is relatively one of the lowest sectors regarding implementing process innovation. Only fruit has a lower percentage. The role of the greenhouse horticulturist is again striking, as described is 36,1% of all process innovation to attributable to these subsectors. With a weighted average of process innovation over 20% across all greenhouse horticulturists it is clear that, again, these subsectors are of importance with respect to innovation in the Dutch agriculture.

6.2 Econometric results: product innovation

Presenting the model according to the limitations and prerequisites as described in the previous chapters results in the outcome as showed in figure 35.

Before interpretations can be made should the model diagnostics be viewed. First the chi-squared outcome to verify whether or not the probability of a likelihood ratio test statistic is extreme or not. The null hypothesis is that the regression coefficients are equal to zero. The p-value is compared to a specified level of alpha (in this model set on 0,05), indicating the willingness to accept a type I error. The fact that the outcome of Prob > chi^2 in this model is equal to 0,0000 indicates clearly that at least one of the regression coefficients is not equal to zero. The chi-square uses a test with the help of degrees of freedom. Consequently is this value of sufficient size to be considered statistically significant. So the model satisfies the prerequisites for interpretation. As can be viewed in appendix I requires the outcome of the Hausman-test the use of random effects.

Looking to the p-values there is a limited number of significant variables. The only variable that is significant on a 99% level is *greenhouse horticulture: vegetables.* The coefficient is also rather large, 1.92; implying being a firm of this type increases the likelihood of being a product innovator compared to a hybrid farm. Two variables are significant on a 95% level: *fruit* with a p-value of 0,013 and a coefficient of 1,695. Second is *family partnership* significant on the 95% level. With a negative coefficient, this implies that having a family partnership as legal form is of negative impact on the likelihood of product innovation compared to the limited liability company. Interesting to see is that *sole proprietorship*, which is significant on a 90% level, is also of negative (-0.738). The last significant variable is the sector *dairy*, with a coefficient of -0.912 and a p-value of 0,089.

To verify the different hypotheses: there is no significant outcome for *profit* (negative coefficient). Further do *education high*, *surface area,* and *age of oldest farmer* have a positive coefficient, but are not significant. Interestingly is the fact that '*connected to external sources of knowledge' (wesok*) is marginally insignificant at a 90% level, but shows a positive coefficient. However these variables are not significant and do not provide sufficient statistic explanatory power for a solid conclusion.

Figure 34: Outcome of the model on product innovation

Logistic regression: Product innovation			
Number of observations: 5149		**Observations per group:**	**min= 1**
Number of groups: 1336			**avg= 3,9**
			max=6
Cox&Snell pseudo r^2 = 0,1394		**Wald chi^2 = 99,08**	
Log likelihood = -754,65681		**Prob > chi^2 = 0,0000**	
Variable	**Coefficient**	**Std. Error**	**P-value**
Arable	-0.449	.5689352	0.430
Greenhouse horticulture vegetables	1.921	.5164318	**0.000 ***
Greenhouse horticulture flowers & plants	0.462	.5539327	0.404
Outdoor horticulture	0.358	.627173	0.568
Fruit	1.695	.6798976	**0.013 ****
Dairy	-0.912	.5366041	**0.089 *****
Cattle	-0.171	.6321254	0.787
Poultry	0.520	.6019493	0.388
Pig	-0.338	.5819066	0.562
Profit	-5.73e-07	4,47e-07	0.199
Education: high	0.166	.4036317	0.681
Family partnership	-0.761	.3546934	**0.032 ****
Sole proprietorship	-0.738	.3850810	**0.055 *****
Partnership	-0.542	.3689472	0.142
Surface area	0.002	.0019722	0.215
Number of farmers in legal form	-0.083	.1715393	0.627
Age of oldest farmer	0.005	.0119383	0.677
Connected wesok	0.295	.1832963	0.108

* significant on a 99% level (0,01)
** significant on a 95% level (0,05)
*** significant on a 90% level (0,1)

6.3 Econometric results: process innovation

The results of the final model of process innovation are showed in figure 36. Again the diagnostics of this model allow it to be interpreted, as the Prob > chi^2 of the model is 0,0000 (the p-value is below 0,05, so the model can be accepted) The log-likelood of this model is -1945,366, again of sufficient level to accept the model as a whole. Also are random effects used (see the relevant Hausman-test in appendix I)

