The Effects of Research on Innovation

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ABSTRACT

This research paper investigates the effects of research in private companies on innovation. Based on literature a set of hypothesis was formulated. Basic research is expected to positively influence radical innovation, and applied research is assumed to have a positive effect on incremental innovation. As part of the study, 42 companies in the Netherlands were examined. R&D Managers were asked to fill out an online survey. The findings were consequently analyzed via different statistical tests such as reliability and validity tests. A regression analysis was conducted to examine the relationships proposed in the hypotheses. Basic research was found to have a relatively small positive impact on radical innovation, which was however not statistically significant. A significant and slightly positive relationship of applied research on incremental innovation was identified. Limitations in the data, such as non-fulfilled assumptions for regression analysis as well as a small sample size leave room for future research on the topic. In addition, similar research in a different setting has the chance to create interesting, and comparable, findings. Implications for methodologies assuming a relationship between research and innovation, are recognized.

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1. INTRODUCTION

Companies create competitive advantages through innovation. (Gupta & Singhal, 1993) Hence it is every companies goal to successfully innovate new products and technologies. That way, a competitiveness and, even more important, the survival of the firm, can be achieved in the long run.

Innovation can be defined as the commercialization of an invention. (Schilling, 2008) Inventions are the results of research, therefore a clear link can be recognized between the research and innovation.

In terms of innovation, one can distinguish between incremental and radical innovation. Incremental innovations refer to improvements in a firm's existing product offerings that better satisfy the needs of its current and potential customers, manifesting themselves as adaptations, refinements or enhancements. Radical innovations refer to innovations that are new to the firm, market or industry; which incorporate a substantially different and new technology; and which provide substantially higher benefits relative to current products in the industry. (Varadarajan, 2009) Thus, as radical innovation provides great benefits to a company, it can be argued that it is in every firm's interest to create radical innovation products and technologies. As previously stated, radical innovations are new to the firm, market or industry, and therefore not easily produced, requiring extensive research efforts. They provide firms with the ability to be competitive in the long run and produce competitive advantages.

Research and development efforts in a firm can be distinguished between basic research and applied research. Basic research deals with the goal to develop a more complete understanding of the subject under study and is not connected to direct practical applications. (Rosenberg, 1990) Basic research involves high uncertainty, is considered as a long term investment and has low commercial objectives. (Howells, 1990) Applied research is used to find practical solutions to technological problems. It is connected with clear commercial objectives and has a defined problem. Applied research can be considered an investment in the medium term. (Howells, 1990)

Lim researched in his paper the relationship between research and innovation in the semiconductor and pharmaceutical industry. He has found positive correlations between applied research and innovation in both industries while the relationship between basic research and innovation in the two industries is insignificant. However, he provides arguments that his method and data might not sufficiently measure the concepts at hand. (Lim, 2004) Rosenberg mentions frequently that basic research can be considered a long term investment, due to its high uncertainty to generate any cash flows in the nearest future. He provides empirical evidence that most firms do not engage in basic research, as it is costly and has a very low chance of producing profitable results. This is caused by the result of basic research, which is mostly knowledge. Knowledge is difficult to protect and often not ready to be instantly used in commercial applications, hence creating difficulties to appropriate the benefits. Discoveries in basic research can give ground to first mover advantages as well as disadvantages, making it even more difficult to determine its profitability. As the goal of basic research is to advance the frontiers of science, the commercial use of its results is not initially in the consideration. (Rosenberg, 1990)

Hence, a gap in the literature can be identified, as little research has been done to investigate the relationship between research and innovation, more specifically between different types of research and innovation. Additionally, the role and significance of basic research in the generation of profitability and innovations has been highly disputed in the literature. (Rosenberg, 1990, Lim, 2004, Grilliches, 1985, Mansfeld, 1984)

It is therefore interesting to apply Lim's research approach, measuring the relationships between basic research and innovation, applied research and innovation, to the manufacturing industry to investigate whether similar relationships exist. Additionally, this research will distinguish between radical and incremental innovation, rather than looking upon the concept of innovation in general. This is based on the assumption that basic research influences radical innovation and applied research influences incremental innovation. The research question, this thesis paper deals with can be formulated as such:

To what extent do research efforts affect a firm's innovation performance?

