Determining the inventiveness of organizations

An explorative case study in the pharmaceutical industry

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I hope you all enjoy reading this research paper!

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Management Summary

Inventiveness is defined in this research as “a measure for originality by the virtue of new ideas derived through a process of invention”. Research has shown that patent data is the most adequate measure for inventiveness within the scope of this research. A constraint coming with this decision is that inventiveness will only be measured in the ideas that are patented by the company, leaving other possible interesting inventions out of the research scope.

Firm characteristics that influence inventiveness within organizations are often presented through the use of categories. This research project has identified four categories which are; contextual variables, structural variables, cultural variables and resource variables. Per category different variables have been investigated from the internal environment of the firm. All characteristics that have some relation with the external environment have been left outside the research scope.
For each researched firm characteristic a relationship with inventiveness was sought en identified. In total 16 characteristics have been found and were visualized in table 2.1. The next step was to construct a theoretical framework which has functioned as the dependent theorem in this research. Additional literature per characteristics was sought to determine what the exact effect on inventiveness was and how it can be measured in companies. For some characteristics the decision was made to group items together since the appropriate measures showed too much resemblance or the expected effect was after all not clear enough. From the literature it can be concluded that the following eight firm characteristics affect inventiveness positively;

1. Firm size *(contextual)*
2. Firm age *(contextual)*
3. Centralization *(structural)*
4. Formalization *(structural)*
5. Intra-firm Linkages *(structural))*
6. Specialization *(resource)*
7. Slack resources *(resource)*
8. R&D intensity *(resource)*

To add precision to the work the theoretical framework has been tested in an empirical setting. The chosen research strategy is an explorative case study. Since the external environment was left outside the research scope it was important to control for any external factors and therefore the cases were selected from the same industry. The author chose pharmaceutical companies because of the measure for inventiveness; applied patents. The literature study has shown that some organizations do not patent their novel ideas but make it a company secret. Since pharmaceutical companies are in a knowledge intensive industry and work with highly specified production processes which are difficult to copy and therefore the willingness to patent is high. The selected organizations are; Abbott Laboratories, GlaxoSmithKline, Merck Sharp & Dohme, Ursapharm Arzneimittel GmbH.

For the empirical research one equation was put central; $X_1 + ... + X_8 = Y_n$. Where the X values represent the eight found firm characteristics and Y represents inventiveness measured in patent count over the period of ten years. All values have been operationalized into measurable objects and fixed performance categories have been established. These performance categories where build out of five blocks where category A consists of the most ideal performance situation and category E consists of the least ideal situation. Four interviews are held, one per case, to gather data on the performance of the cases on the eight firm characteristics that foster invention. Since this is an explorative research data was primarily used to visualize measurement on the characteristics.

Performance has been scored per company and eventually an average performance percentage per company was derived. This means that it was calculated to what percentages the different cases comply with the ideal situation build from the literature study.

Evaluation has occurred through ranking these percentages and comparing this to the patent count over a set period. In total 185 different equations were constructed and an analysis was done for equal distributions of X-values and in equal distribution of X-values where relative weights are taken into account. Based on the thorough literature study it is expected that the performance ranking and a ranking of patent counts follow the same structure. It must be concluded from the results that none of the 185 equations resembles this expected distribution and therefore the efficiency of the model cannot be tested. Explanations are found in literature where other authors state that research on invention studies are often difficult to study in an empirical setting due to the effect of the complexity of invention, no invention is the same so why would the effects be?

Failure of testing the model must be brought down to two levels, either data is inaccurate or the model is inaccurate. A general conclusion that can be made is that the dataset is too small for drawing solid conclusions on the working of the model. An analysis of the potential causes of the failure of testing the model has resolved in the following conclusions which are here described as recommendations for further research:

- Use a larger sample set for the empirical research which enables the analysis of data with proper statistical means and increases validity of the research project.

- Make use of different techniques when exploring the case study to increase data reliability. It is recommended to combine a broad survey with an in-depth interview to gather all information necessary to test the model.

- Apply methods to measure on accurate relative importance levels instead of modelling these in the analysis phase. This can be done through using multivariate statistics like the discriminant function analysis, which are used when there are many independent variables and/or many dependent variables which are correlated to different degrees.

- Measure for the (negative) effects of firm age and alter the operationalization or delete firm age as a characteristic.

- Measure on the quality of the firm characteristics X_5, X_6, X_7, X_8, instead of solely measuring on the existence within the organization.

- A thread of working with innovation theories is that no invention is the same, therefore the effect of firm characteristics will have a different impact per type of invention (Subramanian and Nilakanta 1996). In a future study it is recommended to take upon a differentiation between types of invention so one can more specifically state which firm characteristics are effective in predicting inventiveness.

Table of contents

1. Introduction 8

1.1. Research objective 9

1.2. Research strategy 9

1.3. Research planning 11

2. Literature study 12

2.1. Inventiveness 12

2.2. Firm characteristics that drive inventiveness 17

2.2.1. Contextual variables 18

2.2.2. Structural variables 21

2.2.3. Cultural variables 23

2.2.4. Resource variables 24

2.3. Constructing the theoretical framework 27

3. Methodology 35

3.1. Operationalization of the research variables 35

3.2. Method of disclosure 39

3.2.1. Interviewing 39

3.2.2. Secondary data analysis 40

3.3. Evaluation of the results 40

3.4. Validity and reliability 42

4. Empirical study 44

4.1. Case 1 Abbott Laboratories 44

4.2. Case 2 GlaxoSmithKline 47

4.3. Case 3 Merck Sharp & Dohme 50

4.4. Case 4 Ursapharm Arzneimittel GmbH 52

5. Results 56

6. Conclusion 66

7. Discussion 66

References I

Appendices V

Appendix 1 Interview Scheme V

1. Introduction

Innovation is the process of translating ideas into useful new products, processes or services (Tidd et al. 2009). Innovation is composed of the generation of an idea and the conversion of that invention into a useful application. It represents the opportunity to grow and survive and it provides the occasion to significantly influence the direction of an industry (Jacobs 2007). When viewing innovation in a macro perspective it can be said that it is a critical dimension of economic change. According to the Schumpeterian view economic change revolves around innovation, entrepreneurial activities and market power. For that reason innovation is often seen as the motor for economic change and regarded as a necessity for prosperity (Schumpeter 1934).
Innovation is commonly applied within business level strategies where it is used to achieve competitive advantage (Johnson et al. 2008). It depends on the capability to see connections, to identify opportunities and to take advantage of those situations (Tidd et al. 2009). Past research has shown that the stimulation of innovation can be a boost for economic change (Johnson et al. 2008, Tidd et al. 2009, Schumpeter 1934). When determining whether the stimulation of innovation is indeed necessary it is crucial to have information about the level of innovation within organizations in a nation. Consequently, when one knows what determines the innovative behavior of a single firm one can develop highly specified strategies for improving innovation and bring about economic change. Therefore, it would be interesting to be able to determine the levels of innovation within organizations e.g. innovativeness of organizations.

A crucial first step for innovation is the actual invention of the prospering ideas. Inventions typically possess a level of newness and represents an explorative step forwards (Smith 2010). It is important to make the distinction between invention and innovation, since the first refers to development of ideas or the act of creating something new. While the latter refers to the commercialization of this invention (Ahuja and Lampert 2001). It is important to notice that innovation cannot occur when there is an absence of a novel idea. From this perspective invention is seen as a necessity for, and a manner to herald innovative behavior. In 1934 Schumpeter states that the economic structures must be foremost developed from within the industries through the invention of better and more effective products, processes and services. Therefore this research project will put emphasis on this constant development by focusing on invention within organizations instead of the (often outsourced) commercialization processes that lead to the concept of innovation. As Arthur (2007) proposes in his research paper invention is the least studied subject in innovation studies, but by no means are theories or scientific literature absent. According to Zaltman et al. (1973) in scientific literature invention is often used as a synonym for innovation (or vice versa), which means that authors arbitrarily use the concepts within scientific articles. With this statement the suggestion is made that often literature about innovation is also applicable for invention studies. Within this research project invention is seen as the prelude of innovation, therefore literature on the initiation of innovativeness can be used for investigating the concept of inventiveness too (Kim 1980).

The focus within this research project is on determinants of inventiveness within organizations. According to van Beers et al. (2008) the level of inventiveness is directly influenced by the internal organization of the firm. The external organization in return has obviously an indirect influence on inventive behavior (Beers et al. 2008). This research project will focus on the effects of the internal

organization and will leave the external environment outside the research scope. The question that then arises is which factors of the internal organization are determinants for the level of inventiveness of a firm? A considerable number of researchers have focused on the driving forces behind invention but little is known about the specific firm characteristics that foster inventiveness (Subramanian and Nilakanta 1996, Damanpour 1991). When one knows which firm characteristics enhance the chances for successful inventions, one can use this in advantage to try to stimulate innovation and ultimately bring about economic change. To contribute to scientific research on invention this research project will focus on investigating those firm characteristics that determine inventiveness of an organization.

1.1. Research objective

This research project will focus on identifying firm characteristics that determine inventiveness of organizations. The primary focus is to investigate firm characteristics and their influence on the inventiveness of an organization. The secondary focus is to evaluate whether inventiveness amongst organizations can be predicted using this set of firm characteristics.

This project contributes to science since it brings driving forces of invention together under one noun; firm characteristics. Research so far is limiting this overview since most authors discuss a single driver of innovative behavior in their research; like research and development (R&D) facilities (Harmsen et al. 2000), company size (Chandy and Tellis 2000) or the formation of alliances (Man and Duysters 2005).

The Central question

What firm characteristics determine the inventiveness of organizations?

The sub questions

1. Which firm characteristics that foster invention can be extracted from scientific literature?

2. Are the firm characteristics extracted from literature able to efficiently predict inventiveness?

1.2. Research strategy

The chosen strategy for this research will be a thorough literature study combined with an explorative case study, where the outcomes of the literature study will be briefly tested in an empirical setting. This research project aims to define the relationship (X_1+...+X_n = Y) between 'firm characteristics that foster invention' (X_n) and the 'Inventiveness of an organization'(Y). Several steps have to be taken to fulfil the purpose of this study. The research framework in figure 1 gives an overview of these steps and describes in which research phase the proposed sub questions will be answered.

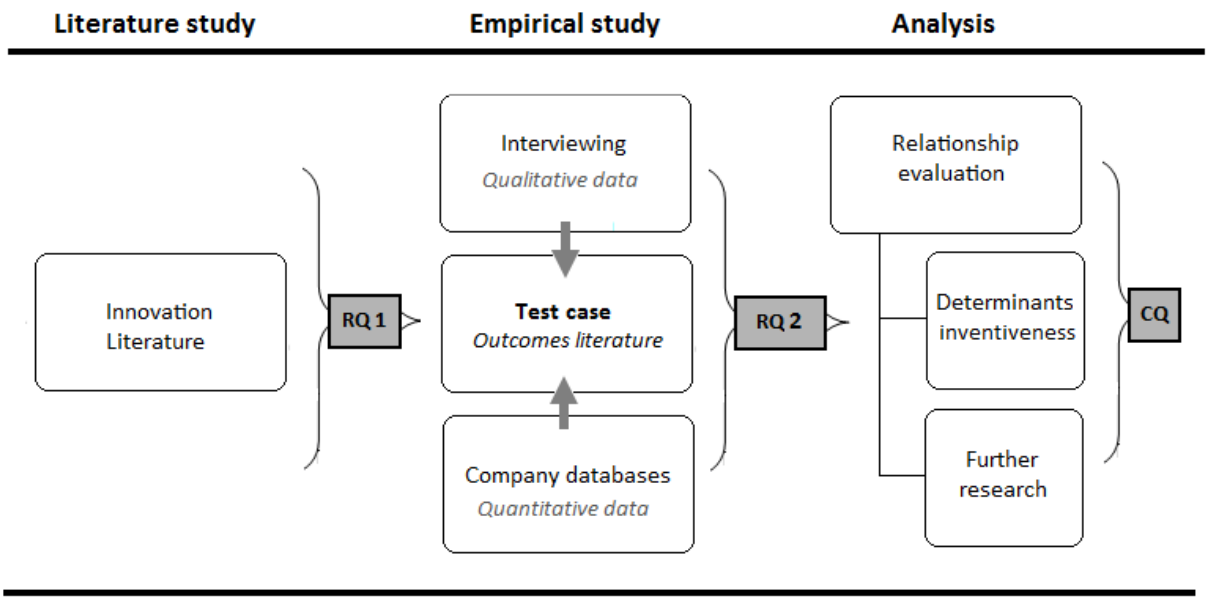

Figure 1: The research framework

Phase 1 - Literature study

To add precision to my work one must first create a better understanding of the concept of inventiveness. To be able to determine inventiveness in organizations one must investigate **literature** and search for those firm characteristics that foster invention. This research will only focus on (internal) firm characteristics since research by van Beers et al. (2008) has shown that inventiveness is directly influenced by the internal organization of the firm therefore aspects of the external environment will be left outside the research scope. The deliverable of this phase is a theoretical construct that contains a number of characteristics that have a positive relationship with inventiveness.

Phase 2 – Empirical study

When the variables of the equation are known (e.g. The characteristics that foster invention and the concept of inventiveness) the study has to be brought to the next level where actual cases are studied and the theorem will be tested in a practical setting. With an explorative case study the researcher tries to get a first understanding of an object or process within a restricted amount of time (Verschuren and Doorewaard 2005). The explorative part means that the researcher will broadly investigate a new theme in research (or a theoretical construct) to evaluate whether it is interesting to investigate the subject more thoroughly. A case study is characterized by a small number of research units, a labor-intensive approach that provides an in depth view of the case, a selective sampling strategy, qualitative research methods and an open observation on location.

A selective sampling strategy will be applied to find **four companies in a similar industry**. This similar industry is important because it has been defined that external environments will be left outside the research scope. Therefore it must be assured that this environment has little influence on the test cases. This can be assured when companies are from the same industry because one may expect that they are subject to similar external influences.

Firm characteristics found will be conceptualized into a measurable object. The next step is to operationalize these concepts, this means that the researcher defines performance levels per characteristic into set categories. For example when school grades of employees influence inventiveness one must first conceptualize which measure will be used (high school vs. university grades) and the operationalization will contain the categorization of grades into effect categories (Grade 8 till 10 = category 5 "perfect match"). Based on the effect categories set in the operationalization it can be determined what a case's match is with the theoretical construct. In other words it will be measured in what degree the characteristics of a case company comply with the found firm characteristics that foster invention. This percentage can be quantified by Y the measure of inventiveness and analysis can be made.

The data on the performance of the four case companies on the firm characteristics must be gathered in two different ways. On the one hand it may be expected that there will be quantitative data necessary such as net income or R&D expenditures but it may also be expected that qualitative data will be necessary for example on the company culture. Therefore two different methods of information disclosure will be applied; **interviewing** for the qualitative data and **secondary data analysis** through the use of public company databases for the quantitative data.

The selection of the case companies will be done after the literature study has been carried out because insights from this research can aid in the decision making process. The decision will be detailed in the methodology chapter of this research paper.

Phase 3 – Analysis

The last phase consists of a combination of the outcomes of the previous two phases. Phase 1 has sought for a theoretical construct e.g. the relationship that must be investigated. Phase 2 has sought for practical evidence to confirm or to disprove this theoretical framework. The deliverable of this phase is the **evaluation** whether the set of firm characteristics defines the level of inventiveness of an organization.

1.3. Research planning

The research planning section describes in which order and what time the research will be executed. In table 1.1 the research project is split up in sections which will guide the project in steps. These steps consist of the research phases described in section 2.3 supplemented with some necessary features that do not answer a specific research question but aid to the project since they provide necessary background or support information.

Table 1.1: Phases of the research project

Project steps	Research question
1. Introduction	
2. Literature study	Answers Q. 1
3. Methodology	
4. Empirical study	Answers Q. 2
5. Results	
6. Conclusion and Discussion	Answers Central Research Question

2. Literature study

In this chapter the literature study necessary to answer sub question 1 will be carried out.
The sub question is formulated as;

Which firm characteristics that foster invention can be extracted from scientific literature?

The findings of this literature study provide a theoretical answer to the proposed equation of Xn = Y. Where the values for X are specified as the firm characteristics that drive inventive behavior and the value for Y is specified by means of a measure for inventiveness. To add precision to the work this chapter will start with creating a thorough insight into the concept of inventiveness (2.1.). Then the research question can be answered by finding firm characteristics that determine inventiveness (2.2.).

2.1. Inventiveness

This section is aimed at revealing what inventiveness is and how this can be measured. The purpose of retrieving this information is to find an objective measure for inventiveness which can aid in the evaluation of the firm characteristics and their significance or effect in determining inventive behavior. This section will discuss the concept of innovation and its dependent relationship with invention and will then move towards the concept of inventiveness.

Innovation vs. Invention

Nowadays growing attention is spent on innovation as a critical success factor for sustaining competitive advantage within organizations (Rhee et al. 2010, Subramanian and Nilakanta 1996, Hult et al. 2004). The adoption of innovative ideas is generally intended to contribute to the performance or effectiveness of a company. The capacity to innovate is amongst the most important factors that impact business performance (Hult et al. 2004). Therefore, innovation is widely seen as the key ingredient for business success. According to Porter (1990), innovative behavior, continuous improvement and change are the three cornerstones leading towards global competitiveness (Porter 1990). Broadly stated, an innovative economy is seen as crucial to realizing social and economic prosperity for its nation (Rogers 2004).

According to Zaltman et al. (1973) the term “innovation” is used in scientific literature in three different contexts:

1) Synonym of invention
2) Synonym of new ideas
3) Process of new idea development & implementation

In the first context innovation is referred to as a creative process by which two or more concepts are combined into a new configuration. The second approach labels very novel ideas with the term innovation, and the latter uses innovation to describe a multidimensional process whereby an individual or a system develops and implements a new idea into the organization (Kim 1980).

Although the first context - were invention and innovation can be used arbitrarily in an article- would have been an easy research assumption, since then all literature from both contexts could be multi applicable for this project, the author regards the third context as most applicable. Innovation is in this research seen as a process which is constituted of different phase, where there is an invention of

a solution to some kind of a problem or need, the commercialization of this idea where it is developed and produced and finally the diffusion meaning that the solution is put into the market and value can be obtained from it (Smith 2010).

Figure 2 provides an overview of the innovation process as provided by Smith, 2010. Innovation literature is saturated with variations in models that represent some aspect of innovation. These variations stem largely from differences in terminology and perspective than that they really vary from what they try to convey as information.

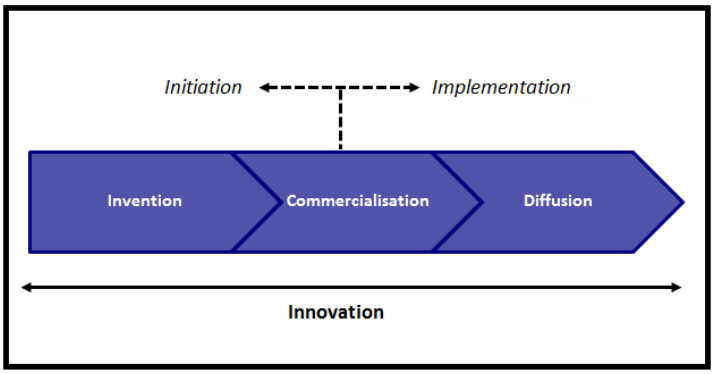

Figure 2: The innovation process (Adapted from Smith, 2010; Kim, 1980)

Most of the models imply two major stages; (1) the initiation stage which is based upon the principle that awareness must be raised, alternatives must be sought and all these concepts must be evaluated on their feasibility. The second stage (2) consist of the implementation of the concept which means that the idea is put into operation, routines are developed and stabilization is pursued (Kim 1980, Zaltman et al. 1973). According to Damanpour and Gopalakrishnan (1998) a categorization based on initiation and implementation is consistent with an approach called the 'ambidextrous theory of innovation'. This theory is built on the principle that a process consists of pre-adoption activities involved with idea generation and the activities that facilitate the implementation of that idea combined with diffusion afterwards. In figure 2, the dotted vertical line represents the decision to adopt, activities before this point are believed to be idea generating or developing (Kim 1980). According to Smith (2010) activities in this phase are the ones that are most commonly associated with innovation.