The variables *surface area*, *age of oldest farmer* and *connected wesok* are all variables that are significant on a 99% level. The coefficients of *surface area* and *connected wesok* are positive, implying that there is a positive relationship between the both and process innovation. So the larger the surface area of a farmer is, the more (marginally) likely it is that he has implemented a process innovation. If a farmer is connected to external sources of knowledge it is also of positive effect on the likelihood of process innovation. The first variable that is significant on a 95% level is *education: high,* with a negative coefficient, this implies that higher educated farmers are less likely to implement a process innovation. The *number of farmers in legal form* is a variable that is significant on the 95% level and is of positive influence on process innovation. When the sectors are taken into account, it is observable that *greenhouse horticulture: flowers and plants* is significant on the 95% level and has a positive coefficient of 0.552. That is the largest positive, significant, coefficient of this model. Finally the dairy sector, the only variable that is only significant on a 90% level has (again) a negative coefficient.

With respect to the other hypotheses it can be observed that *profit* has no significant outcome, although it is only marginally negative and just exceeds the 90% level is it not feasible to interpret statistically.

Figure 35: Outcome of the model on process innovation

Logistic regression: Process innovation			
Number of observations: 5147		**Observations per group:**	**min= 1**
Number of groups: 1333			**avg= 3,9**
			max=6
Cox&Snell pseudo r^2 = 0,0896		**Wald chi^2 = 127,93**	
Log likelihood = -1945,366		**Prob > chi^2 = 0,0000**	
Variable	**Coefficient**	**Std. Error**	**P-value**
Arable	-0.282	.2670765	0.291
Greenhouse horticulture vegetables	0.187	.2737017	0.494
Greenhouse horticulture flowers & plants	0.552	.2750929	**0.045 ****
Outdoor horticulture	0.077	.3211913	0.812
Fruit	-0.786	.4900826	0.109
Dairy	-0.472	.2438814	**0.053 *****
Cattle	-0.314	.3141981	0.318
Poultry	-0.118	.3111548	0.704
Pig	-0.434	.2825245	0.125
Profit	-3.97e-07	2.51e-07	0.115
Education: high	-0.461	.2270266	**0.042 ****
Family partnership	-0.288	.2154680	0.182
Sole proprietorship	-0.506	.2351815	**0.032 ****
Partnership	-0.137	.2249874	0.544
Surface area	0.005	.0011206	**0.000 ***
Number of farmers in legal form	0.207	.0906913	**0.023 ****
Age of oldest farmer	-0.030	.0064392	**0.000 ***
Connected wesok	0.447	.1013602	**0.000 ***

* significant on a 99% level (0,01)
** significant on a 95% level (0,05)
*** significant on a 90% level (0,1)

Chapter 7: Discussion of the results

7.1 Discussion of the results

The aim of this research is to find a satisfying answer on the question: "*Which determinants are important for firm-specific innovation in the Dutch agricultural sector?*" In order to provide sufficient insight in the main question of this thesis is chosen for a research in which different hypotheses would lead to the required insight.. In this conclusion all six hypotheses will be discussed, ending in an overall statement with regard to the main question.

The first hypothesis concerns the relationship between profit of both types of innovation. In principle the main assumption is that profit hampers innovation. In the case of product innovation the coefficient is negative: -5.73e-07, but not significant (0.199). The same pattern is observable for process innovation: -3.97e-07, and also not significant (0.115). Both coefficients are marginally negative and given the insignificance of the outcomes it is not possible to provide a reasonable explanation with regard to the relationship between profit and innovation. All in all, there is not found sufficient evidence to verify the hypothesis. The fact that the outcome is inconclusive could make sense given the characteristics of the variable '*profit'*. In general are many costs incurred before innovations can be done. So a farm needs to have a solid solvability and/or liquidity before an innovation can be implemented. The profit of one year is maybe not sufficient for a farm to act as catalyst for innovation. It could possibly assist in the choice to make the intended innovation in another point of time, but is not the actual cause of the innovation.

Hypothesis II states that small agricultural firms are more likely to innovate than large agricultural firms. To investigate this, the surface area in hectares and the number of farmers in the legal form are taken as a combined proxy for firm size. For product innovation a contrary outcome is observable between these two variables. The coefficient of surface area in hectares is positive and insignificant (0.002 and 0.215). The coefficient of number of farmers in legal form is negative (-0.083), but also not significant (0.627). With respect to product innovation does firm size does not explain anything useful. This is in contrast with process innovation, for both variables positive coefficients can be observed (respectively 0.005 and 0.207). Also are both variables strongly significant (0.000 and 0.023). This implies a positive relationship between firm size and process innovation. In other words; the larger the surface area and the larger the number of participants in the legal form the larger the likelihood is for process innovation. Because the measure used has not been used for indicating the relative economic size should interpreting the innovation effect be done with reluctance.