As basic research is used to grasp a fuller understanding of a certain subject, hence having the objective of gathering new knowledge, and radical innovation being characterized as technology or products that are new to the market or industry, it can be argued that those are correlated. Radically innovative products can be seen as a breakthrough in the market, other companies have not been able to produce anything similar yet. One can consequently argue that radical innovations find their technological origin in breakthroughs in science, which are often achieved through basic research. Moreover, applied research is described as having a clear, practical goal and possessing clear commercial objectives, and incremental innovations being improvements to existing products, so a relationship can be expected to be found between those two concepts.

Further research in this area might allow companies to have a certain guideline on how to create incremental and radical innovation. If positive relationships emerge between the two types of research and the respective types of innovation, firms can invest in a particular type of research, either basic or applied, in order to increase their chances of creating radical or incremental innovative products. This would consequently lead to a significant advantage in the allocation of resources and could potentially simplify the innovation process, making it more structured and easier to organize. Firms could more distinctively plan their research projects according to the needs of the product development and innovation goals, leading to an increase in efficiency of the innovation activities.

Companies, following the goal of reaching a competitive advantage via the means of innovation, are able to choose different theories and strategies to apply to their organization and innovation processes. Three theories, which revolve around the concepts discussed in this paper, will be identified.

An organization can choose from four different strategies, developed by Miles and Snow, as a way to approach their R&D and innovation goals. The four strategies differ in terms of entry into a market and point in time of investing in certain innovative products. Most applicable and related to this situation would be the so called Prospector strategy, which aims to innovate and enter the market as quickly as possible in pursuance of first mover advantages. Basic research, if proven to positively influence radical innovation, should be viewed as essential and valuable to this situation in particular, as it is an important measure to achieve significant first mover advantages. (Miles et al., 1978)

Rothwell designed a theoretical construct which looked at innovation management methods. One that was introduced, which is called technology push, argues that the introduction of an innovation follows a certain pattern. It starts with basic

science, creating a breakthrough. The breakthrough will be developed into a commercialized product, which will consequently be manufactured. The marketing department will then introduce the new product to the market and the customer. Given the indispensable position of basic science, here treated as a synonym for basic research, in the process of innovation, an effect of the relationship treated in this paper, on the management methods of Rothwell can be assumed. Other approaches in his theory evolve around a positive relationship between research and innovation as well. (Rothwell, 1994)

Firms can create innovations in various ways. Chesbrough differentiates between closed and open innovation in his papers. They describe the degree of cooperation and exchange between companies and other institutions in the innovation process. The closed innovation paradigm includes principles like the belief of owning the best research capabilities, completing every step of the research and development process internally and controlling intellectual property so competitors do not profit from it. It is further stated that creating the most and best ideas will lead to dominant position and success in the market. (Chesbrough, 2003) Proving the relationship between research and innovation, is vital for this theoretical view.

The impact and implications of the results of this research on the aforementioned frameworks, will be discussed in this paper.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1 Applied & Basic Research:

Applied Research is characterized as research that possesses rather immediate practical and most likely profitable consequences. Investments in applied research are regarded as short/medium term since the final end product is marketed relatively quickly. Also, the degree of uncertainty is considered to be low to medium.
Basic research is categorized as a long-term investment as it is concerned with general knowledge creation, without having a particular commercial objective. It is associated with high uncertainty and profit potentials are often too uncertain to justify an investment. (Cassiman, Perez-Castrillo, and Veugelers, 2002; Rosenberg, 1990).