Invention

Idea generating and developing activities have been studied for years under the collective noun of invention. Nearly a century ago research by Usher (1929) defined that "at the heart of invention is an act of individual insight in which the essential solution to a problem is derived". The same author staged the process of invention as the perception of some kind of problem, an act of gratification revealing data essential to finding a solution to that problem, recombining that data and eventually critical revision of the solutions that must be mastered (Usher 1954).

Nowadays our perception of invention is widened, as Rhee et al. (2010) stated "The starting point of invention is the creativity by individuals and teams". Literature acknowledges that invention itself is a complex process and difficult, but certainly not impossible, to conduct by individuals. Even Usher spoke in 1929 about a " fortuitous configuration in events" were the individual is presented with data essential for arranging a solution, very often these fortuitous events consist of human interactions (Arthur 2007).

Also for invention numerous different definitions are proposed over the years. Again they may vary in wording but their message is moreover the same. A solid definition is provided by Schmookler

(1966) who describes an invention as: “A new combination of pre-existing knowledge which is not obvious to one skilled in the art at the time the idea is put forward and which satisfies some want”. The latter part of the sentence can be seen as a claim for prospective utility, something can be novel but if it does not serve a purpose there is no prospective utility, and vice versa.

According to Arthur (2007) invention can occur in two different ways as displayed in figure 2.1.

1. The recognition of a need

The invention is then finding a solution to satisfy this need for a better utility. For example Bob Kearns who was driving in his car and noticed that when there was only mild rain the window wipers where working at full speed causing a lot of inconvenience and noise. His invention was a windscreen wiper that works with an interval to adjust to the intensity of the rain (Smith 2010). When invention starts with need recognition a question arises that can be initiated by a number of circumstances, f.e. irritation, an economic opportunity or recognition of a potentially lucrative market. Very often this need is stimulated by an outside incentive (Schmookler 1966). Generally the need is known to some practitioners but is left untouched because no clear solution is evident. Invention starts from a point were limitations are present but quickly transform into a set of desirables for the solution (Arthur 2007). As seen in the example of Bob Kearns, he starts with an inconvenience that the windscreen wipers are moving way to fast but then moves to the desire that he wants to adjust the speed of the wipers. The next step is to scan possibilities that, with further development, will satisfy the desirables of the inventor(s). Such possibilities are often borrowed knowledge, they are appropriated from what already exists; be it other devices, methods or phenomena (Arthur 2007).

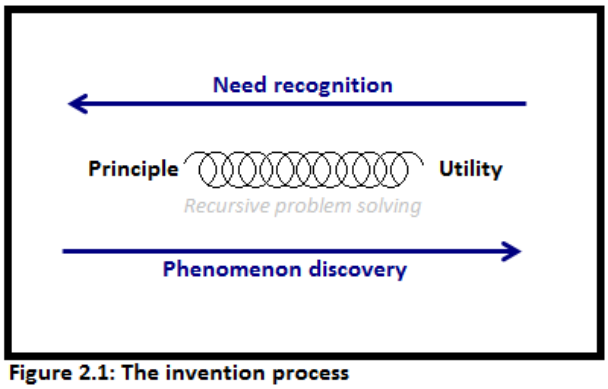

Figure 2.1: The invention process

2. The discovery of a phenomenon

The invention is then finding an application for the phenomenon discovered. For example like the invention of penicillin on a group of staphylococci bacteria by Alexander Flemming. With help of a colleague he investigated this then unknown group of fungi and invented the use of penicillin as a tool for diagnosing influenza (Smith 2010).

When the invention process is initiated by the discovery of a phenomenon one has to search for a purpose to generate value from this discovery. Were the prior process searches for a principle to realize a certain desire, here the inventor(s) is (are) faced with a principle without a utility to serve. Most phenomenons are discovered while searching for some kind of principle and the inventor notices the phenomenon. One must understand that it is one thing to even notice the phenomenon but the biggest challenge comes with deriving a principle and a utility for it (Arthur 2007). For example when X-ray was discovered and its inventors revealed its true magnitude the principle of scanning bones needed to be sought and a utility was found to do health check-ups.

The point that should be remembered from these two approaches is that invention is primarily a process of recursive problem solving (Smith 2010). Each stage of this process requires matching a

need to some kind of principle in use, bringing about new problems and sub problems that must be solved. Often solving these steps in between absorb most of the inventor's time. Because each sub problem entails a non-standard solution which is a mini invention of its own, leading towards a long chain of experimentation (Arthur 2007). In order to endure this process the inventor must use his accumulated knowledge. Conclusively, both wants (need or phenomenon driven) and accumulated knowledge are necessary for invention. Without the want there is no problem and without knowledge it cannot be solved (Schmookler 1966).

Inventiveness

The capacity to originate new ideas is often defined as inventiveness (Rhee et al. 2010). Therefore, a company who often makes use of the invention process scores high on the scale of inventiveness. According to Hult et al. (2004) inventiveness is one of the factors over which management has considerable control and it is seen as a prerequisite for a firm's success. High levels of inventiveness are believed to lead to enhanced organizational performance since they directly influence the levels of innovation in a company (Subramanian 1996). In this research project inventiveness is defined as: *'a measure for originality by the virtue of new ideas derived through a process of invention'*

Literature introduces various quantitative measures for innovation studies, the most common are:

A. The number of applied patents (Kleinknecht et al. 2002, Schoenmakers and Duysters 2010)
B. The percentage of granted patents on overall patent application (Kleinknecht et al. 2002)
C. The number of new product launch announcements (Kleinknecht et al. 2002)
D. The percentage of innovative sales in total sales (Kemp et al. 2003)
E. The number of established projects in one year (Kemp et al. 2003)
F. The percentage of expenditures on R&D in total sales (Kleinknecht et al. 2002)

When measuring inventiveness a researcher tries to quantify the virtue of ideas that are derived through the use of the invention process. The most dominant approach in invention studies is to count the number of ideas based on the number of patents a company holds A. (Schoenmakers and Duysters 2010). The emergence of patent databases has improved the opportunities for research to withdraw information from the patent driver. Opponents argue that standing alone patent information is no accurate indicator for innovativeness since not all inventive ideas are necessarily patented and moreover many patents are never translated into commercially viable products (Griliches 1990). When using measure B. the same arguments hold as those against the use of patent data.

For measure C. the deficiency holds that one can argue whether all new product introductions are invention; for example when a diary producer launches a new flavor of yoghurt. When reviewing what is learned about invention; that it must encounter some prospective utility and not obvious to someone skilled in the art, a serious argument is raised against measuring in product launch announcement. Because the new flavor of yoghurt is very obvious to a dairy producer and there is no prospective utility for the client other than flavor. Therefore it must be said that when working with invention studies new product announcements is an insufficient measure.

For measure D. and E. both arguments contradicting its efficiency can be named. Since invention focusses on the idea generation and development no product is commercialized yet, which means

that there are no innovative sales and projects are open so neither established projects can be counted. R&D activities (measure F.) are seen as an input of the innovation process (Kleinknecht et al. 2002). Inputs are less reliable as indicator since the user can employ the input more or less efficient. Consequently, R&D expenditures as a performance measure is biased.

Based on this evaluation of possible measures for the inventiveness of organizations it must be said that measure A. is the most appropriate one for this type of research. The purpose is to have an objective measure that can aid in the evaluation whether a set of firm characteristics is able to determine the inventiveness of an organization. Before a patent is granted it is reviewed whether the product is indeed novel, non-trivial and useful and therefore the requirements of Schmookler (1966) for invention are met. Consequently, in this research project only patented ideas will be used when discussing the concept of inventiveness. A consequence of this decision that potential viable other inventions which are not patented will be left outside the research scope.

Inference; This section has shown that innovation cannot occur without the invention of some novel idea. It has taught the reader that invention exists of an initiation phase and an implementation phase and that activities in the initiation phase can be described as the invention process. It has been explained that the invention process can take place from need recognition or the discovery of a phenomenon but that the desire for a principle or utility must be present. Inventiveness is defined 'a measure for originality by the virtue of new ideas derived through a process of invention'. Research has shown that patent data is the most adequate measure for inventiveness within the scope of this research. A constraint coming with this decision is that from now on inventiveness will only be measured in the ideas that are patented by the company, leaving other possible interesting inventions out of the research scope.

2.2. Firm characteristics that drive inventiveness

In the previous section it became known that inventiveness is a measure for originality by the virtue of ideas generated through a process of invention. Also, Inventiveness is a prerequisite for a firm's success and competitive survival. But when reviewing organizations in similar task environments some firms are thought of to be more inventive than others. So when the external environment is similar the variation must be created through differences in the internal organization of the firm. Various authors see the appearances of an invention, such as incremental vs. radical or administrative vs. technical, as important explanations for differing factors of inventiveness (Hage and Aiken 1967, Beers et al. 2008). Research on the variance in inventiveness per organization, has moreover shifted towards the characteristics of inventive companies. Research so far has learned that structural properties are highly associated with organizational invention, whereas individual characteristics or attitudes within the organization seem to bring about contradictory and inconclusive results (Kim 1980, Subramanian 1996, Damanpour and Wischnevsky 2006). An interesting remark is raised by Subramanian (1996), this author states that since inventions are hardly similar, organizational characteristics probably have different impacts on the several types of invention. Leading towards a proposition that different firm characteristics will have different effects on the inventiveness of an organization.

This section will contribute to the stream of research on the variances in inventiveness per company. The main aim is to investigate which firm characteristics can be found that foster invention and what the direction of the relationship is. The impact of this decision contains that all aspects regarding the external environment of an organization will be left out of the research scope. It is important to first review all possible characteristics and then select the most plausible for empirical research. Selection will be done based on literature and criteria described for the invention process in section 2.1.

Firm characteristics that influence inventiveness within organizations are often presented through the use of categories. Research on influencing factors of the internal organization is dominated with a focus on structural variables and contextual variables (Hage and Aiken 1967, Subramanian and Nilakanta 1996, Walker 2007). Meaning that most authors try to link inventiveness to the **structure** of an organization. With **contextual** variables one must think of those characteristics on which the organization can hardly make a choice for they are more or less given, or developed over time like the age of a company. Research by Walker (2007) identifies that structures are necessary to create an internal environment favorable to the generation and prosperity of new ideas. But one can argue 'what is a favorable internal environment for invention'? This question has all to do with the company **culture**. Since this research aims to provide a complete overview of firm characteristics influencing inventiveness, culture is also seen as a category (Koberg et al. 2003). A company with a structure that fosters invention, the contextual aspects that are well suited for invention and possess a company culture which is favorable for inventive behavior is not assured that successful invention will occur. What a company needs is a means to deploy the actual inventive behavior. According to Wan et al. (2005) "Failures in invention are often handicapped by a lack of appropriate resources". Therefore a fourth category will be added which consist of **resources** that allow for innovative behavior. In this research project we define four types of determinants of inventive behavior; Contextual variables, Structural variables, Culture variables and Resource variables. Firm characteristics that influence inventiveness will be assigned to one of these four categories.

2.2.1. Contextual variables

In the previous paragraph it was mentioned that contextual variables are those aspects on which a company has little direct influence (Kim 1980). Company characteristics which are commonly attributed to this category are; firm size and age (Subramanian and Nilakanta 1996). In the first section of this literature study we learned that invention is built up of a desire to want something and the accumulated knowledge to solve this want (Schmookler 1966). The age of the company is correlated with the accumulated knowledge that has been bequeathed and therefore firm age and size have to be considered as determinants for inventive behavior. The same line of argumentation holds for CEO age and tenure (Koberg et al. 2003). One can argue that the age or tenure of a CEO can be managed by a company but in practice little companies directly steer these numbers. Therefore CEO age and tenure are seen a contextual variables.

Consequently, there are four firm characteristics attributable to contextual variables;

1. Firm Size (Subramanian and Nilakanta 1996)
2. Firm Age (Kelly and Amburgey 1991)
3. CEO Age (Koberg et al. 2003)
4. CEO Tenure (Damanpour and Schneider 2008)

The next paragraphs will detail the effect of each characteristic.

Firm Size

The size of an organization has repeatedly been found to influence the propensity of invention (Frambach and Schillewaert 1999). Research by Subramanian and Nilakanta (1996) has shown that firm size directly influences the inventiveness of a company. According to Rogers (2004) organizations with a large volume have strong cash flows which allow them to deploy more inventive projects and therefore have a higher chance for successful invention. These strong cash flows are the result of a large sales volume another advantage of this volume can be found when looking at fixed costs. Large organizations can spread their fixed costs widely over their large sales volume making the overall production cheaper. Consequently, large firms are able to bear costs of potential losses of invention which makes them more willing to take upon risks (Camison-Zornoza et al. 2004). The volume of an organization is often measured in the number of employees. Therefore large organizations have a wide employee base which offers them a wide range of knowledge and skills that can be seen as accumulated knowledge necessary for successful invention (Damanpour 1992). According to Frambach and Schillewaert (1999) large corporations have a high need for invention, they need the novel ideas to support and improve their productivity. Based on this line of argumentation one would suggest that large organizations score high on inventiveness.

Damanpour opposes this line of argumentation in his 1992 article where he investigates the relationship between organizational size and innovation. He states that small organizations are more flexible than large ones since they have shorter lines of communication and decision making process involve way less stakeholders. This high degree of flexibility can also be witnessed in the little core rigidities and path dependencies found at small organizations (Rogers 2004). When an organization is young there is sufficient energy and awareness to recognize opportunities for success. Where employee base is an advantage for large corporations it can also be a benefit to small organizations when changes must be implemented. A small company has a less extensive employee base, therefore it is easier to reach out to them or adjust employee incentives (Damanpour 1992).

Results on the direction of the relationship between size and inventive behavior are inconsistent. There are strong arguments that promote the advantage of large organizations but perhaps as many that contradict them and award the advantage to small or medium sized companies (SMEs).

According to Frambach and Schillewaert (1999) these contradicting findings in the role of size are attributable to the correlation between size and other firm characteristics like the structure or the culture of the organization. Evidently, a firm with over 500 employees is in need of a different structure then a company with only 25 employees. The multidimensional character of innovation and in its place invention is therefore considered by many authors as the reason for contrasting results in invention studies related to size (Damanpour 1992; Subramanian and Nilakanta 1996; Camison-Zornoza et al. 2004). According to Kim (1980) size is the major variable that predicts the patterns of organizational structure. Little empirical research is done were varying firm sizes are compared to inventive characteristics of firms, so no conclusive evidence exist on the correlation of different firm sizes with firm characteristics.

For the empirical phase of this research project it is indeed important to find unambiguous results and therefore another approach is taken for looking at this relationship. Within this project inventiveness is conceptualized as the ideas of an organization that are proclaimed through patent applications. A result of this assumption is that novel ideas that are not patented are left out of the research scope. An advantage of this decision can be used to define the relationship between firm size and inventiveness. Multiple authors have researched the concept of patent propensity (Chen and Chang 2010, Arundel and Kabla 1998, Scherer 1965), this type of research focuses on the tendency of organizations to patent their novel ideas. Several studies have shown that firm size positively affects patent performance and the patent counts of an organization (Scherer 1965). Consequently, although there is no conclusive evidence for the relationship between invention and firm size, when looking at inventiveness as a number of patent counts it can be said that ascending firm size positively influences inventiveness (Arundel and Kabla 1998).

Firm Age

Firm age is a characteristic over which the company has no control at all. According to Koberg et al (2003) with increasing age bureaucratic procedures are installed which constrain invention. When organizations mature they develop routines and a status quo, which have a negative relationship to the inventiveness of a company since they allow for path dependencies and rigidities “we do that like this!”, which blocks the recognition or realization of opportunities (Damanpour and Schneider 2008). Therefore older organizations are less equipped for rapid changes since they have had time to formalize relationships and standardize routines (Kelly and Amburgey 1991). Repercussions can prevent these negative influences, such corrective actions can be the active control of standardization and investment in an innovative culture.

Research by Cohen and Levinthal (1990) provide a different view to the concept of firm age, by introducing the subject of absorptive capacity. They define absorptive capacity as “the ability to recognize the value of new information, assimilate it and apply it for commercial ends”. They argue that absorptive capacity is critical for inventive behavior and that it largely depends on the accumulated knowledge within an organization (Cohen and Levinthal 1990). When organizations mature their levels of accumulated knowledge will increase also . Based on this view it can be said that older organizations have an advantage due to the benefits they gain from absorptive capacity.

Research by Huergo and Jaumandreu (2004) has investigated the role of firm age more thoroughly and found that the youngest firms are likely to display more inventive behavior than the oldest ones due to their ability to identify opportunities and have a fresh look on the industry. An interesting remark is proposed by results from the same research that show that the companies between 20 and 36 years of age are most inventive (Huergo and Jaumandreu 2004). An explanation can be found in the strong connection between inventiveness and firms' long term survival in competitive environments. The companies with lower tendency to invent have stopped their activities by the year of 20. Those that survive the early crisis due to their absorptive capacity will be successful for some years but after the 36th year of existence the status quos and routines start to kick in and firm age and inventiveness are negatively related. Taken these statements from several authors in account it can be said that the relationship between firm age and inventiveness shows an irregular inverted U-shape pattern where the age of 20 and 36 mark the boundaries for the optimum.

CEO Age

Earlier we have learned that invention consists of the components accumulated knowledge and a certain desire or want to fulfill (Schmookler 1966). Management on these components is determining for the inventive capacity of an organization. According to Koberg et al. (2003) managers of an older age are believed to be more competent and have bequeathed knowledge on which they can build. With this accumulated knowledge they are able to identify opportunities (desires) for the organization and able to recognize the value of new ideas or information which is an advantage in the invention process. According to Johnson et al. (2008) there is also a disadvantage to matured ages levels of managers since the accumulated knowledge can transform into knowhow which is in time very difficult to depart from. This line of argumentation is underpinned by Smith (2010) who states that over time the willingness to alter strategies different from the core capabilities decreases due to emotional commitment and the fear of cannibalizing firm' success.

Damanpour and Schneider (2008) investigated the relationship between CEO age and inventiveness and found that when the age of the CEO increases the level of incremental inventions decreases. This effect is caused by the feeling of incompetency of younger managers, also the pressure under which they have to excel limits them to act reckless or take risks which are necessary for inventive behavior. Research by the same authors has also suggested that the relationship between CEO age and Invention follows an inverted U-shape but this was not proven in their empirical research. Research by Jones (2010) has investigated the relationship between age and great inventions. His research showed that 42% of the great inventors of our world have done their invention in their thirties. Quickly followed by 30% of the inventors who were in their forties at moment of invention (Jones 2010). Although this research focused on great inventions or even Nobel priced ideas it can be learned that CEO age probably follows some sort of inverted U-shape only the counter parts are not equally distributed. An explanation for this uneven distribution can be found in the fact that young employees are too involved with getting acquainted with company procedures to take upon the inventors role or participate actively in invention processes (Jones 2010). Based on these insights it is assumed that CEO age in relation to inventiveness of the organization is irregularly distributed over an inverted U-shape.