Hypothesis III hypothesises that partnerships as legal structure do positively influence innovation, compared to limited liability companies. The analysis focuses on family partnerships, sole proprietorships and regular partnerships. With respect to these three legal forms an overall negative impact on product innovation can be observed compared to the limited liability company. Family partnership has a negative coefficient of -0.761, with a p-value of 0.032, sole proprietorship -0.739 with a p-value of 0.055. The regular partnership has a coefficient of -0.542 and a p-value of 0.142. The negative coefficient of the family partnership has in this case the largest magnitude. Consequently is having this type of legal form for product innovation in general of negative impact on the likelihood of innovation. This also holds for the other types, however these negative impacts are smaller compared to the family partnership. Although the regular partnership is not significant, it can be interpreted with restraint. The p-value is close to the 90% requirement. It is interesting to observe that there is clear evidence, also significant, that partnerships are less likely to innovate compared to limited liability companies. It is likely that this is caused by the risk seeking behaviour of farmers who are in a limited liability company. They can take more risk, because they are not personally liable for the possible debts made by the firm. If farmers in a partnership or in a sole proprietorship make debts they are personal liable for it. So they have to repay the debts with their own personal assets. It makes sense that they show less risk seeking behaviour as a consequence. This overrules largely the effect of investing for the benefit of the future of the farm. Further is it imaginable that farms, functioning as a family partnership, do have a stronger social binding with each other. This can lead to larger risk-aversion and consequently towards less likely chances of innovation. The family is depending on a solid income and is therefore not inclined to take risk or to change production processes on a large scale. Further are participants of family partnerships, regular partnerships and sole proprietors according to the Dutch law liable for the debts they have made with their firm.

With respect to process innovation the coefficients are again al negative. Family partnership has a negative coefficient of -0.287, but is insignificant due to a p-value of 0.182. The coefficient of sole proprietorship is -0.506 with a (significant) p-value of 0.032. The regular partnership has a coefficient of -.0137, but is insignificant (p-value: 0.544). Again the three legal forms do have a negative impact on the likelihood of innovation compared to limited liability companies. The fact that this is different than with product innovation is because product innovation has a more direct relationship with external farm issues, while process innovation in general refers to internal improvements of example given working together. With respect to interpreting the coefficients of process innovation should be noted that it needs to be done with some restraint, due to the insignificance of two of the legal forms.

Hypothesis IV states that older agricultural entrepreneurs are less innovative than younger agriculturists. The outcome with respect to product innovation was marginally positive with a coefficient of 0.005, but insignificant (0.677). There is no clear evidence for a relation between the two concepts. This is different with regard to process innovation. As can be observed is the outcome significant (0.000) and is marginally negative. The coefficient is -0.030, indicating a negative impact of having an older entrepreneur in the farm on the likelihood of process innovation. This strong significant outcome leads to an undeniably relationship, while in the case of product innovation there is no significant relationship. All in all a partial support for the hypothesis can be observed.

The next hypothesis (hypothesis V) questions the relationship between high educational attainment and the likelihood of innovation. It is expected that a relative high educational attainment leads to higher levels of innovation. For product innovation this is not possible to confirm. The outcome in the model with was insignificant, with a p-value of 0.681. The fact that the coefficient is positive 0.166, indicating a positive relationship is not significantly supported by the data, so the evidence found in this research does not support the hypothesis. With respect to process innovation the coefficient is negative: -0.461, the p-value is 0.042; so the outcome is significant. This outcome is at odds with the hypothesis; a farmer with a high educational attainment is less likely to implement a process innovation. This can possibly be explained by several reasons; a high educated farmer has more possibilities to assess risks with respect to innovation and therefore is innovating less. Achieving a higher degree of education increases the likelihood, at least theoretically, of being well informed with respect to the opportunities and threats of innovations. So the number of innovation is maybe lower, while the quality of the innovation is higher (see paragraph 7.2). Further can it be the case that farmers with a higher education do have another concept of process innovation. This can lead to lower reported process innovation; again this is because of the self-reported levels of innovation of the enquiry of the LEI institute.