According to the National Science Foundation (NSF) classifications, applied research initiatives can be defined as projects with the goal of discoveries that have particular commercial objectives. Basic research is defined as research projects intended at a general advancement of knowledge without having specific economical goals yet being in fields of interest to the firm. (nsf.gov, 2016)

The reason for investing in applied research is obvious. Developing economically successful products is central to many firms. Compared to basic research, the cycle time between the investment in applied research and the economic return is shorter. Therefore, these investments match with the quarterly performance pressure which many firms are dealing with. (Henard & Mcfadyen, 2005)

Initiatives in the applied research incorporate and apply stored knowledge in order to develop new products. Basic research on the other hand adds, deepens and improves the stock of knowledge of firms, which allows them to increase their awareness of recent advancements in technologies, possibly granting the bases for future applied research. (Henard & Mcfadyen, 2005)

Individually and exclusively, basic and applied research do not grant many benefits. As stated by March (1991, p. 71), firms solely investing in basic research "suffer the costs of experimentation without gaining many of its benefits". He further noted, only conducting applied research leaves firms "trapped in a suboptimal stable equilibrium", in which the research produces profitable results but does not lay the foundation for future innovation. (March, 1991)

2.2 Incremental & Radical Innovation:

Incremental Innovations can be characterized as new features, extended product lines, variations or complements of existing products, improving efficiency or product quality. (Tushman and Nadler, 1986; Utterback and Abernathy, 1975).
Usually the changes entailed in incremental innovations are relatively small and involve low to medium risk and uncertainty. (Varadarajan, 2009) Short term competitiveness in the market can be reached through incremental innovation, but long term growth can only be established through radical innovation. (Bessant, 2006)

Radical innovation is defined as a new product, process, technology or service that radically transforms the behavior of firms, users and the structure of markets. (Coccia, 2015) Projects involving radical innovations deal with high levels of uncertainty, due to the fact that often new procedures, equipment and facilities are needed to produce those radical innovations. (Song & Thieme, 2009) In order to develop radical innovations, companies need to fulfill two requirements: creating breakthrough ideas which allow the firm to discover prominent technologies and opportunities concealed in unsorted information; as well as implementing these ideas into profitable, marketable technologies and products through combining resources and exploitation. (Hill and Rothaermel, 2003; Zahra and George, 2002)

As previously stated, the innovation process consists of the commercialization of research results. Based on that, it is obvious that an innovation is an invention which has been modified and developed in order to create value for the customer. There is a direct, apparent connection between research and innovation.

2.3 Relationships

The research on the two relationships between the concepts at hand has been controversial. While the influence of applied research on innovation has been empirically proven, although in a different setting and industry, the effect of basic research on innovation has been vaguely proven, at best. One of the difficulties of determining the effect of basic research on innovation, occurs due to the differing use of variables and concepts in the literature.

The role of basic research has received more attention in the literature. Scholars' opinions differ greatly regarding the effect of basic research on innovation and other concepts. While Lim empirically proved that in the pharmaceutical and semiconductor industry, under his parameters, no relationship between basic research and innovation existed, other scholars looked at the concept of basic research from a more heuristic perspective. (Lim, 2004) Rosenberg looked for reasons, why private companies might perform basic research. He stated that basic research needs to be considered as a long term investment, which comes with an unusually high degree of uncertainty, often scaring firms off, who are shy to invest considerable amounts of resources into a process which best thrives under stable

conditions. These conditions however are not provided in the business environment, discouraging firms to invest in basic research, as the eventual payoff is very uncertain. (Rosenberg, 1990) David et al. described the problem with assessing the effects of research in terms of economic value. According to them "the outputs of basic research rarely possess any intrinsic economic value. Instead, they are critically important inputs to other investment processes that yield further research findings, and sometimes yield innovations. Policies that focus exclusively on the support of basic research with an eye to its economic payoffs will be ineffective unless they are also concerned with these complemental factors." It is argued further that rather than looking at basic research singularly, its value needs to be determined in connection with applied research and development. Basic research interacts with applied research in a complex and iterative manner which increases the productivity of basic and applied research simultaneously, more so than basic research creating readily commercial products. (David, Mowery, Steinmueller, 1994)