CEO Tenure

According to Damanpour and Schneider (2008) managers that are new to a position are bringing a fresh view into the company which is in general more objective and therefore will stimulate invention through the recognition of needs. CEO's with short tenure also have to get acquainted with the company which will result in reticent behavior and disadvantages invention. Over time the manager grows in the job and gains accumulated knowledge which is essential for effective invention (Koberg et al. 2003). The CEO knows the company and has vision for improvement which positively affects invention. According to Walker (2007) in time, strong conformation to the job will lead to over confidence of the manager, thinking the best game is played under his supervision and there is no need for change. Based on these statements it can be expected that CEO tenure and inventiveness follows an inverted U-shape. An inverted U-shape tells us that tenure has a starting point that has little effect on invention, an explanation can be that the managers is new to the job and is not familiar with the organization. An inverted U-shape also tells that there is an optimum to the effect of accumulated knowledge. At some point there will appear a status quo which will lower the recognition of needs by the CEO. Research by Damanpour and Schneider (2008) has empirically confirmed this assumption and found that the relationship between CEO tenure and inventiveness follows an inverted U-shape.

2.2.2. Structural variables

Variables in this category define the internal organization of a company. These are the variables on which the company has considerable control. Literature specifies two types of structure that can be deployed within an organization; Organic and Mechanic structures (Walker 2007). An organic structure is associated with low concentration of management and decision making processes which evolve close to the front line when problems occur. According to Damanpour (1991) organic structures facilitate the initiation of innovations since they create room for experimenting and developing inventions. On the contrary mechanic structures are those structures with concentration of decision making power and formal rules that guide actions and behavior. Mechanic structures foster the implementation of an innovation (Damanpour 1991), and therefore have no influence on inventiveness. To come to firm characteristics organic structures must be brought down to a lower aggregation level. Consequently, both structures described consist of three common variables (Kim 1980, Hage and Dewar 1973). Within this research another variable will be added to these variables; intra-firm linkages since this characteristics is aimed at the active utilization of organic structures. (Walker 2007)

5. Centralization (Subramanian and Nilakanta 1996)
6. Formalization (Damanpour and Gopalakrishnan 1998)
7. Complexity (Koberg et al. 2003)
8. Intra-firm linkages (Walker 2007)

The next paragraphs will detail the effect of each characteristic.

Centralization

This concept refers to the location of the decision making authority and the participation in decision-making throughout the organization (Subramanian and Nilakanta 1996). This can be centralized which means that the management team will be located at one (geographical) place and the organization is characterized by hierarchical decision making. Decentralization means that there are reduced layers of hierarchy and greater lateral communication throughout the company (Wan et al.

2005).Literature is conclusive about the impact of centralization; greater decentralization of authority is positively related to the inventiveness of a firm (Aike and Hage 1971). Research by Damanpour and Gopalakrishnan (1998) has shown that when an organization is divided into more than one sub unit this positively influences the initiation of innovation. This functional differentiation can be compared to a decentralized structure (Johnson et al. 2008) and therefore a positive relation between invention and decentralization is found. Evidently, ideas for invention are often generated at a bottom level where need recognition is more obvious, generally this is at some distance from a decision-making authority that has to approve and continue the invention process. A bottom-up process is typically easier when less levels of hierarchy have to be encountered. Therefore, the more centralized an organization the more channels of communication through which the idea has to travel (and noise can be added). Thus a high degree of centralization restricts the flow of critical information and counteracts the emission of insights essential for effective decision making (Kim, 1980). A meta-analysis of the relationships between organizational invention and potential determinants by Damanpour (1991) has showed that there is a negative relation between centralization and invention. Combining all information together it can be concluded that decentralized structures have a positive relationship with inventiveness.

Formalization

In general formalization refers to the existence of formal policies and procedures and the emphasis on employees following these structures when conducting organizational activities (Subramanian and Nilakanta 1996; Kim 1980). Rules and the rigid observation of procedures restrict employees in their activities and therefore restrain inventive behavior like noticing a performance gap or recognizing a potential need. Companies characterized with high levels of job codification discourage the initiative of their employees in considering alternatives or suggesting inventive ideas. Informal organization structures facilitate inventiveness because of the openness and flexibility which encourages the idea generation. It has been empirically proven that formalization has a negative effect on the initiation stage of the innovation process (figure 2) (Damanpour and Gopalakrishnan 1998). Consequently it can be expected that deformalized structures have a positive relationship with inventiveness.

Complexity

The construct of complexity involves organizations carrying out the most complex types of work (Koberg et al. 2003). It is said to be that those kinds of organizations develop formal systems to create overview and maintain high efficiency levels, leading towards stability and resistance to change. Highly complex organization seems to do well in the initiation stage because they often have high values of employee specialization leading towards idea generation and development. On the contrary, highly complex organizations perform less on the implementation of inventions because their degree of specialization hedges the decision making process (Kim 1980). It is generally assumed that the positive relation between complexity and initiation outweighs the negative one between complexity and implementation (Damanpour and Gopalakrishnan 1998). Evidently, complexity is positively related to inventiveness.

Integration vs. Intra-firm linkages

The concept of integration refers to the deliberate application of methods that integrate the operation of a variety of subsystems to accomplish common goals for the organization (Kim 1980). At the heart of integration subjects are the beliefs about the effect of cross-functional team development and shared responsibility (Walker, 2007). The merit value of integration lays in the fact that one brings all inventive characteristics of an organization together and tries to strive for synergy.
Intra-firm linkages are conceptualized as structural connections between individuals from different functional sub units. Although authors apply different terminology all stress the stimulation of the exchange of ideas and collaborative efforts by the means of cross-functional team development (Koberg et al. 2003). The term used in this research project will be intra-firm linkages because the author believes that this term suggest more about its actual content.

The added value of these intra-firm linkages in relation to the structural variables of section 2.2.2. is that with a decentralized structure alone the sharing of information is not guaranteed. The same holds for formalization, it is not sure that employees make effective use of the room for seeing gaps and opportunities. Intra-firm linkage do not assure that this will happen but indeed it stimulates the creative process by individuals and teams as necessary for inventive behavior (Rhee et al. 2010). Research by Muffato and Panizzolo (1996) has shown that invention is associated with program managers who structurally applied cross-functional coordination and create connections amongst their employees. Lateral relationships and a widened job responsibility creates a cultural environment that is favorable for inventive behavior (Muffatto and Panizzolo 1996). Also, according to Koberg et al. 2003 intra-firm linkages show a positive relationship towards invention.
Consequently, the existence of intra-firm linkages is positive related to inventiveness of organizations

2.2.3. Cultural variables

This paragraph contains firm characteristics that can be grouped as having a relation to some cultural aspect of the organization.

9. Shared values (Damanpour and Wischnevsky 2006)
10. Willingness to take risks (Tushman and O'Reilly 1997)
11. Willingness to exchange knowledge (Wan et al. 2005)

The next paragraphs will detail the effect of each characteristic.

Shared values

Values can be conceptualized as preferences about some desired organizational outcome (Hage and Dewar 1973). Many authors stress the necessity of shared values within an organization but few detail the exact values that foster invention (Damanpour and Wischnevsky 2006; Walker 2007). According to Wan et al. (2005) there must be a believe in a innovative culture for an organization to be inventive. An innovative culture is defined as a culture that supports and rewards activities contributing to the innovativative behaviour of an organization. It is essential that employees believe that inventive behaviour is valued for them to deploy those types of behaviour. Collective norms and organizational vision must support this view in a way that inventive behavior is fully positioned as a company mission. There are no authors who succesfully researched shared values in a relationship to invention. The difficulty with shared values is that the impact depends on single employees rather than a company strategy. As Ajzen (1991) proposed with his theory of planned behavior, the visual behavior of people is an interplay of someone‘s beliefs, attitudes, norms and intention to perform

some kind of behavior. Therefore to really share values in a company in a way that they are actually followed by intended behavior is a process that is very difficult to guide by managerial control (Ajzen 1991). A company board can state that there are shared values within the company but whether inventive behavior follows this intention is very difficult to verify. Evidently, no conclusive relationship between shared values and invention can be formulated since the direct effect is unknown.

Willingness to take risk

The invention process is generally seen as a risk taking activity since it forces an organization to depart from their current rules of the game and completely reivent them. For a firm who is successful it seems to be cannabalizing the operational success with a 50/50 chance on improved results (Smith 2010). According to Tushman and O'Reilly (1997) firms who deploy higher levels of risk taking behaviour are likely to take up more invention projects and therefore can be called more inventive then organizations unwilling to take high risks (Wan et al. 2005). But little is known about the exact levels of risk, what is meant with higher levels, higher than what? Since no information is evident about the ideal levels of risk taking behavior no conclusions can be drawn on the direction of the relationship.

Willingness to exchange knowledge

Employees who are willing to freely exchange knowledge throughout the firm contribute to the inventiveness of organizations. Intra-firm linkages provide connections for employees to exchange information and to share development in the invention process. But the sole fact that those channels are present will not immediately mean that employees use them appropriately. Therefore an effective integration of knowledge and experience can only occur when employees are willing to engage in those activities (Wan et al. 2005). A highly inventive organization will focus on cultural activities that can foster the willingness of knowledge exchange amongst their employees. Such activities are for example company brainstorm groups or pilot studies (Tidd et al. 2009).

Performance on this characteristic is strongly related to the intentions of employees (Wan et al. 2005). The general organization culture can prescribe employees to share knowledge, employees can be willing to share but whether they actually share the specialized knowledge within the company remains unknown. Also, most authors that stress the importance of deliberately exchanging knowledge throughout company networks fail to conceptualize this variable. They solely mention the importance of sharing knowledge similar as to sharing the same values but do not quantify any optimum level or even prove a relationship scientifically. As a result no conclusive effect can be formulated between inventiveness and the willingness to exchange knowledge.

2.2.4. Resource variables

Resource variables can be specified into two main categories; knowledge and organizational slack (Damanpour 1991). Of course in mainstream organization studies there are much more categories that can be conceptualized under the subject of resources, but they have not come up within research after firm characteristics that foster invention. The following firm characteristics can be categorized as resource variables:

12. Specialization *"Availability of knowledge"* (Subramanian and Nilakanta 1996)
13. Communication channels *"Diffusion of knowledge"* (Wan et al. 2005)

14. Learning organization *"Creation of knowledge"* (Walker 2007)
15. Slack resources (Subramanian and Nilakanta 1996)
16. R&D Intensity (Hall and Bagchi-Sen 2002)

The next paragraphs will detail the effect of each characteristic.

Specialization

The construct specialization refers directly to the existence of employees with specialized knowledge and skills in multiple areas of the business scope (Subramanian and Nilakanta 1996). When the individuals in an organization possess high degrees of specialized information, idea generation and development will occur more often. It is said that a greater variation in specialists provides a wider knowledge base and therefore increase 'cross fertilization' of new ideas (Damanpour, 1991). Thus, organizations with high levels of specialization are more inventive than organizations that possess low levels of specialized employees (Damanpour and Gopalakrishnan 1998). Evidently, specialization is positive related to inventive behavior of organizations.

Communication Channels

High levels of specialized information are useless when there is no dispersion within an organization. Communication channels should be in place to transfer knowledge to all corners of the organization and to stimulate effective use of the specialized knowledge base (Wan et al 2005). It is also important that the internal environment is favorable to the survival of ideas, every time a message goes through a communication channel some kind of noise is added to the message. Therefore it is important that communication channels are effective and do not need to cross through many hierarchical layers of the organization (Tidd et al. 2009). Research by Damanpour (1991) has shown that communication (internal and external) has a positive relationship with inventiveness of organizations.

Learning Organization

The term learning organization is provided to firms that stimulate the learning of its employees and try to strive for continuous improvement. Learning organizations develop when there are pressures from the competitive business environment and an organization needs to adapt continuously (O'Keeffe 2002). In section 2.1. we learned that innovation, continuous improvement and change are the main determinants for organizational viability. Learning organizations are developed to manage these constructs to remain a competitive position in their business environment (Smith 2010). According to Rogers (2004) a highly trained workforce is an advantage when developing inventive behavior. A trained workforce will be motivated to notice opportunities and will possess some accumulated knowledge to turn opportunities into business solutions (Walker, 2007). Although some authors stress the importance of a trained and highly skilled workforce in order to achieve the essential accumulated knowledge, little information could be obtained about the actual direction of the relationship with inventiveness (Walker, 2007). Consequently, no unambiguous relationship between inventiveness and learning organization could be formulated.

Slack resources

In general slack just means that you have additional resources that are not yet necessary for operation. For example employees have 10% of excessive time which they may spend on inventive behavior. Or there are additional raw materials which may be used for experimentation. Broadly

stated, slack resources are surplus resources that are available for experimentation and therefore foster inventiveness of organizations (Subramanian and Nilakanta 1996). When a company has such surplus resources they can explore opportunities in advance e.g. the need is not present yet and therefore phenomenon may be discovered. Another advantage of slack resources is the fact that whether the invention process results in a failure there is no immediately effect for the operations of the company since the used resources were surplus (Walker 2007). A last opportunity exist for companies who can use their slack resources to purchase inventions from other parties and skip some stages of ' recursive problem solving' in the invention process. Therefore, slack resources are positively related to inventiveness (Wan et al. 2005).

R&D Intensity

Research and development is the use of resources to create new knowledge and to develop new and improved products, processes or services. R&D efforts can be seen as the stage where ideas for innovation are generated and worked out into feasible concepts e.g. invention. Since companies constantly seek for new competencies to surpass their competitors, R&D departments are utilized to provide new ideas for the company and hopefully new strategies to encounter (Tidd and Bessant, 2008). R&D drives invention since those departments are especially focused on generating inventive ideas which might not have come up under normal circumstances (Kemp et al. 2003). Findings of the research by Hall and Bagchi-Sen (2002) suggest that investments in R&D have a direct effect on patent-related invention. Conclusively, it can be said that R&D intensity has a positive effect on the inventiveness of an organization.

Inference; The past four sections have investigated possible firm characteristics that foster the inventiveness of organizations. These firm characteristics can be categorized in four groups which are; Contextual variables, Structural variables, Cultural variables and Resource variables. For each category firm characteristics have been found and where possible a relationship with inventiveness has been defined. Table 2.1. contains an overview of the found characteristics and their corresponding relationship.

2.3. Constructing the theoretical framework

Table 2.1 provides an overview of the firm characteristics as found in the literature study with their corresponding relationship to the concept inventiveness. Where "+" stands for a positive liniar relationship, "- / +" for an undecided relationship, "0" means that there is no conclusive scientific evidence and the graph means that the relationship follows an (irregular) inverted U-shape outline.

Table 2.1: *Overview of firm characteristics*

Contextual variables		**Cultural variables**	
Firm size	- / +	Shared values	0
Firm age	∩	Willingness to take risk	0
CEO age	∩	Willingness to exchange knowledge	0
CEO tenure	∩		
Structural variables		**Resource variables**	
Centralization *(decentralized)*	+	Specialization	+
Formalization *(informal)*	+	Communication channels	+
Complexity	+	Learning organization	0
Intra-firm linkages	+	Slack resources	+
		R&D intensity	+

A common problem within innovation studies is that there is a lack of uniformed terminology. The same is reoccurring within this project as some firm characteristics sound very different but entail a similar explanation. Hence for the sake of validity of this research it is necessary to group some elements together since they serve the same purpose and otherwise will show high levels of correlation and spoil outcomes of the research. Also, there are some firm characteristics that do not have a corresponding effect because literature was not conclusive or did not provide basic evidence for a relationship with inventiveness. This section will focus on constructing a theoretical framework containing those firm characteristics that will be studied in the multiple case studies of the empirical phase of this research. Also, per firm characteristic it will be investigated how performance can be measured.

Contextual variables

Firm Size

An essential part of invention studies is the conceptualization of firm size, since the way firm size is measured can have an effect on the relationship between organizational size and other firm characteristics. Research by Camisón-Zornoza et al. (2004) has summed quantitative measurements for the variable firm size; Physical capacity (f.e. # of machines), Number of employees, Input measures, Output measures or the financial resources. In the meta-analysis of the same authors it came forward that number of employees is by far the most applied measure in innovation studies. The motivation that is offered for this choice is that it is a direct measure that is easy to conceptualize and easy to find in publicly available data. Based on these statements the author chose to use number of employees as the measure for firm size. Research by several authors has proven that firms size can be categorized along the lines of employees into three categories; small (1-99 employees), medium (100 – 500 employees) and large (> 500 employees) sized (Santarelli and Sterlacchini 1990, Acs et al. 1994).

Firm Age

The conceptualization of firm age is very easy because its term suggests a measurement in years after foundation of the organization. Research has learned that the variable firm age follows an inverted U-shape curve in relation to inventiveness, with its optimum between 20 and 36 years of operation (Huergo and Jaumandreu 2004). The U-shape is formed by the understanding that very young organizations suffer from (knowledge) barriers of entry and very old organizations are stuck in path dependencies and core rigidity that restrict them to be inventive.

CEO Age

Although literature seems to suggest an inverted U-shape relationship there is little known about its optimal relation with inventiveness. Knowledge about the great inventors of history can provide some indication but it can hardly be used as an outcome. Another deficiency with CEO age is the fact that this variable is strongly influenced by the concept of centralization and firm size (Koberg et al. 2003). Research has learned that a decentralized structure will positively influence the inventive behavior of an organization. Taken into account that we have just learned that the larger the firm the larger their inventiveness measured in patent count will be, one may expect that a large organization with a decentralized structure will be more inventive than one that does not comply with these characteristics. The question that then arises is what is the influence of a CEO when the organization is decentralized and has a large employee base? Scientific literature is not convincing on this variable since little research has been done on the exact effect of the relationship. Consequently these insights have led to the decision to remove the variable from the theoretical construct.

CEO Tenure

Scientific research has proven that CEO tenure follows an inverted U-shape (Damanpour and Schneider 2008), but there are no direct figures provided to measure an optimum tenure level. Also, arguments can be raised to question the influence of CEO tenure on large decentralized organizations. There is also a correlation with the variable firm age that weakens the effect of CEO tenure; obviously a young organization cannot have a CEO with long tenure. It is important to mention that these insights are a product of the previous research phase without the whole picture of influencing firm characteristics these conclusions could not have been drawn. Consequently these new insights have led to the decision to remove CEO tenure as a variable from the theoretical construct.

Inference; This section has learned that the variables 'firm size' and 'firm age' will be included in the theoretical framework and therefore will be tested in an empirical setting. Consequently, the appropriate measures necessary for the operationalization of the empirical setting are provided. A lack of direct measures and the apparent correlations with other contextual variables have led to the decision to remove 'CEO age' and 'CEO tenure' from the theoretical framework. Those variables will not be tested in the empirical setting of this research project.