Hypothesis VI states that agricultural firms that have few connections with external sources of knowledge are less likely to innovate. The coefficient in the model with respect to product innovation shows a value of 0.2947 and a p-value of 0.108. The significance threshold is not met, so the outcome of the model does not significantly support the hypothesis. The relationship in the process innovation model is positive and significant. The coefficient is .447 with a p-value of 0.000. Indicating the same positive relationship as described in the case of product innovation. The evidence in this research indicates a negative relationship.

Further are the subsectors in which the farm is active included as a control variable, to verify the impact of the primary farming activity on innovation. The hybrid sector is used as a comparison, because this indicates the most heterogenic farming activity. The greenhouse horticulture vegetables and the fruit sector show a (very) positive coefficient (1.920 and 1.695) with significance levels of respectively 0.000 and 0.013 a strong indication that being a farmer in this subsector increases the likelihood of product innovation. On a 10% significance level is the dairy subsector also significant. With a negative coefficient of -0.912 is the likelihood of implementing a product innovation by a dairy farmer less likely than a hybrid farmer.

In the model of process innovation are also sectoral variables included. Interesting to observe is the difference between sectors. Benchmarked against the hybrid farms is the greenhouse horticulture flowers & plants significant on a 5% level (0.045) and the coefficient is positive (0.552). This implies an increased likelihood of innovation, when being a farmer of this type. For dairy farmers the coefficient is negative (-0.472), but significant on a 10% level (0.053). The negative coefficient shows that being a dairy farmer does decrease the likelihood of being involved in process innovation. The subsectors fruit and pig are close to significant, however cannot be interpreted properly.

The outcomes of the different hypotheses are shown in an overview, see figure 37. Based upon the model used it is possible to state whether or not evidence is found in favour or against the hypothesis. This is indicated by a '+', if supported; by a '-' if rejected or a '0' if the desired level of significance is not met.

Figure 37: Overview with respect to hypotheses

Conclusion		
'+' indicates significant support in favour of the hypothesis '0' indicates no significant results '-' indicates significant support against the hypothesis		
Hypothesis	**Product innovation**	**Process innovation**
I	**0**	**0**
II	**0**	**+**
III	**-**	**-**
IV	**0**	**+**
V	**0**	**-**
VI	**- / 0**	**-**

These outcomes can provide the necessary insight for answering the main question of this thesis. The role of profit regarding innovation in the agricultural sector is inconclusive. There is not found convincing, significant, evidence to verify whether or not the hypothesis is correct. Additional research is required to provide sufficient insight.

The size of the farm is of partial effect on levels of innovation, stimulating the scaling up in the agricultural sector has consequently some positive effects on innovation. However, without a proper measure for the relative size of an agricultural farm, this explanatory determinant should be interpreted with large caution.

The legal form is an issue with a clear outcome. It is most likely that the limited liability, as a benchmark variable, is considered to be more innovative than the other legal types. This is mainly because of the presence in Dutch law of liability exonerations for the limited liability company. Due to the fact that innovation is associated with taking risks, it makes sense that innovation is more frequently done in this type of legal form.
The effect of older entrepreneurs active in a farm is partially present. Stimulating policies with respect to lessen the participation of elderly in farms can be of partial positive influence on innovation. Improving the height of education among farmers should not be a necessary goal, because there is no proven significant positive effect of high education and innovation levels. Finally is the contact with external sources of knowledge indispensable for higher levels of innovation. If farmers do have contact with these external sources the likelihood of innovation increases.

The subsector in which a farm is active is also important regarding the likelihood of innovation. Depending on the type of innovation are there noticeable differences across subsectors.

7.2 Policy recommendations

As stated in the introduction the aim of the Dutch government is to increase the levels of innovation in the Dutch agriculture. Furthermore the innovativeness of a firm should determine the size of governmental subsidies. The aim is around the 15%. As can be concluded based upon this research this is a rather high target. If the levels of product innovation and process innovation are analysed it is seldom the case that a subsector achieves innovation level higher than 15%. The policy intention to achieve this percentage is not in accordance with the results found in this research and the underlying dataset. Instead of focusing on 'output' the government should aim for the quality of innovation and a more focus policy of innovation. Especially the greenhouse horticulture sectors and the outdoor horticulture are successful in implanting innovations. The government therefore should consider to what extent different subsectors should be supported and how policies should be implanted. There is a substantial difference between the subsectors; too aggregated policy aims are therefore not recommended. A policy focus on the different strengths and weaknesses of the different subsectors should have priority. Further is the stimulations of connections with external sources of knowledge a good starting point for increase overall levels of innovation, apparently are farmers more inclined to innovate when they have linkages with other sources of knowledge. Improving the knowledge exchange and the linkage between farmers is therefore a good stimulator for innovation.