In a study, performed by Griliches, in the American manufacturing industry, the relationship between R&D expenditures, especially for basic research, and productivity were investigated. R&D expenditures turned out to positively contribute to productivity growth, with basic research appearing to be more relevant as a productivity determinant than other types of R&D. (Griliches, 1985) Research by Mansfeld also dealt with R&D effects and determinants. Industry wide data from the chemical and petroleum industries showed that for a firm, if a firm's total R&D expenditures were kept constant, the innovative output was directly analogous to the percentage of the R&D expenses dedicated to basic research, indicating that basic research efforts positively influence a firm's innovative performance. Conclusively he suggests policy makers to acknowledge the relevance of long term R&D and basic research, in order to increase productivity. (Mansfeld, 1984) Ultimately, the definitions of basic research and radical innovation create the sense of correlation between the two concepts. Since basic research deals with gaining new knowledge of a certain subject, advancing the borders of science, developing new technologies; and a radical innovation is the creation of a completely new product and as argued by Norman are created by technology changes. (Norman, 2014). Keeping the above mentioned arguments in mind, a possible relationship between the concepts can be assumed. A hypothesis has been constructed, linking the two as:

H1: Resources allocated to basic Research positively influences Radical Innovation Performance

While the literature shows studies researching the relationship between research and innovation, and also looks to the effects of basic research, applied research, distinctively separated as a construct, has not received a lot of attention. Lim constructed hypotheses in his model, which treated the relationship between applied research and basic research as independent variables and innovation as the dependent variable. Using objective measurements for both concepts, namely publications as measure for research and patents for innovation, he provided empirical, significant evidence for the relationship between applied research and innovation. Basic research had no influence on the dependent variable in his study. Analyzed were 1700 US companies, operating in the semiconductor and pharmaceutical industries. (Lim, 2004) Apart from Lim's study, the effect of applied research on innovation, more specifically on incremental innovation, has been investigated quite limitedly as the topic of research papers. Applied research is being performed with a clear commercial objective in mind (nsf.gov, 2016), are counted upon to deliver a return on investment in the short/medium term and have relatively low degrees of uncertainty. (Cassiman, Perez-Castrillo, and Veugelers, 2002) Keepinng in mind that incremental innovations also involve low amounts of risk and uncertainty and allow immediate competitiveness due to only small changes in a product or product line, a correlation between the two can be assumed due to their similarities. (Varadarajan, 2009) Based on this, a hypothesis is derived which states:

H2: Resources allocated to applied Research positively influences Incremental Innovation Performance

The proposed hypotheses are visualized in Figure 1.

The streams in literature suggest different effects of basic research. Rosenberg and David et al. discussed the difficulty of observing the outputs of basic research as economical valuable and Lim showed that there was no relationship between basic research and innovation in the semiconductor and pharmaceutical industry. Considering that Griliches and Mansfeld, whose studies have proven the impact of basic research on innovation and productivity, have performed their research in the manufacturing industry, a very similar setting to the study performed in this paper, their findings will be embedded in the following hypotheses. Along with Lim's finding of applied research's impact on innovation

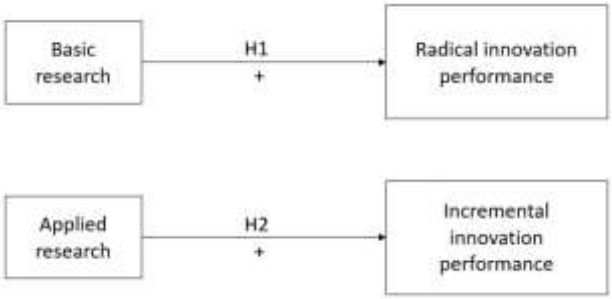

Figure 1 – Expected relationships between concepts

3. METHODOLOGY

3.1 Operationalization

The survey used to gather data was adopted from the Master Thesis of Marc Zaadnordijk (2012). It consisted of scales adopted from literature, where suitable ones existed. For this research, the scales of basic research, applied research, incremental innovation and radical innovation were used.