Structural variables

Centralization

For this research it is necessary that one can measure the compliance to a certain variable in order to draw any conclusions on the organizational inventiveness. Research by Hage and Aiken (1967) has shown that centralization can be measured along the lines of two sub variables:

1. Participation in decision making processes
2. Hierarchy of authority

In the literature study necessary for section 2.2. it became clear that Hage and Aiken (1967) functioned as pioneers on the matter of measuring structural variables in innovation studies. Several authors have used their methods since (Kim 1980, Subramanian and Nilakanta 1996, Damanpour and Gopalakrishnan 1998). In their research they used indicators developed by Hall (1963) to measure on the two sub variables, these indicators can be viewed in table 2.2.

Table 2.2: *Indicators for measuring centralization* (Hall 1963)

Participation
1. How frequently do you usually participate in the decision to hire new staff
2. How frequently do you usually participate in the decisions on the promotion of any of the professional staff
3. How frequently do you participate in decisions on the adoption of new policies
4. How frequently do you participate in the decisions on the adoption of new programs
Scale: Never – Seldom – Sometimes – Often – Always
Hierarchy of authority
1. There can be little action taken here until a supervisor approves a decision
2. A person who wants to make his own decisions would be quickly discouraged here
3. Even small matters have to be referred to someone higher up for a final answer
4. I have to ask my boss before I do almost anything
5. Any decision I make has to have my boss's approval
Scale: Strongly disagree - Disagree – Neither agree nor disagree – Agree – Strongly agree

Hage and Aiken (1967) selected the respondents for their research semi-randomly. They gathered data from all executive directors and department heads in an organization. From departments with over 10 employees they selected randomly 33% of the people as respondent. And from departments with less than 10 employees they randomly selected 50% of the people as respondent. It must be mentioned that they did not gather information from people in a non-supervisory administrative function or employees working in maintenance (Hage and Aiken 1967). For valid research results it is important to interview employees in some kind of supervisory position with responsibility in decision making processes.

Respondents were asked to score the statements on a five point Likert scale as provided per set of question in the table. Then the scores were averaged per respondent into one score per sub variable. The statements seem to be very alike and one can argue whether this is indeed necessary. Most authors using these questions to measure on centralization used as a method of disclosure a large survey sent to over 250 respondents. When a researcher has no direct contact with a respondent it is important to work thoroughly since answers cannot be verbally verified, therefore questions are sited in multiple forms to really grasp solid inputs for the research (Ghauri and Gronhaug 2005).

Formalization

We now know informal characteristics of an organization have a positive effect on its inventive behavior (Subramanian and Nilakanta 1996). Formalization can be split up in two sub variables (Hall 1963):

1. Job codification e.g. the degree to which a job is systemized or pre structured
2. Rule observation e.g. the degree of thoroughness applied in enforcing rules

Richard Hall (1963) has also provided the indicators for measuring on these sub variables. Table 2.3. provides an overview of these indicators and their associated Likert scale.

Table 2.3: *Indicators for measuring formalization* (Hall 1963)

Job codification
1. *I feel that I am my boss in most matters*
2. *A person can make his own decisions without checking with anybody else*
3. *How things are done here is left up to the person doing the work*
4. *People here are allowed to do almost as they please*
5. *Most people here make their own rules on the job*
Scale: Strongly disagree - Disagree – Neither agree nor disagree – Agree – Strongly agree
Rule observation
1. *The employees are constantly being checked on for rule violations*
2. *People feel as though they are constantly being watched to see that they obey all the rules*
Scale: Strongly disagree - Disagree – Neither agree nor disagree – Agree – Strongly agree

Additional information about working with these indicators of Hall (1963) can be found under table 2.1.

Complexity

The variable complexity involves organizations which are carrying out the most complex types of work (Koberg et al. 2003). We learned that high complexity influences inventiveness positively due to the often high values of employee specialization which in return leads towards novel idea generation and development (Damanpour and Gopalakrishnan 1998). In wording complexity seems to stress a lot of similar aspects as the characteristic specialization, where skill and training levels are put central. What now becomes apparent is that the most complex types of work mostly are done by the most specialized persons in an organization. Evidently, when one must choose a measure for complexity Hagen and Aiken (1967) suggest to use a concept named occupational specialty which is the number of different kinds of work that exist in one organization, which is very similar to a measure for specialization. Most authors choose either to describe complexity in combination with a training variable, or used specialization which contains both of these elements (Damanpour 1991, Subramanian and Nilakanta 1996). The author believes that the concepts complexity and specialization do differ on some points but that it is very difficult to measure complexity with a different measure then specialization. Since the term complexity is on itself not unambiguous and there are no other measures apparent in literature the decision is made to group complexity under the noun of specialization and to remove the concept complexity as such from the theoretical framework as a positive influence on inventiveness.

Intra-firm linkages

Section 2.2.3. has learned that the deliberate efforts and the existence of structural linkages effect inventiveness positively (Walker 2007). Intra-firm linkages is perhaps the most difficult variable to

measure since no public information is available on this subject. The measure for this variable must be a qualitative method that is aimed at disclosing company information about whether they put an effort to make structural connections between the employees (Muffatto and Panizzolo 1996). Examples can be the percentage of cross functional team design as a part of their decision making processes. Or the number of cross functional meetings as a percentage of their projects. At last one can try to disclose whether there are internal networks like a young professional cluster (Koberg et al. 2003). For this research the decision was made to measure on the percentage of projects organized in a cross functional setting. The motivation for this choice is that improvement projects often emerge from the recognition of a need and the active strive to find a matching solution, which resembles the process of invention described in section 2.1. Expressing intra firm linkages in a percentage tells us what proportion of collaborating time is used to combine knowledge within an organization. Please recognize that it states collaborating time, no organization can perform all activities cross-functional! So an optimal score on this variable will tell us that non-job-specific activities evolve in a cross-functional manner which fosters invention. The author therefore assumes that cross functional teamwork is at this moment the most accurate measure for the relationship between intra-firm linkages and inventiveness.

Inference; this section discussed all structural variables and its associated measures. For 'centralization', 'formalization' sub variables are introduced to simplify the measurement on these characteristics. Centralization will be measured using degrees of employee participation and hierarchy of authority. Formalization will be measured using levels of job codification and rule observation in the firm. Since the concept 'complexity' has a lot in common with the concept of specialization and measures that are apparent seem to be the same, the decision was made to eliminate complexity from the theoretical framework. For the characteristic 'intra-firm linkages' it has been defined that this variable will be measured as a percentage of cross functional teamwork in the organization.

Cultural variables

Shared values

An inventive organization should have shared values meaning that there is preference for some desired organizational outcome (Hage and Dewar 1973). Although most authors agree on the fact that shared believes effect inventive behavior, very little is known about the direction of this effect or what those values or believes should contain. This study focusses on finding those firm characteristics that foster inventiveness of an organization, therefore it is important that the different characteristics are quantified and measurable in follow-up studies. The difficulty with shared values is that the impact depends on single employees rather than a company strategy. As Ajzen (1991) proposed with his theory of planned behavior, the visual behavior of people is an interplay of someone's beliefs, attitudes, norms and intention to perform some kind of behavior. Therefore to really share values in a company in a way that they are actually followed by intended behavior is a process that is very difficult to guide by managerial control (Ajzen 1991). A company board can state that there are shared values within the company but whether inventive behavior follows this intention is very difficult to verify. As a result the decision is made to remove shared values from the theoretical framework of this study.

Willingness to take risk

In section 2.2.3. it became known that firms who deploy higher levels of risk taking behavior are likely to take up more inventive projects which increases their chances for success (Wan et al. 2005). Since no information is evident about the ideal levels of risk taking behavior it is very difficult to use this characteristics in the theoretical framework. The decision is therefore made to remove this variable from the theoretical framework as a positive influence on inventiveness.

Willingness to exchange knowledge

The difficulty with this variable is the fact that performance is strongly related to the intentions of employees (Wan et al. 2005). The general organization culture can prescribe employees to share knowledge, employees can be willing to share but whether they actually share the specialized knowledge within the company remains unknown. Also, most authors that stress the importance of deliberately exchanging knowledge throughout company networks fail to conceptualize this variable. They solely mention the importance of sharing knowledge similar as to sharing the same values but do not quantify any optimum level or even prove a relationship scientifically. These findings have led to the decision to remove the willingness to exchange knowledge from the theoretical framework.

Inference; this section has discussed all cultural variables and were in place its associated measures. The difficulty of cultural variables is that often the employees are responsible for performance on a variable. This section has learned that company values are not always followed up by inventive behavior due to the norms and beliefs of the individual employees. The main reason for removing; 'shared values', 'willingness to take risk' and 'willingness to share knowledge' is the lack of a specified relationship in table 2.1. and limiting information on appropriate measures and ideal performance quantitates.

Resource variables

Specialization

A lot of specialized employees in an organization fosters inventive behavior since it stimulates cross fertilization of ideas (Damanpour 1991). Therefore specialization is positive related to inventiveness. Specialization can measured along the lines of two sub variables (Hall 1963):

1. Occupational specialties
2. Training activity

Where occupational specialties is a collective noun for the different kinds of specialized jobs in an organization and training activity represents the active contribution to specialization. According to Kim (1980) occupational specialties can be measured using the number of different kinds of work in one organization. Training activity can be conceptualized as the degree of formal training beyond the college degree of your employees and professional training for each social position in the organization (Hage and Aiken 1967). When measuring this one should obtain information on the type of training activity (broad or depth perspective), the way this training type option is provided (obligated or free choice) and which combination of formal and professional training is used. The combinations that are known by literature are visualized in table 2.4.

Table 2.4: *Indicators for measuring training activity (Hage and Aiken 1967)*

	Training beyond college degree	Professional training
Category 1 *Intensive training*	Presence	Presence
Category 2 *Formal training activity*	Presence	Absence
Category 3 *Professional training activity*	Absence	Presence
Category 4 *No specialized training activity*	Absence	Absence

The categories are hierarchically ranked, formal training scores higher than professional training since the characteristic specialization is about the specialized knowledge and complementary skills. Therefore organizations training specialized knowledge are more inventive than organizations that only train specialized skills without the necessary knowledge levels.

Communication channels

As this section started it was mentioned that a lot of terms are overlapping. Communication channels are a perfected example of this problem since this variable has a lot in common with intra-firm linkages. Only intra-firm linkages also stresses human activity moving along the lines of the channels, but in fact all human activity involves some level of communication. It is fair to say that indeed communication channels also contain an infrastructural aspect like intern telephone networks or video chat which are used by some organizations. But the most important aspect to remember is that those channels stimulate the effective diffusion and use of (specialized) knowledge within a company. As intra-firm linkages have the same purpose and serve a wider function through the deliberate formation of cross functional teams, the decision is made to group communication channels under the noun of intra-firm linkages and remove this variable from the theoretical framework.

Learning organization

In the way specialization is conceptualized in this section – as occupational specialty & training activity - , it resembles closely the conceptualization of a learning organization. Notice that a learning organization is not mere the application of a training facility but also contains a philosophy of believing in the power of continuous improvement and renewal (Hult et al. 2004). But consequently this philosophy is again a matter of individual employee performance and therefore very difficult to measure upon. Evidently, although the author believes that a learning organization can be a strong asset of an organization seeking for inventive success, scientific evidence does not underpin this believe and therefore the variable learning organization must be grouped under the collective noun specialization where it is measured in the sub variable training activity.

Slack resources

Research by Subramanian and Nilakanta (1996) states that slack resources should be measured using the net income, since it represents exactly those resources that are available for the initiation stage of innovation e.g. invention. The author believes that looking simply at net income is not sufficient for the purposes of the research. The mere fact that a company has a high net income does not say anything about their inventiveness since one does not know how they use it. Since the advantage of slack resources is in the opportunity to experiment it is important to measure on this also. Information that should be obtained concerns the availability of employees, capital and stock to be

able to experiment (Damanpour 1987). Furthermore it is interesting to known whether there are procedures or rules about the spending of slack resources f.e. 10 % of the work time can be devoted to a project of the employees' choice. And what is done when employees fail in their inventive attempts.

R&D intensity

An often used measure for conceptualizing R&D intensity is the total investment in R&D (Kleinknecht et al. 2002). The deficiency of this measure is that organizational size is strongly correlated to this measure, large organizations have more capital to spend and therefore can afford large R&D budgets. Therefore it is important to also have some input about the R&D spending as a percentage of total sales (Hall and Bagchi-Sen 2002). Then the correlation affect is mediated since large organizations will have higher sales volumes. Low R&D intensity are percentages under 30% and high can be measured as above 30% (Hall and Bagchi-Sen 2002). For this research project it is also interesting to know how R&D is organized; centralized vs. decentralized, whether there is employee participation and what is communicated about the invention process within these departments.

Inference; This section has learned that the variables 'specialization', 'slack resources' and 'R&D intensity' will be tested in an empirical setting. Consequently, the appropriate measures necessary for the operationalization of the empirical setting are provided. A lack of direct measures and the apparent resemblance with other variables have led to the decision to remove 'communication channels' and 'learning organization' from the theoretical framework. Those variables will not be tested in the empirical setting of this research project.

Theoretical framework

The outcomes of the previous sections are all combined into the theoretical construct visualized in figure 2.2. Evidently, this literature study closes with the theorem that firm characteristics can be categorized in four types of variables and that these categories contain the 8 firm characteristics that have proven in previous scientific research to affect inventiveness measured in applied patent data positively.

The next step is to test this theorem in an empirical setting where there is controlled for the environmental settings. This because the environmental factors were left outside the research scope and therefore it must be assured that all cases are exposed to similar external factors. Then, it will be evaluated whether this set of firm characteristics can be used to determine inventiveness in organizations. Variables that are not included in this framework will be left outside the research scope from this point forward.

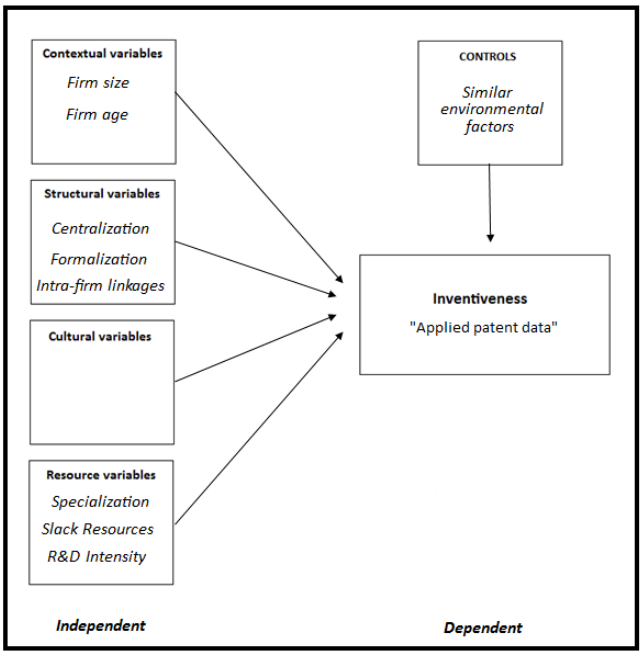

Figure 2.2: Theoretical framework

3. Methodology

This chapter describes the methodology that is used for the empirical part of this research. In the research proposal it has been defined that the research strategy is a thorough literature study in combination with an explorative case study to investigate the theorem in a practical setting. Explorative means that it is a first analysis of a new research concept where there is an intensive analysis of one or more research units. In section 3.1. the selected firm characteristics will be operationalized into measurable objects for the empirical study. Section 3.2. explains the methods of disclosure and within section 3.3. it will be explained how evaluation of the study can occur and on what basis conclusions will be drawn. Finally, section 3.4. will assess the overall validity and reliability of this study.

3.1. Operationalization of the research variables

Before the different methods for data gathering can be explained it is important to first conceptualize the research variables. Conceptualization means that you transform a theoretical variable into a framed object, table 3.1. provides an overview of the conceptualization of the 8 firm characteristics. The different measures visible in the last column were investigated in the literature study section 2.3., therefore this table must be seen as a comprehensive summary.

Table 3.1.: *Conceptualization of the firm characteristics that foster invention*

	Characteristic	Sub-characteristic	Measure
X_1	**Firm Size**		# of employees[1]
X_2	**Firm Age**		# of years since the foundation of the company[1]
X_3	**Centralization**	*Participation*[2]	"The degree of participation in decision making processes" [3] Q: 3 interview questions to measure[7]
		Hierarchy of authority[2]	"The locus of the decision making authority" [3] Q: Four interview questions to measure[7]
X_4	**Formalization**	*Job codification*[2]	"The degree of job codification in an organization" [3] Q: Four interview questions to measure[7]
		Rule observation[2]	"The degree of thoroughness expressed in enforcing rules" Q: Three interview questions to measure[7]
X_5	**Intra-firm linkages**		"The effort expressed to integrate the workings of various sub organizations for innovation" [3] Q: Three interview questions to measure
X_6	**Specialization**	*Occupational specialties*[2]	# of different kinds of work[3]
		Professional training activity[2]	"The degree of formal or professional training"[3] Q: One interview question to measure[7]
X_7	**Slack resources**		# of net income[5] Q: Four interview question to measure
X_8	**R&D intensity**		# expenditures of R&D as % of total sales[5] Q: One interview question to measure
Y	***Invention***		# of patent applications[6] measured over a period of 10 years

1) Camisón-Zornoza et al., 2004 2) Hage and Aiken, 1967 3) Kim, 1980 4) Rogers, 2004 5) Subramanian and Nilakanta, 1996 6) Kleinknecht et al., 2002 7) Hall, 1963

#= Quantitative measure Q= Qualitative measure

It is important to mention that when applied patent data will be used as a measure to evaluate inventiveness it is necessary to measure the application of patents over a fixed period of time. Research has shown that authors use different time spans like five years (Schoenmakers and Duysters 2010) or even fifteen years (Ahuja and Lampert 2001), consequently there is no uniform appropriate time scale. Within this research a period of ten years will be used, since two of the four case companies are very young and therefore an legitimate average must be created to evaluate the inventiveness per company. In this case five years would be too short of a period and application for patents over fifteen years would not be able to calculate for some of the cases.

Now that it has been defined what information needs to be captured for the eight firm characteristics and dependent variable Y, it is important to determine how the captured information must be interpreted. A common way to create measurable objects is operationalization. Here one defines possible performance categories which are used to conduct an overall performance assessment of a case. Per research variable a number of result categories are defined and the findings of the empirical study will be scored according to this categorization. In this research the result categories are called weight categories because this research investigates an equations with eight X-values and one Y value. To test the effectiveness of this equation one must know the weight of the individual X-values.

Within this research five weight categories will be determined per variable moving from A) the ideal situation to E) the least ideal situations within the constraints of this project. The number of five weight categories have been chosen because of the measurement of the qualitative variables. Results will be measured on a 5-point Likert scale, so weight categories must contain an equal distribution to not have to mix up result to conform to a different scale. The value of the five weight categories has been derived from the literature study. In some occasions only the ideal situation has been found through the literature study, then the four other categories have been established based on gradual spread but this will be detailed in the next section.

Table 3.2. provides an overview of the operationalization of the eight firm characteristics. The left columns provide an overview of the different firm characteristics and the top row shows the appropriate weight categories. Per variable it will now be discussed how the values per weight category are established. In table 2.1. in the literature study the relationships per firm characteristic and inventiveness has been defined. When a positive linear relationship was concluded the filling in of the weight categories will also move gradual. For variables that have an U-shaped relationship with invention, a similar distribution of weight categories will be followed.