Finally it is important to realize that the attempt to stimulate 'innovation' is rather difficult and problematic, because of the broad concept it contains. As can be seen in this research is there an apparent difference between process and product innovation. For the government it should be wise to distinguish clearly between types of innovation and with policies trying to influence types and appearances of innovation rather than generalize innovation too much. Not only individual farmers benefit from a more specified approach, but also the government because it is more able to quantify the levels and success rate of innovation.

7.3 Limitations and points for further research

One of the major problems regarding the dataset is that the innovation is self-reported. A farmer decides whether or not he has innovated. Problematic is that every individual has another perception with regard to innovation. This leads to a subjective measurement, which can be problematic for the interpretation of the data. As described in paragraph 3.1 there are several regions of agriculture to distinguish in the Netherlands. In the south-west, for example, is the arable sector important, while in the east there is a dominance of more animal orientated farms. Further research between the geographic localization and innovation can provide interesting insights; especially with respect to the historical differences between the areas should different levels of innovation be observable.

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V Appendices

Appendix I: Hausman-test, product innovation

	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
arable	14.83571	-.449323	15.28503	1371.514
greenhouse~r	31.02081	1.919559	29.10125	2922.165
greenhouse~e	14.63402	.4623955	14.17162	1679.079
outdoor	.0539167	.3579489	-.3040322	1.465012
dairy	-15.59955	-.9122047	-14.68734	1012.692
cattle	-14.78992	-.1709401	-14.61898	1012.691
poultry	-.6519575	.5201604	-1.172118	2549.309
pig	.380242	-.3375926	.7178346	1.331788
Profit	-7.39e-07	-5.73e-07	-1.66e-07	4.19e-07
educhigh	-14.31077	.165892	-14.47667	1137.819
Family_par~p	-.0674999	-.760814	.6933141	.9872487
Sole_propr~p	-1.176384	-.7383737	-.4380103	1.108212
Partnership	-2.530689	-.5420308	-1.988658	1.305616
Surfaceare~a	.0464246	.0024462	.0439784	.0224234
Numberoffa~s	.1853563	-.0833943	.2687506	.4974722
Ageoldestf~r	.014385	.0049682	.0094168	.0426376
Samenwerki~d	.2851357	.2946876	-.0095519	.1390708

```
                b = consistent under Ho and Ha; obtained from xtlogit
 B = inconsistent under Ha, efficient under Ho; obtained from xtlogit

Test:  Ho:  difference in coefficients not systematic

          chi2(12) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                   =        4.75
        Prob>chi2 =      0.9659
```

Appendix II: Hausman-test, process innovation

	(b) fixed	(B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
arable	-.3472307	-.2817964	-.0654343	.6933477
greenhouse~r	-.4356466	.1870669	-.6227135	1228.288
greenhouse~e	-14.64067	.552231	-15.1929	1031.789
outdoor	-14.61408	.0765132	-14.6906	1031.788
dairy	-.4319205	-.4718838	.0399633	.5855829
cattle	-.582518	-.3138453	-.2686726	.5837918
poultry	-.6597506	-.1180504	-.5417002	1.195929
pig	.4855981	-.4338335	.9194316	.9857966
Profit	-2.08e-07	-3.97e-07	1.89e-07	1.07e-07
educhigh	-1.719892	-.4608094	-1.259082	.8028649
Family_par~p	.041239	-.2875803	.3288193	.5173838
Sole_propr~p	.1419256	-.5057148	.6476404	.6695319
Partnership	.5232244	-.1366532	.6598777	.6023934
Surfaceare~a	.0180262	.0048273	.0131989	.0073723
Numberoffa~s	.0551815	.2065846	-.1514031	.2231539
Ageoldestf~r	.0230299	-.0296031	.052633	.0157701
Samenwerki~d	.4305259	.446551	-.0160251	.0743519

```
                b = consistent under Ho and Ha; obtained from xtlogit
 B = inconsistent under Ha, efficient under Ho; obtained from xtlogit

Test:  Ho:  difference in coefficients not systematic

          chi2(12) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                   =        5.32
        Prob>chi2 =      0.9466
```