3.1.1 Independent variables

The scales for basic research were based on Rosenberg (1990), Lichtenthaler and Lichtenthaler (2009) and Garud and Navar (1994). 5 items measured via a 7-point Likert scale the company's degree of performing basic research internally in their proprietary R&D department. Scoring high on this scale implies that the company performs high amounts of basic research

Applied research was measured via a 4 item, 7-point Likert scale, created based on Nonake (2000) Lichtenthaler and Lichtenthaler (2009) and Cohen and Levinthal (1990). As with the former variable, a high score indicates a high degree of applied research being performed.

3.1.2 Dependent variables

Scales for the two dependent variables, Incremental Innovation and Radical Innovation, were adopted from Atuahene-Gima (2005). In total, 4 items, based on 7-point Likert scales were used to assess the innovation performance of the firm. Scoring high on these items signifies a high performance in the respective area of innovation.

3.2 Data Collection

A data set, containing data on the variables to be researched upon, along with a number of other variables as well as control variables, has been provided. The data set has been created as part of a Master Thesis by Marc Zaadnoordijk and consists of 42 cases, manufacturing firms in the Netherlands. (Zaadnordijk, 2012) As part of this research project, more cases were supposed be collected, using a survey, also created in the aforementioned Master Thesis research project. Collecting more cases would have allowed us to have more information, a more representative sample and will reduce uncertainty. More than 200 companies in the Netherlands were contacted and E-mails of R&D managers were gathered, since personalizing the email, which asks the addressee to participate in the survey, increases the chances of receiving a response to the survey, the companies were called in order to find out the email addresses of R&D managers. (Fox, Crask, Kim 1998) Due to a delay in sending out the surveys, a very low response rate was attained. The survey consists of 86 questions, most of them based on the Likert Scale, while others are open questions. They focus on different variables, including the ones, that this research will be built upon. In order to collect data, databases like company.info were used to select companies based on criteria such as having an In-house R&D department, employing at least 100 FTE.

3.3 Quantitative Analysis

The gathered data will be statistically analyzed using SPSS. Due to the fact that a positive relationship between the independent and the dependent variables is expected, a regression analysis will show the strength and significance of the relationship. Regression analysis is most suited for the modelling of a relationship between two variables and testing hypothesis. The research will be non-experimental, as the independent variables will not be manipulated. The statistical model will consist of the two independent variables, namely resources allocated to basic research and applied research, and the dependent variables, radical innovation and incremental innovation performance. The respondents are asked to compare their organization's performance to their competitor's as well as rating the introduction of radical and incremental new products to the market in the last three years. Therefore, some measurements are ordinal. In order to be able to use the data for a regression analysis, the ordinal measurements will be treated as intervals. The specific model of analysis is General Linear Model (GLM)

4. RESULTS

Primarily the data will be checked for reliability and validity as well as normality, as it is one of the requirements for a regression analysis.

A test for reliability is Cronbach's Alpha. The results of the statistical test can be found in Table 1. A value of .7 and above is considered as acceptable. However, lower values are sometimes used in the literature. (Nunnaly,1978) Considering the given scores for Cronbach's Alpha for the four variables, it can be concluded that all of them meet the threshold of the reliability criterion. Although the value for Radical Innovation is slightly below 0.7 it will be considered as reliable, as the difference is rather small.

	Cronbach's Alpha
Applied Research	.790
Basic Research	.814
Incremental Innovation	.735
Radical Innovation	.694

Table 1: Reliability Statistics

Validity of the constructs was tested by performing a factor analysis in SPSS. Considering the values shown in the component matrices for each of the four variables, all of the items scored above the threshold of .6, as can be seen in Table 2. Any value above .6 is regarded as acceptable. (Park, 2002) Hence, all items included will be used as they are, according to the factor analysis, valid.