X_1 Firm Size

Literature study has learned that one can define small, medium and large sized companies (Santarelli and Sterlacchini 1990). For the operationalization two categories have been added; very small and very large. This decision was made because three companies are very large and one is medium to small sized. When working with strictly the measures of Santarelli and Sterlacchini (1990) the advantage of large companies was not separated enough from those of medium sized organizations.

Table 3.2.: *Operationalization of the firm characteristics that foster invention*

	Concept	Weight categories				
		A	B	C	D	E
X_1	**Number of employees**[1]	$X_1 > 2500$	$500 < X_1 < 2500$	$100 < X_1 < 500$	$50 < X_1 < 100$	$X_1 < 50$
X_2	**Years since the foundation of the company**[2]	$20 < X_2 < 36$	$15 < X_2 < 20$ $36 < X_2 < 45$	$10 < X_2 < 15$ $45 < X_2 < 55$	$5 < X_2 < 10$ $55 < X_2 < 65$	$X_2 < 5$ $X_2 > 65$
X_{3a}	**Participation**[3] (High)	Average 5 points Likert	Average 4 points Likert	Average 3 points Likert	Average 2 points Likert	Average 1 point Likert
X_{3b}	**Hierarchy of authority**[3] (Low)	Average 1 point Likert	Average 2 points Likert	Average 3 points Likert	Average 4 points Likert	Average 5 points Likert
X_{4a}	**Job codification**[3] (Low)	Average 5 points Likert	Average 4 points Likert	Average 3 points Likert	Average 2 points Likert	Average 1 point Likert
X_{4b}	**Rule observation**[3] (Low)	Average 1 point Likert	Average 2 points Likert	Average 3 points Likert	Average 4 points Likert	Average 5 points Likert
X_5	**Cross functional team design**[4]	$80\% < X_5 < 100\%$	$60\% < X_5 < 80\%$	$40\% < X_5 < 60\%$	$20\% < X_5 < 40\%$	$X_5 < 20\%$
X_{6a}	**Different kinds of specialized work**[5]	*No scale can be provided**				
X_{6b}	**Training type category**	Intensive training	Formal training	Professional training	No specialized training	n/a
X_{7a}	**Net income**[6] **per employee** ($)	$X_7 > 100.000$	$75.000 < X_7 < 100.000$	$50.000 < X_7 < 75.000$	$25.000 < X_7 < 50.000$	$X_7 < 25.000$
X_{7b}	**Slack resources** (High)	Average 5 points Likert	Average 4 points Likert	Average 3 points Likert	Average 2 points Likert	Average 1 point Likert
X_8	**Investment in R&D as % of total sales**[7]	$X_8 > 30\%$	$22\% < X_8 < 30\%$	$14\% < X_8 < 22\%$	$6\% < X_8 < 14\%$	$X_8 < 6\%$

1) Arundel and Kabla 1998 2) Huergo and Jaumandreu 2004 3) Hall 1963 4) Muffatto and Panizzolo 1996 5) Kim 1980 6) Subramanian and Nilakanta 1996 7) Hall and Bagchi-Sen 2002

X_2 Firm Age

In the literature study it has been found that organizations between 20 and 36 years of age score the best on inventiveness (Huergo and Jaumandreu 2004), therefore this resembles ideal situation A. A gradual distribution has been used to identify appropriate values for the other categories. This gradual distribution was conducted based on literature stating the constraining effect of barriers to entry at start and the constraining effect of routines and path dependency after 36 years of operation.

$X_{3,4}$ Centralization and Formalization

For measuring the variables centralization and formalization a method of Hage and Aiken (1967) has been used as explained in section 2.3. of this research paper. Literature study has learned that low centralization and formalization has a positive effect on inventiveness of an organization. The distribution of this effect is perceived as linear because scientific evidence by multiple authors has shown that the more decentralized or informal the organization the higher the inventiveness (Subramanian and Nilakanta 1996, Kim 1980, Hage and Aiken 1967). Please bear in mind that they all used a similar conceptualization of the variables centralization and formalization as applied in this research. So high decentralization can be viewed as a high participation in decision making process and low hierarchy of the decision making authorities. No conclusions can be drawn about aspects outside this conceptualization; for example geographical location, a subject often related to centralization. The distribution of weight categories follows the 5-point Likert scale on which the performance of these characteristics is measured.

X_5 Intra-firm linkages

The literature study has shown that intra-firm linkages must be measured as a percentage of cross functional team work in projects carried out by the organization. The ideal situation is that all project work is organized in a cross-functional manner. It can be imagined that in some organizations cross-functionality is not equipped so therefore a margin is built in of 100% till 80%. The least ideal situation is also clear, this is where an organizations conducts projects strictly within departments and cross-functionality scores a zero. Values of weight categories in between have been constructed using a gradual distribution.

X_6 Specialization

Firm characteristic X_{6a} cannot be measured due to the sample size. According to Hage and Aiken (1967) occupational speciality must be measured counting the numbers of different jobs in an organization. But these authors used a sample size of 314 interviews over 16 different organizations, for them it was possible to categorize them. In this explorative research only 4 interviews will be held with respondents from 4 different companies so no grouping can be done. A scale cannot be provided either since Hage and Aiken (1967) did not use an objective scale but evaluated occupational speciality per company in respect to the performance of other companies. Specialization will therefore be measured based on results of X_{6b}. For this variable the literature has shown that a distribution based on intensive, formal, professional and no-specialized training activity must be used .

X_7 Slack resources

For characteristic X_7 literature prescribes to measure the net income. The author has made the edition to measure the net income raised per employee. The reason for this decision is the fact that three out of four companies are rather large whilst one is a small player in the industry. The net income measured for this company will not come close to the incomes of the other three companies. When measuring the net income per employee one corrects for the effect of firm size and figures can be easily compared.

X_8 R&D intensity

Literature has learned that R&D intensity must be measured as a percentage of total sales, then one knows what the relative investment in R&D is. Research has shown that the ideal score on R&D intensity is over 30%. From this point the other categories have been established using a gradual distribution.

3.2. Method of disclosure

Two methods for information disclosure will be used; interviewing and data analysis. The firm characteristics that have been found in the literature study consist of variables that are represented by qualitative data and variables that must be represented by quantitative data. For the first group an interview will be used to reveal tacit knowledge and to measure performance levels on the different (qualitative) firm characteristics such as formalization or centralization. A data analysis of databases containing company information will be used to provide values for the firm characteristics that can be expressed numerical, such as firm size or age.

3.2.1. Interviewing

Interviewing is the first method of information disclosure that is chosen for this research. The reason for this method is that tacit knowledge needs to be obtained about the presence of firm characteristics in organizations. Often firms do not communicate about themselves publicly whether they are centralized or formal, therefore an interview per company should reveal this information.

There are three types of interviews: structured, semi-structured and unstructured interviews (Punch, 2005). In structured interviews, questions are planned and standardized in advance and fixed response categories are determined. As a result, the interviewer is not able to go to any depth. Moreover, flexibility and variation are minimized (Punch 2005). The second type is unstructured interviews, this interview is not standardized and the possibility exists to discuss the respondent's reaction, opinion and behavior (Ghauri and Gronhaug 2005). The final type is a semi-structured interview. Semi-structured interviews differ from unstructured interviews since the main topics and questions are planned in advance (Ghauri and Gronhaug 2005). In this research a semi-structured interview is used for the following reasons. In a semi-structured interview the interviewer is able to ask subsequent questions which suit the interviewee's replies in order to obtain extensive and detailed answers (Yin 1994). Some structure is necessary to ensure that tacit knowledge is revealed and the necessary information is captured instead of information that could also be gathered through other sources.

When one wants to compare cases reciprocally it is important that there is a control on the environmental factors. In the literature study it has been learned that environmental factors can

have an effect on invention but will be left outside the research scope. Therefore one must assure that those effects cannot come up in the empirical research and thus all companies must preferably be in the same industry. Consequently, 4 interviews will be held with respondents from pharmaceutical companies. The author chose pharmaceutical companies because of the measure for inventiveness; applied patents. The literature study has shown that some organizations do not patent their novel ideas but make it a company secret. Since pharmaceutical companies are in an knowledge intensive industry and work with highly specified production processes which are difficult to copy and therefore the willingness to patent is high (Chen and Chang 2010). This makes pharmaceutical companies equipped for the case study.

The following organizations have been selected for the case study:

- Abbott Laboratories *Product specialist*
- GlaxoSmithKline *Innovation manager*
- Merck Sharpe & Dohme *Senior research manager*
- Ursapharm Arzneimittel *Product specialist*

These companies have been selected based on preliminary patent count evaluations and their position in the pharmaceutical industry. The first three are large players in the industry but show very different patent counts per year and per period. The last company is a small player in the industry, this company has been selected to evaluate whether the selected firm characteristics correlate with organizational size. The different respondents per company have been selected based on the criteria provided by Hagen and Aiken (1967), who identified that one must interview employees with a supervisory position with responsibility in decision making processes and who is not working in an administrative or maintenance function.

Questions in the interview scheme are built upon the sub-characteristics defined in paragraph 2.3. The questions that are used for disclosing information per characteristics are derived from research by Hage and Aiken (1967) which have been used by multiple authors over the past decades to measure on structural variables in qualitative settings. The complete interview scheme can be found in appendix 1.

3.2.2. Secondary data analysis

The second method for information disclosure is a data analysis of databases containing company information. As the operationalization scheme in table 3.1 has shown there are eight sub characteristics that involve some kind of quantitative measure. The author has chosen to derive these measures from databases instead of the interview because then the interviews can entirely focus on revealing tacit knowledge and an in depth view is insured. Besides that the chances are very low that the respondents have information on these exact items which would spoil the empirical data. There are three databases selected from which the information can be drawn: Hoover's Company Records, Kompass and Orbis.

3.3. Evaluation of the results

Chapter four will contain the information captured with the methods of disclosure described in the previous two sections. Then chapter five of this research project will contain the results and an evaluation must be made for the second research question e.g. whether the theoretical construct is indeed efficient in determining the inventiveness of organizations. To do so the outcomes of chapter

four will be filled out in the operationalization table (3.2.). For each organization a grade card will be made, since one knows how the organization scores on the weight categories of the investigated eight firm characteristics. Based on this grade card the performance of the four cases can be determined and analysis about the relationship between X and Y values can be made.

The results cannot be analyzed by statistical means since the sample is too small. Perhaps this would have been the most solid method but due to time constraints other methods where sought to analyze the dataset. What can be done is evaluating what the influence of the performance on X values is on the total value of Y. In other words one can review the scores on the eight characteristics, assume a certain position of Y in respect to the other companies and eventually analysis whether assumption is proven. This is a very basic test to evaluate the efficacy of the model but since this is a preliminary research the mere value must lay in seeking an approach to work with the constructed model. Three types of analysis will be done to test the effectiveness of the model:

1. Comparison of equal distributed X values
2. Comparison of in equal distributed X values
    a. One differing variable; *weight 0.5 & 2*
    b. Two differing variables; *weight 0.5 & 2*
    c. Three differing variables *weight 0.5 & 2*
3. Modeling the ideal situation

1. Equal distribution of X values

To be able to evaluate the set of X values in comparison to the Y value the performance per individual company must evolve into a percentage that resembles the compliance to the ideal situation e.g. the theoretical framework (figure 2.2.). This percentage will be derived by quantifying all weights into numbers; weight category A will be assigned value 5, weight category B will be assigned value 4 and so on up till weight category E which will be of value 1. A percentage can be derived adding all categories up and dividing this by the ideal value when a company would have scored only A's. Therefore a 100% performance score would be scoring eight times a five on all weight categories. When applying this type of analysis one automatically assumes that all firm characteristics have the same relative importance. Based on the four unique company performance percentages a hierarchal distribution can be made for the inventiveness of the companies, where rank one represents the most inventive company of the set and rank four the least inventive company of this set. Please note that it states least of those four not of the whole industry. When the ranking is made the corresponding Y values must be entered. For this explorative research the expected relationship is that the ranking in Y values will also be hierarchical. Then one has explored the effect of the constructed theoretical framework and recommendations for further research can be made.

2. In equal distribution of X values

When comparing the in equal distributions of X values the same method applies as for the normal distribution but now one does not assume that firm characteristics are of similar importance. This type of analysis will be applied for three different levels. One will investigate whether one variable is of less (weight 0.5) or more (weight 2) importance, whether two variables are of less or more importance and eventually it will be investigate whether a model with three variables of less or more

importance can be found matching the assumed effect of the theoretical framework. This method will deliver 184 new equations of X and Y variables and one must sought for those equations that comply to the expected relationship where a ranking in company performance percentages will reflect the ranking in applied patent counts.

3. Modeling the ideal situation

A last method that can be applied to investigate the relationship between X and Y values is modeling X values to a shape that it matches inventiveness of the organizations. Then the applied patent counts will be used as evaluation tool and one will seek for a combination firm characteristics and relative importance weights per company that complies to the ranking of Y.

3.4. Validity and reliability

Validity is concerned with the integrity of the conclusions that are generated from a piece of research (Bryman and Bell 2003).

Internal validity

Internal validity refers to the soundness of findings that specify a causal relationship (Bryman and Bell 2003). In order to increase the internal validity of this research, triangulation is applied, which is the use of multiple sources of evidence. Sources which are used in this research are scientific literature, interviews with four different companies - where we control for the environmental factors - and secondary data analysis. Overall a broad focuses has been applied for gathering information within this research and therefore it can be said that the internal validity is high.

External validity

External validity is concerned with the question whether the results of a study can be generalized beyond this particular research (Bryman and Bell 2003). This research project is built upon the development of theoretical propositions which are tested in a practical setting through the use of a case study. Within this case study there is a control for the environmental influences because all cases are from the same industry. Therefore an explorative case is built to identify possible causal relationships between the theory and practice. Since a systematic manner for deriving results has been applied results can be generalized to a lower aggregation level where conclusions are derived for inventiveness in general. But it must be said that since the effects of environmental factors are left aside it can be that results will not be applicable in very different industries. Consequently, the external validity of this research is mediocre. But since this is an explorative study used for generating input for further studies this mediocre performance is a very acceptable outcome.

Reliability

Reliability is concerned with the question whether the results of a study are repeatable (Bryman and Bell 2003). This research project consists of two major parts; the literature and the empirical study. One can of course argue whether a different author would come up with the same result because he or she could prefer different articles or interview respondents. But it must be said that the literature study has been carried out very thoroughly where over 70 different authors are used to create an insight in the firm characteristics that foster inventiveness. Because of this large number of different inputs the chance is very low that the author has missed some important aspects of the theory. For the empirical part clear variables have been used that are operationalized. When another person

would repeat the research on these variables the chance that he or she would derive different results will be very low since there are clear plans for the interview and basic measures for all quantitative variables. When another researcher would decide on another operationalization scheme differences will obviously occur but the operationalization is based on a solid literature study and there are no obvious other measures present yet. Concluding, some arguments could be raised against the repeatability of this research but due to the clear guidelines and systematic approach it can be said that the reliability is high.

4. Empirical study

This chapter will detail the results from both the qualitative and quantitative research methods. Findings will be presented per case in order to provide an in-depth insight into the companies and their performance on the characteristics. Each case will provide a broad introduction about the company and then discuss the performance on the selected firm characteristics.

4.1. Case 1 Abbott Laboratories

Abbott Laboratories is one of the market leaders in the pharmaceutical industry. The company is devoted to discovering new medicines, new technologies and new ways to manage health problems. Their product portfolio consists of nutritional products, laboratory diagnostics, medical devices and pharmaceutical therapies. Abbott has several sales, manufacturing, research and development and distribution facilities around the world to be close to "where the customers need them" (www.abbott.com 2012). Figure 4.1. provides some key figures about the company. It is important to mention that Abbott laboratories managed to increase the global sales by 10.5% over the year 2011. The CEO states in the annual report that this massive growth is a result of continued focus on key areas and enhanced R&D productivity (AR-Abbott 2011). Another interesting insight gained through the annual report is the fact that R&D investments have increased with over 1 billion dollar from year 2009 till 2010 and this year half a billion was added to the budget again (AR-Abbott 2011). Representing a massive increase in R&D spending of 32% in two years.

Abbott
A Promise for Life

CEO	Miles D. White
Firm Size	91,922 employees
Founding date	1888
Total sales 2011	$ 38,851 Million
Net income 2011	$ 4,728 Million
R&D Investment	$ 4,129 Million
Patents	25,540

worldwide.espacenet.com
Search term: 'Abbott Lab*'

Figure 4.1: Key figures (AR-Abbott 2011)

With the interview information was captured about the strategies or existence of procedures to promote inventive behavior in an organization. The following quote from the product specialist at Abbott Laboratories illustrates their attitude towards invention and experimentation:

> *"Within the organization we are very open to innovation. All ideas that fit within the regulation of the organization are approached positively. Per rayon we have a budget that we can freely spent on team goals or novel ideas, the only restriction is that we have to move within the boundaries of the law and company regulations. So yes we receive some time and especially money to experiment but of course we always hope these trials do not fail. I must honestly say that when the event of a failure appears it is really a matter of whether any regulations have been offended or not what the reaction in the organization will be. Sometimes things are eventually not as promising when you look deeper into it and then you as main responsible must realize that and react immediately. I think that is where the value of preliminary R&D studies lies since this offers you some basic references for the ideas and you can decide whether to move further or quite the experiment. " (Product specialist Abbott 2012)*

Performance on the selected firm characteristics

Qualitative data has been selected using the Annual Reports of organizations and sometimes an addition was made using the database Orbis. (In the methodology chapter it was stressed that three databases would be used but research has learned that Wageningen University claims to have access but in reality no information can be drawn from those databases since the license is not renewed.)

$X_{1\ \text{Firm size}}$ 91,922 Employees (AR-Abbott 2011)

$X_{2\ \text{Firm age}}$ 124 Years (AR-Abbott 2011)

An interview was held with a product specialist of Abbott Laboratories to receive answers for the qualitative questions of this research. For the concepts centralization, formalization and slack resources statements where provided which should be ranked on a Likert scale moving from 1 to 5. Table 4.1. visualizes the scores on these scales for the variables $X_{3ab,}$ X_{4ab} & X_{7b}, per variable it is indicated whether the desired outcome was an average of 1 (low) or an average of 5 (high). The end of each blue row indicates the average score on the sub variable.

Table 4.1: *Results interview questions* ***Abbott Laboratories***

X_{3a} Participation (High)	**3**
1. How frequently do you usually participate in the decision to hire new staff	2
2. How frequently do you usually participate in the decisions on the promotion of staff	2
3. How frequently do you participate in decisions on the adoption of new policies	3
4. How frequently do you participate in the decisions on the adoption of new programs	4
X_{3b} Hierarchy of authority (Low)	**1**
1. There can be little action taken here until a supervisor approves a decision	1
2. A person who wants to make his own decisions would be quickly discouraged here	1
3. Even small matters have to be referred to someone higher up for a final answer	2
4. I have to ask my boss before I do almost anything	2
5. Any decision I make has to have my boss's approval	1
X_{4a} Job codification (High)	**2**
1. I feel that I am my boss in most matters	3
2. A person can make his own decisions without checking with anybody else	3
3. How things are done here is left up to the person doing the work	2
4. People here are allowed to do almost as they please	1
5. Most people here make their own rules on the job	1
X_{4b} Rule observation (Low)	**4**
1. There are a lot of rules to which I have to conform	5
2. The employees are constantly being checked on for rule violations	4
3. People feel as though they are constantly being watched to see that they obey all the rules	2
X_{7b} Slack resources (High)	**4**
1. The employee base is intensive for the work that we must do	4
2. There are sufficient financial resources to start up new projects or experiment	4
3. The current stock allows for new projects to start or to experiment with	3

X_5 Information about the cross functional team design, was measured using an open interview question on de existence of structural connections and cross functional teamwork. The opinion of the respondent on this matter can be best visualized through the following quote:

> *"You can always learn from others. When you have a lot of individual responsibility in your daily activities you tend to develop some routines in carrying out your job. The risk is that you can end up with a tunnel vision but when you are then forced to cooperate within cross functional teams, someone can have a whole different vision on a matter or problem which provides you with new information for completing the job" (Product specialist Abbott 2012)*

This answer is not sufficient to measure performance on this particular firm characteristic but additional interview question 3b delivered an estimated percentage of 70% cross functional team design.