	Factor Analysis, Component Matrix Score
Applied Research	Item 1: .803 Item 2: .785 Item 3: .802 Item 4: .749
Basic Research	Item 1: .786 Item 2: .855 Item 3: .655 Item 4: .701 Item 5: .782
Incremental Innovation	Item 1: .890 Item 2: .890
Radical Innovation	Item 1: .881 Item 2: .881

Table 2: Validity Statistics

Normality is tested for by using the Shapiro Wilk test. The results can be found in Table 3. Both independent variables exceed the cutoff for significance at a 0.005 level, hence we can assume normality for the data. The dependent variables, incremental and radical innovation, score below the threshold. Therefore, normality cannot be assumed. This creates difficulty regarding the execution of a regression analysis, as normally distributed data is a requirement to run the analysis. Other assumptions were checked. Independence of errors is assumed, since all respondents filled out the survey independently and not together. The linearity assumption is not fulfilled, as can be seen in the scatterplots in Figure 2 and Figure 3. No linear pattern emerges. The homoscedasticity assumption is fulfilled. Figures 4 and 5 show, that for both hypotheses, the residuals possess the equal distance to the line along all values for the independent variable.

	Shapiro Wilk Test
Applied Research	0.55
Basic Research	.339
Incremental Innovation	.009
Radical Innovation	.023

Table 3: Normality Statistics

Table 4 shows descriptive statistics of the 4 variables. By looking at the means, it is apparent, that applied research as well as incremental innovation have scored higher, on average, in the survey than basic research and radical innovation. Also, the maxima are higher for the two aforementioned variables, than for basic research and radical innovation.

	Mean	SD	Min	Max
Applied Research	4.226	1.338	1	6.25
Basic Research	3.471	1.299	1	5.8
Incremental Innovation	4.798	1.366	1	7
Radical Innovation	3.524	1.497	1	6

Table 4: Descriptive Statistics

Non-parametric correlational statistics were performed by using Kendall's tau b. It is more suitable in this case than other

correlational measurements, i.e. Spearman's Rho, as Kendall's tau works better with a small data set. (Fredricks and Nelson, 2007) For both hypotheses, the correlation is slightly positive, however neither is statistically significant.

Kendall's tau b (N=42)	Applied Research
Incremental Innovation	.175 p=.065

Table 5.1: Correlation H1

Kendall's tau b (N=42)	Basic Research
Radical Innovation	.077 p=0.248

Table 5.2: Correlation H2

As a positive relationship is expected between the constructs, in both hypotheses, a regression analysis, using GLM, was executed. It needs to be kept in mind, that not all of the assumptions for a regression analysis were fulfilled. Hypothesis 1 states that basic research positively influences radical innovation. The R^2 for this model is low, with a value of 0.02. Additionally, the model is not statistically significant with a p value of .374, as it exceeds the threshold of an alpha of 0.05. The relationship is weakly positive, as indicated by the positive slope of the regression line, with a value of .16. Taking into account the outcomes of the test, the proposed relationship between basic research and radical innovation is not proven and unreliable.

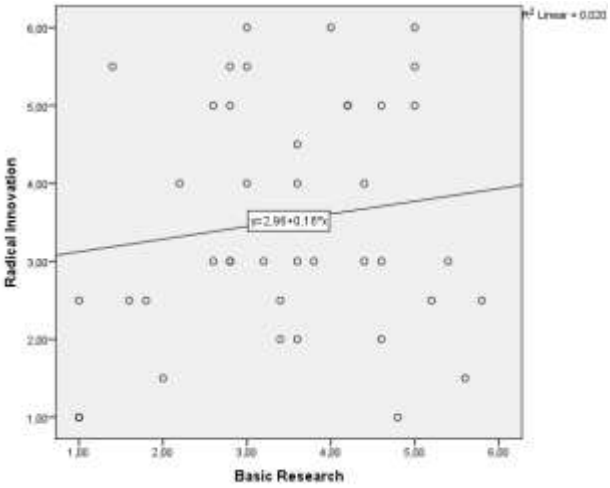

Figure 2: Effect of Basic Research on Radical Innovation

As proposed by Hypothesis 2, a positive relationship between applied research and incremental innovation is predicted. The gradient of the regression line shows a marginally positive relationship, namely 0.33. The model is statistically significant with a p-value of .039, since it is smaller than the alpha of 0.05. The depicted model explains .102 of the variance, as implied by the R^2 value. Because there is a positive relationship, the model does explain part of the variance in the dependent variable and it is statistically significant, the H0 hypothesis is rejected.