X_6 This variable will be measured using the training type which is applied in the organization. From the interview we have learned that Abbott invests in formal as well as professional training. The following quote from the interview illustrates this result:

"There is budget for each employee to follow an additional education relevant to the current job but also when you want something totally different for yourself in the near future within Abbott there is time and money reserved to follow training in other fields or skill to strengthen your competences." (Product specialist Abbott 2012)

X_{7a} From the literature study we have learned that slack resources should be measured in net income. In this research project net income will be expressed per employee (explanation see p. 32). The net income raised by Abbott over the year 2011 is $ 4,728 Million divided by 91,922 employees this delivers a net income per employee of 51,440 US dollars.

X_8 R&D intensity can be measured by the amount of money invested in R&D expressed as a percentage of total sales. R&D investments for Abbott Laboratories were calculated as $ 4.129 Million of the year 2011 (AR-Abbott 2011). Dividing this by the $ 38,851 Million earned as total sales delivers an R&D intensity of 11%.

In the interview a question was also dedicated to learning more about how R&D is organized per company. This information can be relevant when one wants to interpret or evaluate the amount of money invested in research.

> *"We are an organization with of course intensive R&D research, at the moment we have 4 pharmaceutical research centers of which lay three in the USA and one here in Europe in Germany. An objective in our organization is to get information as close to the sources as possible. In a pharmaceutical company we work with something called medical representatives which are the sales people from the different products. They have direct contact with doctors and get very close to where our products are used. As a pharmaceutical company we are not allowed to contact customers directly so doctors and other medical staff is an important source of information for our organization. When our medical representatives face questions, problems or perceive a particular need in their work field communication*

starts immediately with people of other departments to see whether we can find solutions." (Product specialist Abbott 2012)

Y Inventiveness will be measured using the number of applied patents per company in the period January 2000 – June 2012. There are a number of online databases that store patent data like; WIPO, Orbit, Qpat, Espacenet, Google-patens. When researching for the number of patents per organization a difficulty occurred that all these databases reported different patent counts. Variations of more than 10,000 patents difference where very common. The decision was made to select one trust worthy database and report paten counts per organization according to their records. The author chose to use the worldwide search option of Espacenet, because this database offered the largest country coverage and included applied patent data. Please note that the worldwide search option is not the standard search option visualized when visiting the website of www.espacenet.com.
Using the following query "Abbott Lab*" and "2001 2011" a patent count of 9,319 has been measured (worldwide.espacenet.com 2012).

4.2. Case 2 GlaxoSmithKline

GlaxoSmithKline (GSK) is also a large company in the pharmaceutical industry which states that they are a "science-led global healthcare company" (www.gsk.com 2012). The company produces medicines, vaccines and consumer healthcare products that are used by millions of people around the world. Production at GSK is characterized by the strive to directly contribute to customer health and indirectly to the well-being of economy and wider society (AR-GSK 2011). Figure 4.2. provides an overview about the key factors of GSK (financial figures have been calculated from British pounds into US dollars using a ratio of 1:1.54). The total sales over 2011 have decreased by 4% with respect to the year 2010. The total investment in R&D was held constant but the rate of return on these investments has increased, mainly because of the launch of three new pharmaceutical products (AR-GSK 2011). Over 80% of the investments in R&D are spent on pharmaceutical research. From this budget 27% is spent on the actual discovery of inventions. This is a relatively small percentage but GSK works with over 50 'external discovery engines' which are partners that collaborate in the discovery of inventions by opening up new areas of science and sharing risks (Orbis 2012).

Figure 4.2: Key figures (AR-GSK 2011)

Within the interview information was captured about the strategies or existence of procedures to promote inventive behavior in an organization. The following quote from the innovation manager at GlaxoSmithKline illustrates their attitude towards invention and experimentation:

"We work with a business model of co-creation; this means that we try to involve main stakeholders in the development of our new products. We learn from the people working in the healthcare industry where the gaps are and which needs can be fulfilled. I think it is important to not just be inventive but also try to add value to broader society. A lot of companies in our industry are mere revenue seeking, and therefore producing to sell. We try to bring solutions to the market that are necessary and are a contribution to society." *(Innovation Manager GSK 2012)*

Performance on the selected firm characteristics

$X_{1\ \text{Firm size}}$ 97,389 Employees (AR-GSK 2011)

$X_{2\ \text{Firm age}}$ 12 Years (AR-GSK 2011)

An interview was held with an innovation manager of GlaxoSmithKline to receive answers for the qualitative questions of this research. For the concepts centralization, formalization and slack resources statements where provided which should be ranked on a Likert scale moving from 1 to 5. Table 4.2. visualizes the scores on these scales for the variables $X_{3ab,}$ X_{4ab} & X_{7b}, per variable it is indicated whether the desired outcome was an average of 1 (low) or an average of 5 (high). The end of each blue row indicates the average score on the sub variable.

Table 4.2: *Results interview questions* ***Glaxosmithkline***

X_{3a} Participation (High)	**3**
1. *How frequently do you usually participate in the decision to hire new staff*	3
2. *How frequently do you usually participate in the decisions on the promotion of staff*	2
3. *How frequently do you participate in decisions on the adoption of new policies*	3
4. *How frequently do you participate in the decisions on the adoption of new programs*	4
X_{3b} Hierarchy of authority (Low)	**1**
1. *There can be little action taken here until a supervisor approves a decision*	2
2. *A person who wants to make his own decisions would be quickly discouraged here*	2
3. *Even small matters have to be referred to someone higher up for a final answer*	1
4. *I have to ask my boss before I do almost anything*	1
5. *Any decision I make has to have my boss's approval*	1
X_{4a} Job codification (High)	**2**
1. *I feel that I am my boss in most matters*	3
2. *A person can make his own decisions without checking with anybody else*	3
3. *How things are done here is left up to the person doing the work*	1
4. *People here are allowed to do almost as they please*	2
5. *Most people here make their own rules on the job*	1
X_{4b} Rule observation (Low)	**4**
1. *There are a lot of rules to which I have to conform*	5
2. *The employees are constantly being checked on for rule violations*	4
3. *People feel as though they are constantly being watched to see that they obey all the rules*	3
X_{7b} Slack resources (high)	**4**
1. *The employee base is intensive for the work that we must do*	3
2. *There are sufficient financial resources to start up new projects or experiment*	5
3. *The current stock allows for new projects to start or to experiment with*	3

X_5 At GlaxoSmithKline 60% of team work is organized in a cross functional manner. The reason for this percentage is the fact that building knowledge bridges is one of the main pillars of the company strategy. The following quote illustrates the existence of cross functional team design at GSK:

> *"Communication and collaboration between people from different departments or specialty background is an essential part of our strategy. We try to make connection amongst or employees to induce inventive behavior but perhaps more important we try to establish these connections also with our indirect customers like doctors or other medical staff. To enable the employees to freely interact with each other we have a special company variant of twitter, here information about current projects can be posted or interesting topics can be raised." (Innovation Manager GSK 2012)*

X_6 Training is organized as a substantial part of the overall company strategy. GSK constructed a future goal for the year of 2016 and uses training to steam the employees ready for delivering this vision. As part of this objective they offer formal and professional training to their employees:

> *"Every organization has its obligation to train the employees, so of course we have our own training program. In line with our vision for 2016 we have a company theme called empowerment, which resembles the stimulation of people to take responsibility within the organization. The training is focusing on solid feedback methods and 'leaders as supporters' guidelines.... The average level of education in our organization lays very high, most employees have a University degree, we want to maintain and increase this extensive chunk of special knowledge by providing formal training where necessary to constantly develop our employees' skill levels. " (Innovation Manager GSK 2012)*

X_{7a} GlaxoSmithKline earned a net income of $ 9,141 Million over the year 2011, when reviewing this in the perspective to the 97,389 employees in the same year this leads to a net income per employee of 93,865 US dollars (AR-GSK 2011).

X_8 R&D investments for GSK are $ 6.174 Million over the year 2011 (AR-GSK 2011). Dividing this by the $ 42,176 Million earned as total sales makes a R&D intensity of 15%.

> *"At GSK around 14,000 people work in our R&D centers across the globe this is a rather large percentage of scientists working in one company. To accelerate our invention process we also collaborate in R&D with partner organizations. We chose for these open innovation structures due to the increased speed of inventing and development and the opportunity to share costs and risks." (Innovation Manager GSK 2012)*

Y Inventiveness will be measured using the number of applied patents per company. Using the following query "glaxosmithkline" and "2001 2011" a patent count of 3,709 has been measured (worldwide.espacenet.com 2012).

4.3. Case 3 Merck Sharp & Dohme

Merck Sharp & Dohme (MSD) is a global health care company that brings health care solutions to the market through the development of medicines, vaccines, biologic therapies for improving the well-being of people and animals. MSD is a research intensive organization where a lot of attention en money is spent on research for new medicines (www.msd.nl 2012). During the year of 2011 the organization focused on revenue growth strategies, cost reductions through efficiency gains and making strategic investments in new product launches. As a result the worldwide sales have increased with 2 billion US dollars which resembles a 4% revenue growth (AR-MSD 2012). A possible explanation for this growth can be found in the shortening in R&D investments, in respect to the year 2010 a negative growth can be witnessed of 24%. This seems rather massive but it must be mentioned that in the year 2010 the budget was almost doubled in respect to the year 2009 because of "in progress" R&D activities that must be paid for due to a take-over.

Figure 4.3: Key figures (AR-MSD 2012)

An interview has been held to capture information about the strategies or existence of procedures to promote inventive behavior in an organization. The following quotes from the senior manager at Abbott Laboratories illustrate the company' attitude towards invention and experimentation:

> *"Within our organization employees are encouraged to deploy problem solving behavior on their own. If a single employee recognizes a certain need in the industry or business environment we have the 'Just do it' mentality which inspires him or her to seek for an inventive solution. Of course sometimes are such projects too large to bear on the shoulders of one employee but then we have the agreement in our organization that one will search for back up and bright ideas within his own tier. In the event that this particular tier has not the decision making authority or budgets for the inventive project, employees from a higher ranked tier will be asked for assistance. Due to this mentality and active training on the just do it mentality people here feel encouraged to experiment." (Senior Manager MSD 2012)*

> *"When people constantly experiment with new things they will inevitably make a mistake some day and that is not a problem here. But to make sure that no failures will be made that could have been expected or foreseen we use parameters to measure the potential effects of invention, by which we can decide whether to continue with our projects." (Senior Manager MSD 2012)*

Performance on the selected firm characteristics

$X_{1\ \text{Firm size}}$ 86,000 Employees (AR-MSD 2012)

$X_{2\ \text{Firm age}}$ 121 Years (AR-MSD 2012)

An interview was held with a senior manager of Merck Sharp & Dohme to receive answers for the qualitative questions of this research. For the concepts centralization, formalization and slack resources statements where provided which should be ranked on a Likert scale moving from 1 to 5. Table 4.3. visualizes the scores on these scales for the variables $X_{3ab,}$ X_{4ab} & X_{7b}, per variable it is indicated whether the desired outcome was an average of 1 (low) or an average of 5 (high). The end of each blue row indicates the average score on the sub variable.

Table 4.3: *Results interview questions* ***Merck Sharp &Dohme***

X_{3a} Participation (High)	**5**
1. *How frequently do you usually participate in the decision to hire new staff*	5
2. *How frequently do you usually participate in the decisions on the promotion of staff*	4
3. *How frequently do you participate in decisions on the adoption of new policies*	5
4. *How frequently do you participate in the decisions on the adoption of new programs*	5
X_{3b} Hierarchy of authority (Low)	**1**
1. *There can be little action taken here until a supervisor approves a decision*	1
2. *A person who wants to make his own decisions would be quickly discouraged here*	1
3. *Even small matters have to be referred to someone higher up for a final answer*	1
4. *I have to ask my boss before I do almost anything*	2
5. *Any decision I make has to have my boss's approval*	1
X_{4a} Job codification (High)	**3**
1. *I feel that I am my boss in most matters*	3
2. *A person can make his own decisions without checking with anybody else*	5
3. *How things are done here is left up to the person doing the work*	4
4. *People here are allowed to do almost as they please*	2
5. *Most people here make their own rules on the job*	3
X_{4b} Rule observation (Low)	**4**
1. *There are a lot of rules to which I have to conform*	5
2. *The employees are constantly being checked on for rule violations*	4
3. *People feel as though they are constantly being watched to see that they obey all the rules*	2
X_{7b} Slack resources (High)	**2**
1. *The employee base is intensive for the work that we must do*	1
2. *There are sufficient financial resources to start up new projects or experiment*	4
3. *The current stock allows for new projects to start or to experiment with*	1

X_5 Cross functional team design is fully implemented within MSD. All teamwork occurs in a cross functional setting since the organization believes that this lies at the core of inventive behavior. The following quote illustrates this approach at Merck Sharp and Dohme;

> *"Cross functional team design is one of the main pillars of the strategy objective within MSD. Almost all teamwork will occur in cross functional settings since we believe that two know more than one and a different perspective to a topic can sometimes be just what you need to*

see an inventive opportunity. Additionally we have a board member meeting every day, although for 15 minutes we still have the opportunity to discuss the most important topics and keep motion in projects high." (Senior Manager MSD 2012)

X_6 At MSD large budgets are spent on the individual training of their employees;

"At MSD a relatively large percentage of the employees will receive an imposed training program. At the moment we strive to train 1 out of 2 employees in the department where we research and produce the active ingredients of pharmaceutical products. Besides this specialized training program to induce the problem solving behavior of our employees, every employee will receive training to reinforce their specialized skills." (Senior Manager MSD 2012)

Consequently employees of MSD are following imposed training programs that can be both formal and professional of nature.

X_{7a} Over the year of 2011 MSD has earned a net income of $ 6,392 Million. When dividing this by the 86,000 employees of the company a net income per employee is generated of $ 74,362 (AR-MSD 2012).

X_8 In 2011 MSD has invested 6,174 Million US dollars in R&D activities, in the same year they generated a total sales of $ 48,047 Million which leads to an R&D intensity ratio of 18% (AR-MSD 2012).

"Worldwide MSD deploys 16 research and development centers where research is done in specific areas. In the pharmaceutical industry regulations are very strict so therefore the room to freely experiment is bounded and with that the need for control on potential effects increases. Therefore each R&D site has its own specialism and area of research. As an employee who is not a member of the R&D brigade of MSD you will be informed about the clinical test results from products leaving phase II or III and of course the new product launches. (Senior Manager MSD 2012)

Y Inventiveness is measured using the number of applied patents per company. Merck Sharp & Dohme is the European name for Merck & Co, almost all patents are therefore applied under the name of Merck & Co. Using the following query "merck co" and "2001 2011" a patent count of 10,330 has been measured (worldwide.espacenet.com 2012).

4.4. Case 4 Ursapharm Arzneimittel GmbH

Ursapharm is an international company that has been active over the past 35 years with the transformation of inventive pharmaceutical concepts into successful medicinal products and devices (www.ursapharm.de 2012). Ursapharm is amongst the market leaders in ophthalmology care. The production program includes besides eye care also the preparation of general medicines in their product portfolio. A unique aspect of the complexity of Ursapharm is the fact that they function as the executive partner in research collaborations (Orbis 2010). In figure 4.4. some key figures about Ursapharm can be witnessed. Perhaps the most striking difference with the other three cases is the small number of employees that work at this company. Though, Ursapharm is an interesting case

example since the company is known for their people driven mentality, they claim to thrive on the creative power of their employees which forms the base for an exceptional market position and is the dynamic power behind innovative development (www.ursapharm.de 2012).

A product specialist of the German company Ursapharm has been interviewed. One of the questions was about the existence of strategies or procedures to promote inventive behavior in an organization. The following quote illustrates the attitude towards invention and experimentation:

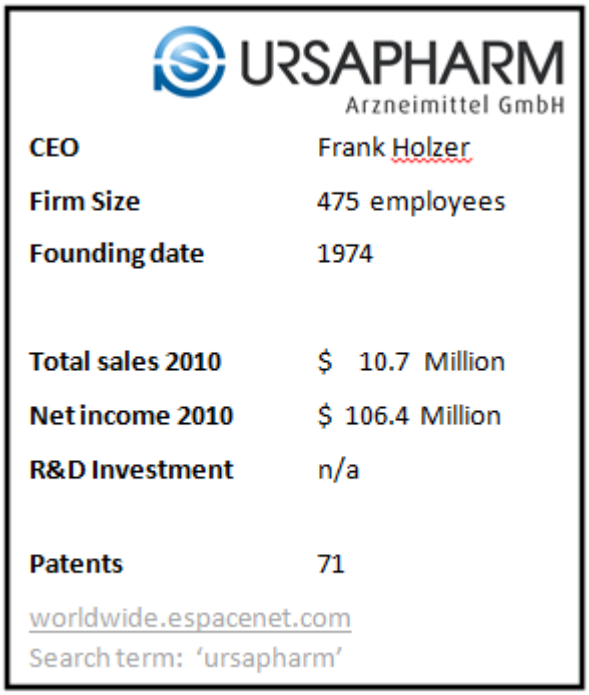

Figure 4.4: Key figures (Orbis 2010)

> *"The headquarters in Saarbrücken Germany are responsible for developing general innovation strategies. They conduct market research and preliminary studies to identify potential needs of our customers or gaps in the pharmaceutical industry. Here in the Dutch branch of the organization we are concerned with the development and sales of the COMOD®-system which is a specialized eye care product. If we have a novel idea resulting from our own experiments we can communicate this with our German colleagues and they will give it proper attention. Since we are a rather small company in comparison to the big players of the industry we have less financial resources to spend on experimentation. Of course in the R&D departments we do but in our organization we cannot coop with too many failures so that is why strategy is determined by the management team."* *(Product specialist Ursapharm 2012)*

Performance on the selected firm characteristics

$X_{1\ \text{Firm size}}$ 475 Employees (Orbis 2010)

$X_{2\ \text{Firm age}}$ 38 Years (Orbis 2010)

An interview was held with a product specialist of Ursapharm to receive answers for the qualitative questions of this research. For the concepts centralization, formalization and slack resources statements where provided which should be ranked on a Likert scale moving from 1 to 5. Table 4.4. visualizes the scores on these scales for the variables $X_{3ab,}$ X_{4ab} & X_{7b}, per variable it is indicated whether the desired outcome was an average of 1 (low) or an average of 5 (high). The end of each blue row indicates the average score on the sub variable.

Table 4.4: *Results interview questions* ***Ursapharm Arzneimittel GmbH***

X_{3a} Participation (High)	**3**
1. How frequently do you usually participate in the decision to hire new staff	4
2. How frequently do you usually participate in the decisions on the promotion of staff	2
3. How frequently do you participate in decisions on the adoption of new policies	1
4. How frequently do you participate in the decisions on the adoption of new programs	3

X_{3b} Hierarchy of authority (Low)	2
1. *There can be little action taken here until a supervisor approves a decision*	2
2. *A person who wants to make his own decisions would be quickly discouraged here*	2
3. *Even small matters have to be referred to someone higher up for a final answer*	2
4. *I have to ask my boss before I do almost anything*	2
5. *Any decision I make has to have my boss's approval*	1
X_{4a} Job codification (High)	**3**
1. *I feel that I am my boss in most matters*	4
2. *A person can make his own decisions without checking with anybody else*	4
3. *How things are done here is left up to the person doing the work*	3
4. *People here are allowed to do almost as they please*	3
5. *Most people here make their own rules on the job*	3
X_{4b} Rule observation (Low)	**3**
1. *There are a lot of rules to which I have to conform*	4
2. *The employees are constantly being checked on for rule violations*	3
3. *People feel as though they are constantly being watched to see that they obey all the rules*	1
X_{7b} Slack resources (High)	**4**
1. *The employee base is intensive for the work that we must do*	4
2. *There are sufficient financial resources to start up new projects or experiment*	4
3. *The current stock allows for new projects to start or to experiment with*	3

X_5 Ursapharm scores very low on the cross functional team work variable. Since the organization is so small and people have therefore broad responsibilities it is difficult to construct teams that are cross functional and practical at the same time due to f.e. geographical distance. An estimated average of 20% of the teamwork is cross functional, such events occur for example when new strategies are discussed.

> *"We make little use of cross functional teamwork in our organization. Due to the small number of people that work here and the rather specialized production sites that lay across Europe and India our jobs are very specified. We have contact on a regular basis with offices in the Benelux but these meetings are sales related and I can hardly see them as cross functional."* *(Product specialist Ursapharm 2012)*

X_6 Training is offered organization wide and aims to improve the competence and skill levels of the employees. It can therefore be said that Ursapharm offers professional training:

> *"Training is centrally organized in our company. About once a year we have training in Germany to improve on our professional skills and competences. There is little room for training with the purpose to intensify the knowledge levels of single employees, but it is indeed possible to take up an additional education yourself then some financial support and study time is offered by the company."* *(Product specialist Ursapharm 2012)*

X_{7a} It was rather difficult to receive financial figures about Ursapharm Arzneimittel GmbH, since they are the only company that is not active on the stock market they are not obligated to make financial details public. The databases with company information only included figures from the year 2010. Several emails to the company have found no response and therefore no information about

2011 could be captured. The author chose to measure the other three companies over the year 2011 since their financial figures are of a complete different range and therefore the influence is negligible. Ursapharm earned a net income of 10,681 thousands of US dollars over the year 2010, when reviewing this in the perspective to the 475 employees in the same year this leads to a net income per employee of 22,486 US dollars (Orbis 2010).

X_8 Unfortunately the company record downloaded from database Orbis did not contain financial figures on R&D investment. Therefore the respondent was asked to indicate the percentage of R&D intensity. The respondent has searched in private company databases and has indicated that the R&D intensity must lay around 11% for Ursapharm.

> *"R&D is centrally organized in Saarbrücken and as a result there is little involvement from other departments who are not conducting research. I am directly involved with R&D activities when concept products are entering the latest phases of the development cycle and a product launch is expected and must be planned." (Product specialist Ursapharm 2012)*

Y Inventiveness will be measured using the number of applied patents per company. Using the following query "ursapharm" and "2001 2011" a patent count of 39 has been measured (worldwide.espacenet.com 2012).

5. Results

This chapter consists of an analysis of the results from the empirical research. Where the previous chapter only summed the results from the interviews and the secondary data analysis, this chapter will try to make connections between different types of results. The method for analysing the results has earlier been described in chapter 3.4. With this analysis the second research question will be answered:

Are the firm characteristics extracted from literature able to efficiently predict inventiveness?

First the findings of the empirical research must be scored on the operationalization table (#3.2 p. 30). The next step is to establish the expected relationships per case e.g. $X_1 + ... + X_8 = Y_{case\ 1}$. The value of this chapter is offered through the verification whether the expected relationships 'the theoretical framework' can be found within the results of the empirical study. As this is an explorative study the results on this evaluation will be used as input for new scientific research.

Performance evaluation on $X_1 + ... + X_8$

Table 5.1 provides a summary of chapter four, where each of the firm characteristics is quantified per company. The light blue rows underneath the X-values represent the corresponding performance category, as defined in the methodology chapter.

Table 5.1: *Scoring the 4 cases on the operationalization table (3.2)*

	Abbott	GSK	MSD	Ursapharm
X_1	91,922	97,389	86,000	475
Firm size	**A**	**A**	**A**	**C**
X_2	124	12	121	38
Firm Age	**E**	**C**	**E**	**B**
X_{3a}	3	3	5	3
	C	**C**	**A**	**C**
X_{3b}	1	1	1	2
Centralization	**A**	**A**	**A**	**B**
X_{4a}	2	2	3	3
	D	**D**	**C**	**C**
X_{4b}	4	4	4	3
Formalization	**D**	**D**	**D**	**C**
X_5	70%	60%	99%	20%
Intra-firm linkages	**B**	**B**	**A**	**D**
X_6	Formal & Professional	Formal & professional	Formal & professional	Professional
Specialization	**A**	**A**	**A**	**C**
X_{7a}	$ 51,440	$ 93,865	$ 74,326	$ 22,486
	C	**B**	**C**	**E**
X_{7b}	4	4	2	4
Slack resources	**B**	**B**	**D**	**B**
X_8	11%	15%	18%	11%
R&D Intensity	**D**	**C**	**B**	**D**

The largest differences in performance categories can be witnessed for the characteristics firm age, intra-firm linkages, Slack resources and R&D intensity. For the other four characteristics it can be said that two or more companies score in the same performance category. Figure 5.1. provides an overview of the performance per company measured in weight categories. For the variables centralization and formalization the measure consisted of two sub variables which have now been summed in one average.

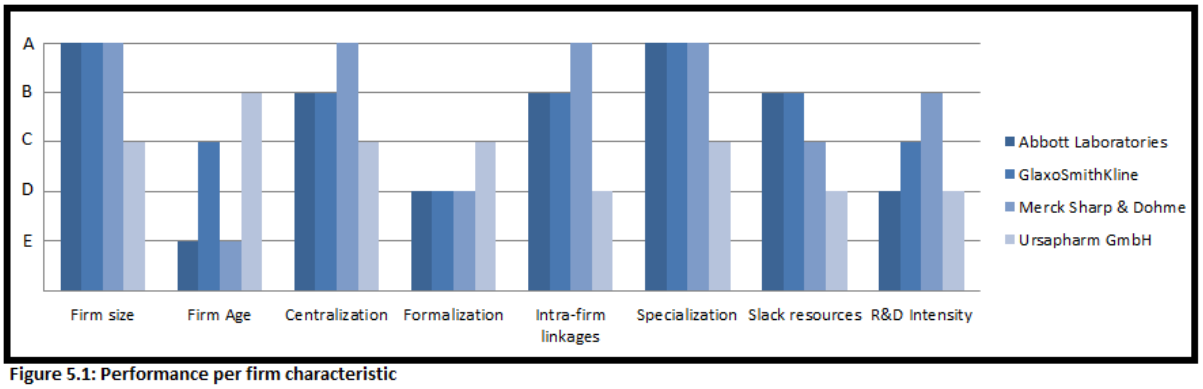

Figure 5.1: Performance per firm characteristic

Based on the overall performance scores some interesting remarks regarding literature can be made.

Advantages for SME's

Based on the literature study the advantage for SME's lays in higher levels of flexibility and the awareness for recognizing opportunities for success due to the shorter lines of communication and less formalized routines (Rogers 2004, Damanpour 1992). Based on what has been research it may be expected that SME's will score high on the characteristic formalization which measures the existence of formalized routines and score low on centralization which measures the decision making authority in an organization. These expectations have been met partially, what can be viewed in figure 5.1. is that Ursapharm Arzneimittel GmbH indeed scores above average on the variable formalization and below average for the variable centralization but these scores are not very conclusive. A possible cause can be the fact that both variables are measured using two sub variables that are probably not firm size specific; participation and job codification. The difference between Ursapharm and the other three cases is too small to really state that literature expectations have been met.

Ursapharm was selected as a case to see whether the eight characteristics could be privileged to larger organizations due to financial reasons or strategic opportunities. It can be witnessed in table 5.3. that for some characteristics medium sized firms score lower because it is compared to performance of other size. This is the case for characteristics intra-firm linkages, specialization and slack resources. For the first two it can be said that a medium sized firm has less financial means to invest in collaboration and training. On the other side it was also mentioned by the product specialist of Ursapharm that in a medium sized organization the need for cross-functional collaboration is less. Since employees have widened responsibilities and the organization is transparent enough to follow operations and share knowledge with colleague, the need for information of other departments is less present.

Advantages for large organizations

According to the different authors reviewed for the advantages on large firm size, the benefit can be found in the strong cash flows and financial resources that are present for large organizations (Camison-Zornoza et al. 2004). Another beneficial trait for large firms can be found in the extensive employee base that provides a wide range of knowledge and skills to profit from. Based on these findings it may be expected that large organizations score high performance weights on the characteristics specialization and slack resources. Specialization is the variable that measures any benefits from highly skilled employees and slack resources measures on the benefits of surplus resources like financial means. From figure 5.1. it can be learned that these expectations are met within this research project. For firm size and specialization the similarities are obviously present since all three firms scored A categories on specialization. This result underpins what was found in the literature study, Damanpour (1992) stated that larger corporations have an extensive employee base and therefore have an advantage when it comes to specialization. Organizations want to utilize this advantage and therefore invest in maintaining this knowledge base and increasing it by means of formal and professional training. For slack resources no A categories are scored but it can be witnessed that the large organizations are on the top of the distribution for this variable. Only MSD scores a category lower but this can be explained due to their poor score on surplus human resources. Evidently, the expectations formed in the literature study have been met.

Firm size & Formalization

Literature has shown that large organizations are more inventive than medium or small sized firms, it also became clear that inventive organizations should possess low levels of formalization (Subramanian and Nilakanta 1996). Based on literature it could be expected that large corporations are characterized with low levels of formalization. From figure 5.1. it can be concluded that the large organizations in this research project are characterized with high levels of formalization. So the expected relationship is not underpinned by empirical evidence. This high formalization may be explained due to the enforced governmental rules for pharmaceutical companies. All respondents indicated to be pressured with a lot of safety rules to which they have to conform in order to stay in business. These government regulations are translated into narrow job codifications and a robust set of rules to which employees have to comply. It may be expected that when one chooses a different industry the scores on formalization will be higher.

Another explanation for this result may be the fact that often large organizations are forced to be decentralized, for management to have still control on their employees there is a high degree of job codification “what should an employee do?” and an even higher degree of rule observations “do the employees confirm to the company rules. Research by Subramanian and Nilakanta (1996) also describes the possible existence of a correlation between these two variables. Only this relationship cannot be underpinned with evidence gathered within this study. As one can see the variable centralization scores an average C category at Ursapharm, where levels of formalization are the lowest of all companies. Evidently, it cannot be concluded from this research that high levels of decentralization lead to higher levels of formality within the organization.

Research by Damanpour tried to proof a negative relationship between highly formal organizations and inventiveness. This relationship could not be proven scientifically and an argumentation provided for the hold off of an effect was attributed to the positive effects of highly formalized

structures. The author argues that in some occasions well-established routines and specified job descriptions foster successful introduction of inventions within companies. A parallel is made to Zaltman's (1973) classification in initiation and implementation phases of innovation. Where initiation evolves under low formalization and implementation thrives from high formalization levels. Research has shown hardly significant values for the first relationship, the latter has not been proven by scientific means yet. Since there is an absence of a scientific explanation the conclusion must be drawn that this unexpected relationship between large corporations and high levels of formalization is an specific attribute of the industries strict safety regulations.

Slack resources & R&D intensity

Slack resources are scored very differently amongst the four cases. From the interviews it could be learned that all four of the companies indicate that there are sufficient financial sources for experimentation. The differentiation that can be witnessed in figure 5.1. can be explained through the lack of surplus time or employees to take upon creative projects and experiment. One would expect to see a similar distribution for the quantitative measure R&D intensity but here a complete different dispersion can be observed. The expectations of a similar distribution evolves from literature which states that often surplus resources are used to invest in additional R&D or experimentation activities (Damanpour 1992). This expectations is not met at all within the empirical study of this project. A cause can be found when one pays a closer look to the measures applied for both variables. Slack resources is measured with a percentage of net income earned whilst R&D intensity is measured as a percentage of total sales. Net income is what is left of the total sales when costs like R&D are subtracted. So expectations from literature do not apply for this research due to the constraints of operationalization. What can be said is that organizations with high net incomes left after relatively low R&D intensity expenditures do not make use of the slack resources advantage like literature suggests. This is the case for Abbott Laboratories and GlaxoSmithKline.

Performance evaluation of Y

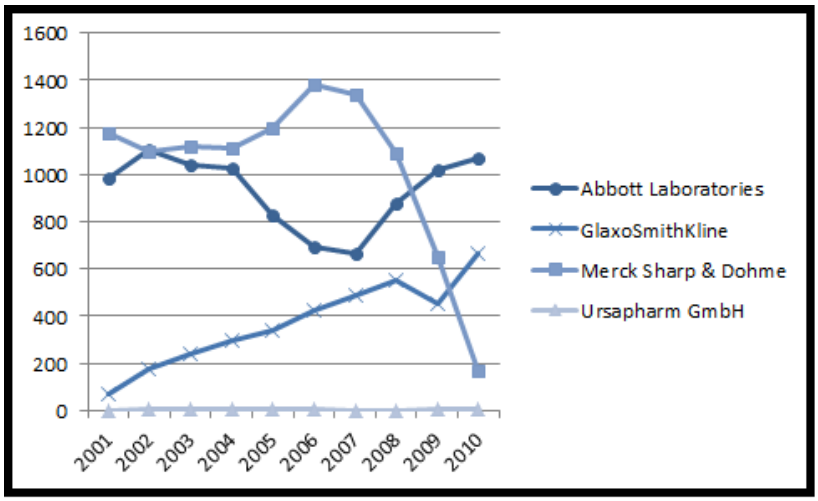

Figure 5.2: Applied Patent Counts per year (worldwide.espacenet.com 2012)

The next step for analysing the results is to have a closer look to the distribution of applied patent data. In figure 5.2. the spread of patent counts can be witnessed per company. In the following sections relationships will be discussed that have shown results that are different than could have been expected.

Firm age vs. Inventiveness

Literature has shown that firm age is distributed over an inverted U-shape where increasing absorptive capacity leads to increasing inventiveness in the first years and where eventually the build-up of routines and core rigidities decreases the levels of inventiveness over time (Huergo and

Jaumandreu 2004). Based on these theories it can be expected that the older organizations will have a decreasing patent count number since the inventiveness levels must be decreasing and the younger organizations will have an increasing patent count due to gained absorptive capacity advantages. From figure 5.2. it can be derived that GlaxoSmithKline, as being the youngest company in the sample, clearly shows an increasing trend over the past 10 years. From under a hundred patents applied for in their second year of operation up to nine times as much after only ten years of operation. For the oldest organizations, Abbott Laboratories and MSD, a remarkable result can be witnessed. Where MSD shows a firm descending trend line in the past five years with a decrease of over 500 applied patents a year starting from 2008. On the contrary Abbott laboratories who is three years older shows a relative constant distribution of time, a depth can be seen but the starting point in 2001 of around 1000 patents applied for per year can also be witnessed in 2010 when more than 1000 patents were counted. So the assumption that age would affect inventiveness negatively after the year of 36 is not underpinned by the empirical data gathered. Based on the data gathered it must even be said that the oldest company of the sample, Abbott Laboratories, shows the most stable distribution in patent counts over the 10 year period of time investigated.

R&D intensity & Inventiveness

Literature has shown that an R&D intensity of over 30% can be perceived as the ideal situation for fostering inventiveness within organizations (Hall and Bagchi-Sen 2002). Based on these findings it can be expected that organizations with R&D intensity scores close to the ideal situation will book the highest results on inventiveness measured as applied patent counts. The dataset shows that hierarchy in R&D intensity scores follows a distribution where MSD leads, GlaxoSmithKline follows and Abbott Laboratories & Ursapharm have a shared third position. When looking at figure 5.2. it can be viewed that actual patent counts do not resemble this distribution. It can be viewed that Abbott with a less than ideal R&D investment percentage scores very well on the scales of inventiveness and also is able to maintain a rather solid distribution of time. The proposition that R&D intensity is linearly positive related to Inventiveness is not underpinned by the data gathered within the empirical study. This does not mean that this proposition is not true since after all for the other three companies the conclusion can be made that R&D Intensity efforts are traceable within the inventiveness performance per company.

Evaluation of the results X_1 + ... + X_8 = Ycases

Evaluation of the relationship can be done based on comparing the performance of the four cases to their patent count over a fixed period of time. Based on the individual average performance a ranking can be established. From the literature a theoretical framework has been constructed which consists of 8 firm characteristics that foster inventiveness in organizations. In combination with the operationalization table 3.2 it can now be said that organizations performing closest to the ideal situation of the theoretical framework will be most inventive in comparison to the other three organizations. Consequently, it is expected that the organization with the highest ranking will be the most inventive e.g. have the highest patent count. For the expected relationship to be through – and the research question to be positively answered - the ranking of case performance must take the same for as when you rank the Y values per case. As described in the methodology chapter three types of analysis will be used; comparison of equal distributed X values, comparison of in equal distributed X values and modelling the ideal situation.

Comparison of equal distributed X values

This analysis is built upon the assumption that all firm characteristics have the same relative weight in the equation. Evaluation will take place based on the ranking of the Average Performance (AP) and the ranking of matching Y values.

Table 5.3: *Performance on the equal distributed firm characteristics*

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	AP	Y
MSD	5	1	5	2	5	5	3	4	75.0%	10,330
GSK	5	3	4	2	4	5	4	3	75.0%	3,709
Abbott	5	1	4	2	4	5	4	2	67.5%	9,319
Ursapharm	3	4	3	3	2	3	2	2	55.0%	39

In table 5.3 it can be witnessed that the expected relationships have not been underpinned by empirical research. The green colour marks the results that are corresponding, the red colour marks the results that do not match. Based on the expected relationships from the literature study it was expected that Abbott laboratories would have the second largest patent count and that GlaxoSmithKline would follow after that. From the figure it can be witnessed that the ranking of GlaxoSmithKline is out of place since it scores exact the same percentage as the performance leader MSD. The next paragraphs will elaborate on explaining the lack of confirmation in the relationship between firm characteristics and inventiveness.

Comparison of in equal distributed X values

This analysis is built upon the assumption that some firm characteristics have a different relative weight in the equation. Due to the explorative nature of this research the impact of relative weights has been calculated up till a set of three equally different weights. The following new relationships have been made:

1. One X-value has weighing factor 0.5 (8 new equations)
2. One X-value has weighing factor 2 (8 new equations)
3. Two X-values have weighing factor 0.5 (28 new equations)
4. Two X-values have weighing factor 2 (28 new equations)
5. Three X-values have weighing factor 0.5 (56 new equations)
6. Three X-values have weighing factor 2 (56 new equations)

For these 184 new equation similar tables as 5.3 have been constructed. Analysing these tables has led to the result that none of the new equations projects the expected distribution where MSD would have top rank performance percentage, followed by Abbott, then comes GlaxoSmithKline and last Ursapharm will represent the bottom of the ranking. This outcome could have been expected based on the outcomes of table 5.3, here one can see that GSK and Abbott have very similar performance scores but only differ on value X_2 and X_8. In both occasions Abbott scores in a lower performance category than GSK, so it is impossible to create a situation with this dataset where Abbott would outperform GSK in performance percentages. This is very unfortunate since we now know that with the constructed dataset it will not be able to answer the second research question.

Modelling the ideal situation

Based on the selected analysis tools the third method was to model the ideal situation for the X-values in a way that they are effective in predicting inventiveness levels. This will not be possible due to the reasons explained in the previous paragraph. But since this is a preliminary study it is very important to evaluate further what the possible causes are for a failure of the model and what should be changed in further research.

Possible causes for failure of the model

From this point on one must evaluate whether the failure is a cause of inaccurate data or of an inaccurate model. One could argue whether the information captured within the interviews was reliable and valid for the research goals set. In table 5.3. it can be witnessed that the main differences between organizations are encountered for the quantitative measures e.g. data that has been published by organizations themselves. It could be that information gathered on the qualitative variables was inaccurate and therefore too little variance amongst companies was found. But when one would work the model leaving all qualitative variables out, the model still does not comply to the expected relationship. Therefore it can be concluded that the reliability of the interviews cannot be the main explanation for failure of the model.

Since this was an explorative research a small number of research units have been investigated due to time constraints. As a result the opinion of one is perceived as the truth for a whole company. The average performance and with that the expected ranking is therefore based on one opinion. For a higher validity and a renewed vision to the expected relationships it is important to broaden the sample size of the case study respondents in a future research. Since a selection strategy based on commonly accepted literature has been used the author believes that the right people have been interviewed for this study. But it must be acknowledged that some questions can be placed with the respondent of GSK who is an innovation manager. He was very positive about the performance of GSK on several of the questions. For example that GSK had a no profit strategy, but when reviewing the relationship between net income and R&D investments it could be witnessed that GSK earned the most net income and invested not the most in R&D of the group, whilst the manager proclaimed differently. It can be that since he is mainly responsible for these processes and procedures he has an optimistic opinion instead of a realistic view. It could therefore be that the average performance scores are higher than would have been if another respondent was interviewed, or if data was derived from multiple respondents per company.

On the account of inaccurate data one could also argue whether the used scales within operation where correctly set. A review of literature has learned that invention studies using firm characteristics often are featured with insufficient data and relationships that cannot be proven scientifically. One could argue whether the weight categories were set correctly. Most of the weight categories show a linear distribution of performance scores, assuming that the linear distribution is correct and only the distribution is insufficient, one can reposition the arguments by stating that results still show a similar distribution only weights are incorrect. When weight categories are scaled wrong this would not have an effect on the working of the model.

Moving to inaccuracy of the model, it can be that also the distribution of weight categories is modelled incorrect, meaning that relationships are not linearly (or as assumed). Another review at literature has brought up one author underpinning the possible existence of non-linear relationships. Research by Chen and Chang (2010) has investigated firm size in relation to inventiveness and proclaims to have found an non-linear relationship. This outcome cannot immediately be used as an explanation for the failure of the model since in that research project firm size was differently conceptualized; as the number of assets of a firm and they merely focused on radical inventions instead of invention as a whole. But the author must acknowledge that the possible existence of non-linear relationships are partly responsible for explaining the failure of the model. Earlier on it has been concluded that the influence of firm age and R&D intensity is different than could be expected based on literature. It can therefore be said that the operationalization of these variables does not comply to empirical outcomes and the a different pattern of distribution must be revised for further research.

For firm age we learned that Abbott Laboratories exists already 112 years at the start of the measurement period. Although literature only focuses on the negative effects of path dependency and routines the opposite is also true. An organization that has already core competences and a solid understanding of the market can advantage from this position and therefore research and develop more accurate and perhaps easier. This is underpinned by the dataset showing very constant high patent counts per year (average 1000). This result is new to literature since all reviewed authors were using U-shaped measures for firm age. Further research must elaborate on this new found relationship and indicate whether Abbott Laboratories is the exception or the rule.

About R&D intensity it can be concluded that within this model its importance is not equal to the other variables. In the analysis where in equal distributions were compared to each other one could view that equations where X_8 was regulated differently than the other variables a distribution closer to the Y distribution was visible. This is a very odd outcome since most invention studies stress the importance of R&D for successful invention in organizations. What can be concluded from this research is that the intensity of R&D is not a determinant for inventiveness and apparently the effectiveness of this characteristic is important to measure for.

Another explanation for the failure can be in the fact that a variable has been overlooked or not included in the model. Based on what can be expected by literature and outcomes of other research by different authors there are no clear indications that there is a variable missing. When reviewing discussion sections of authors researching invention studies as well there are no suggestions made that they have the idea variables are missing or certain failures cannot be explained in research. What is more likely is that the mutual relationships between firm characteristics are overlooked. Because the data sample is to small it is difficult to draw conclusions on correlating effects between variables. But it is possible that ignoring these effects are responsible for the failure of the model.

At last failure of the model can be explained by the fact that this study only investigated the existence of the firm characteristics. For some variables X5, X6, X7, X8 it has not been investigated what is done with the existence of these variables. For example training can be bad or slack resources can be used to run errands for the boss. Now it is assumed that the mere existence is

positive but based on the outcomes of this research it can be suggested that this is not the truth one must specify the exact quality of the firm characteristics.

Recommendations for further research

Since this is an explorative research it is very important to learn from the outcomes and formulate recommendations for further research that will improve external validity. The learning outcomes and recommendations will be summed in this section.

- Use a larger sample set for the empirical research which enables the analysis of data with proper statistical means and increases validity of the research project. This large sample set does not only mean companies but also increase the number of respondents per company. In the literature it has been defined that one can categorize respondents into three categories, it is recommended to use this categorization to increase internal validity.

- Make use of different techniques when exploring the case study. Now some survey type questions were inserted in an interview, it would be highly recommendable to send out prior to the interview a survey to ask for basic details and check off the first five questions. An additional advantage is that one knows already more about the case and sharper questions can be raised. For additional examples see Subramanian and Nilakanta (1996).

- Apply methods to measure on accurate relative importance levels instead of modelling these in the analysis phase. This can be done through multivariate statistics, which are used when there are many independent variables and/or many dependent variables which are correlated to different degrees. The test used for this research is discriminant function analysis (DISCRIM). Such an analysis can be used to evaluate whether the dependent variables of groups are truly different and on which independent variables they differ (Tabachnick and Fidell 2000). Such a technique also allows for testing correlation effects.

- Measure for the (negative) effects of firm age and alter the operationalization or delete firm age as a characteristic. Now firm age has a negative effect on overall performance whilst the data set suggest that there is also a strong positive effect for older organizations. It is important that the relationship is revised and a different relationship is expected.

- There can be some correlation be expected between sub variable participation and job codification. Organizations where there are formal rules for the job and there is a strong control on the compliance it is less likely that employees will be asked to participate of feel encouraged to do so on their own.

- Measure on the quality of the firm characteristics X5, X6, X7, X8, instead of the existence of them. No the mere existence is perceived as positive whilst one does not know for sure that good things are done with this existence and therefore the relationship with invention is under some suspicion.

- When interviewing make sure one has respondents with similar backgrounds. This is very difficult if you do not personally know the respondents, since on first sight job profiles may look the same but can differ widely in responsibility when one looks further into it. A survey prior to the actual interview can aid in this problem or one can compare salary groups of the respondents to make sure that they are at the same power level of the organization. For this research it has been a negative influence that one of the respondents was an innovation manager, so it is recommended to interview truly objective respondents.

- CEO influence has been left outside the research scope due to the limited effects of one person on an organization of thousands of people. But it would be interesting to measure manager influence in a further research project. The interviews have learned that the attitude of a senior manager is determining for the deployment of inventive programs.

- A thread of working with innovation theories is that no invention is the same, therefore the effect of firm characteristics will have a different impact per type of invention (Subramanian and Nilakanta 1996). In a future study it is recommended to take upon a differentiation between types of invention so one can more specifically state which firm characteristics are effective in predicting inventiveness.

6. Conclusion

In this chapter the central research question that has been raised in section 1.2. will be addressed. This question was formulated accordingly:

What firm characteristics determine the inventiveness of organizations?

To answer this research question a literature study has been carried out to search for firm characteristics that foster invention. To add precision to my work also some literature about the concept inventiveness has been investigated to search for an appropriate terminology and measures to use within this study. Consequently, inventiveness is defined in this research as "a measure for originality by the virtue of new ideas derived through a process of invention". After an evaluation of six measures for inventiveness research has shown that patent data is the most adequate measure for inventiveness within the scope of this research. A constraint coming with this decision is that inventiveness in this research project only contains the ideas that are patented by the company, leaving other possible interesting inventions out of the research scope.

This research project is built up of two phases where the most extensive one includes a thorough literature study on the characteristics of a firm that foster invention and where the latter part consists of an explorative test to determine whether these found characteristics are in practice efficient for determining inventiveness.
Through the use of over 70 scientific articles firm characteristics have been investigated that seem to have a link with fostering inventiveness in organizations. In total 16 characteristics have been found and it can be concluded that these are all elements that positively affect inventiveness at some point of their curve. To be able to answer the research question it was important to investigate the relationship between the independent firm characteristic variables and the dependent variable inventiveness (Table 2.1). Since this paper aimed to provide a thorough overview of literature on influencing characteristics of invention and narrow this down to a specific set of firm characteristics that do seem to effect this positively it was necessary to evaluate the importance of all 16 variables. Additional literature per characteristics was sought to determine what the exact effect on inventiveness was and how it can be measured in companies. For some characteristics the decision was made to group items together since the appropriate measures showed too much resemblance or the expected effect was after all not clear enough. Evidently, a theoretical framework was constructed delivering a set of firm characteristics that determine inventiveness of organizations:

1. Firm size
2. Firm age
3. Centralization
4. Formalization
5. Intra-firm Linkages
6. Specialization
7. Slack resources
8. R&D intensity

From this point it can be said that the research question is answered since firm characteristics that determine inventiveness in organization have been investigated successfully and conclusions can be drawn based on literature. However this research tries to make a first attempt of testing the constructed theorem and evaluating performance in a practical setting through the use of an explorative case study. Since there must be a control for all environmental factors companies from a similar industry must be selected. Within this project the model will be tested in the pharmaceutical

industry due to the industries high willingness to patent ideas, the selected organizations are; Abbott Laboratories, GlaxoSmithKline, Merck Sharp & Dohme and Ursapharm Arzneimittel GmbH.

For the empirical research the following equation was put central; $X_1 + ... + X_8 = Y_n$. Where the X values represent the eight found firm characteristics and Y represents inventiveness measured in patent count over the a period of 10 years. Through the operationalization of the variables inventive performance per company was determined and the working of the model could be tested through evaluating performance with respect to the accompanying patent counts. In total 185 different equations were constructed and an analysis was done for equal distributions of X-values and in equal distribution of X-values where relative weights are taken into account. Based on the literature study it was expected that when companies comply to the ideal situation per characteristic their inventive patent count would resemble these advantages and show a higher count than for companies with characteristics that are less than ideal. Conclusively, for the model to be able to efficiently predict inventiveness based on the eight selected firm characteristics, equations must be sought where the ranking of company performances equals the ranking of the inventiveness value Y. It must be concluded from the results that none of the 185 equations resembles this expected distribution and therefore the efficiency of the model cannot be tested. Explanations are found in literature where other authors state that research on invention studies are often difficult to study in an empirical setting due to the effect of the complexity of invention, no invention is the same so why would the effects be?

Failure of testing the model must be brought down to two levels, either data is inaccurate or the model is inaccurate. The dataset used for the empirical setting has proven to be too small for deriving solid results on efficiency of the model. But from the dataset some conclusions can be drawn regarding the firm characteristics in the model. Since this is an explorative test of the model these conclusions are formulated into recommendations for further research.

First of all pharmaceutical organizations are characterized with high formalization levels, based on the literature it was expected that this would negatively influence the inventive performance but this research has shown that it can also be an advantage since there are some boundaries to experimentation. Therefore the relationship between formalization and inventiveness must be reviewed and some non-linearly effects can be expected based on these results.

Based on literature it was expected that firm age follows an inverted U-shape curve where over time inventiveness is effect negatively due to the development of harsh routines and path dependencies. From the empirical results it can be concluded that this is not true for pharmaceutical companies. It can be learned that the oldest company in the sample provided the most solid and high patent counts over a period of time. This is information that contradicts the general opinion in literature and therefore will adjust the model construct, so more attention must be paid to the exact effects of the relationship or the variable must be removed since now it muddles the outcomes.

Another conclusion can be drawn on the part of R&D intensity. Based on literature it was expected that high R&D intensity rates positively influence inventive performance of organizations. Empirical data contradicts this finding by showing that organizations with low R&D intensity can belong to the group with high patent counts. Now one can argue that this organization performs perhaps better on

the other seven characteristics but this is definitely not the case. Therefor the conclusion must be drawn that intensity of R&D efforts is perhaps not as important as the quality or the efficiency of the efforts. Consequently an organization can spend large financial amounts on R&D but this will not mean that inventive outcome is influenced accordingly. This last explanation about the difference between existence en the quality of a variable is a line of argumentation that is an important conclusion of the empirical phase. Now the model only analysis whether a certain variable is present within the company but it is not verified what the company does with this presence. For further research this deficiency must be solved to explore the working of the model further more.

Evidently, it can be said that the research question has been answered but that some adjustments have to be made to the model to ensure a more efficient working of it. The recommendations made for further research and exploration of this model are therefore the main outcomes of this project.

7. Discussion

This chapter consists of a critical analysis of the results and recommendations for further research. The critical analysis consists of indicating the consequences related to the constraints applied within this research project.

General Discussion

The research strategy for this project has been an explorative case study. The largest percentage of time invested in this research has been dedicated to a very thorough literature study. The outcomes of this literature review have been tested in an empirical environment. Ideally one would have done multiple interviews per organization but due to the time constraints the decision was made to explore the empirical field with four interviews. An advantage of the empirical test was that the found firm characteristics have been conceptualized and operationalized in a way that they are most applicable for further research. The disadvantage of the empirical test is the explorative nature and the limiting number of respondents. Now the opinion of one is used to judge the performance of a complete organization. The value of the literature study is very clear since it contributes to invention studies by indicating those characteristics that foster invention in an organization. The value of the empirical study must be sought in the additional knowledge gained about testing the proposed relationship and the limitations and recommendations discovered for further research.

Limitations of the research

The limited data set and time constraints that prevent to measure on the quality of the characteristics. Now it has only been researched whether a certain firm characteristic exists but it has not been investigated how good a company is in delivering the characteristic. This was a too broad goal for the time of this research project but it must be taken into account when this study continues.

The limited number of cases made the application of a statistical test impossible. When a large sample size was used and more respondents per organization were interviewed a statistical test could have been used to determine relative weights and correlation effects.

The selection of the sample companies was done based on a brief evaluation of patent counts, two organizations with high and two with low patent counts. Later on in the project I learned that all databases report very different counts. Sometimes the counts differed by 20,000 on total patent applications per company. I learned that one has to work with very accurate searching terms but even when these were applied the results differed per database. Unfortunately after I learned this I calculated the patent counts using 1 database and as a result the nice distribution was gone and three companies scored relatively high patent counts and one scored very low patent count. This is a limitation because now it was even more difficult to draw conclusions on the dataset because companies could not be paired based on inventiveness.

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Appendices

Appendix 1 Interview Scheme

Introduction
Job description respondent place in the organisation and FTe

Explanation
The aim of this interview is to add some practical examples to my research focussing on the influence of firm characteristics on the inventiveness of an organization. I will ask you some questions which investigate these firm characteristics and how they are deployed within the organization. It would be helpful when you could bring forward some examples to underpin answers for open questions.

Start Interview

Could you indicate to what extent the following statements hold for your participation in decision making? *Choose from: Never – Seldom – Sometimes – Often – Always*

Participation	
5. *How frequently do you usually participate in the decision to hire new staff*	
6. *How frequently do you usually participate in the decisions on the promotion of any of the professional staff*	
7. *How frequently do you participate in decisions on the adoption of new policies*	
8. *How frequently do you participate in the decisions on the adoption of new programs*	

Could you indicate to what extent the following statements apply to the organization?
Choose from: Strongly disagree - Disagree – Neither agree nor disagree – Agree – Strongly agree

Hierarchy of authority	
6. *There can be little action taken here until a supervisor approves a decision*	
7. *A person who wants to make his own decisions would be quickly discouraged here*	
8. *Even small matters have to be referred to someone higher up for a final answer*	
9. *I have to ask my boss before I do almost anything*	
10. *Any decision I make has to have my boss's approval*	

Could you indicate to what extent the following statements are valid for your job?
Choose from: Strongly disagree - Disagree – Neither agree nor disagree – Agree – Strongly agree

Job codification	
6. *I feel that I am my boss in most matters*	
7. *A person can make his own decisions without checking with anybody else*	
8. *How things are done here is left up to the person doing the work*	
9. *People here are allowed to do almost as they please*	
10. *Most people here make their own rules on the job*	

Could you indicate to what extent the following statements hold for your job?
Choose from: Strongly disagree - Disagree – Neither agree nor disagree – Agree – Strongly agree

Rule observation	
4. There are a lot of rules to which I have to conform	
5. The employees are constantly being checked on for rule violations	
6. People feel as though they are constantly being watched to see that they obey all the rules	

Could you indicate to what extent the following statements apply to the organization?

Choose from: Strongly disagree - Disagree – Neither agree nor disagree – Agree – Strongly agree

Slack Resources	
4. The employee base is intensive for the work that we must do	
5. There are sufficient financial resources to start up new projects or experiment	
6. The current stock allows for new projects to start or to experiment with	
Slack Resources	
7. The employee base is intensive for the work that we must do	
8. There are sufficient financial resources to start up new projects or experiment	
9. The current stock allows for new projects to start or to experiment with	

Now some open questions will follow, if possible it would be nice to hear some examples to underpin your opinion.

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1. **Does your organization deploy special procedures or actions that promote inventive behaviour of employees?**
    a. *Is there room for experimentation?*
    b. *What happens in case of a failure*?

2. **Another aspect of an inventive culture is the availability of specialized employees and structural training of employees to build an intensive knowledge base, how is this implemented within the organization?**
    a. *Who decides what training is followed by a single employee (Imposed or chosen)?*
    b. *Is training a method to broaden or to intensify employee skill levels*?
    c. *Is there formal training beyond the college degree?*

3. **Structural connections between employees from different departments can aid in understanding of problems and stimulate idea generation, what part of teamwork is organized in a cross functional way?**
    a. *Do you encourage cross functional team work through a special method?*
    b. *On average, what percentage of projects is organized in a cross functional settings?*
    c. *Are there non-work related social groups or networks that employees can join?*

4. **R&D is commonly associated with an inventive culture due to the extensive idea generating capacity, how is R&D organized in your company?**
    a. *When looking at geographical locations would you say that R&D is centralized or decentralized in your organization?*
    b. *How are other employees involved in the research and development processes?*

End of interview

Are there additions that you would like to make or other topics that you would like to stress?

Thank you for your cooperation!