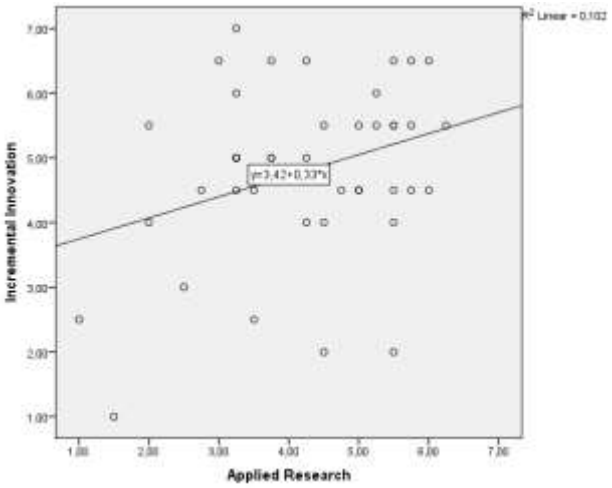

Figure 3: Effect of Applied Research on Incremental Innovation

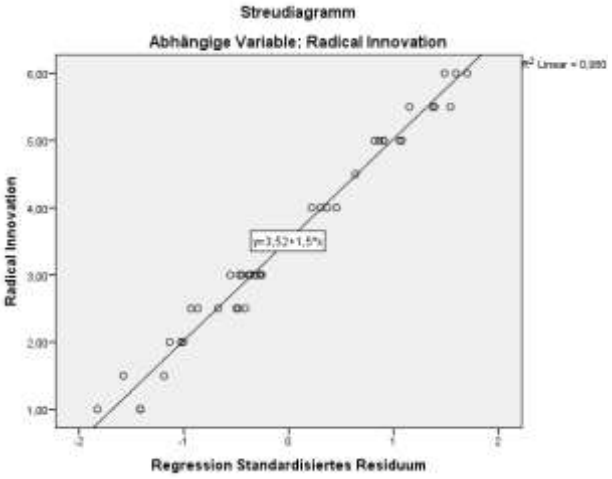

Figure 4: Residual Plot Hypothesis 1

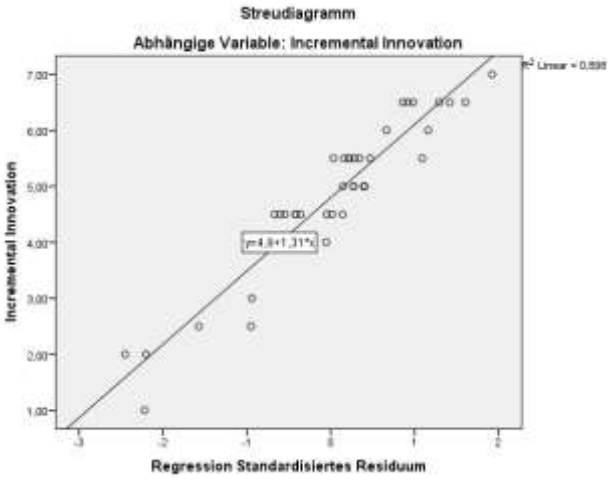

Figure 5: Residual Plot Hypothesis 2

4.1 Additional Analyses

Further analyses were conducted, testing the same relationships, but with interchanged independent variables. Accordingly, a linear regression model between applied research and radical innovation was created and another regression model tested the relationship between basic research and incremental innovation.

As in the previous analyses, not all assumptions for a linear regression analysis were fulfilled. Both models showed a small positive relationship and explained only a low degree of variance in the dependent variable (R^2 of less than 0,07). Simultaneously, neither model was statistically significant. As these relationships were not the main focus of the study and turned out to be insignificant, they will not be discussed.

5. DISCUSSION

In order to stay competitive in today's market, firms need to innovate regularly, as technology changes occur rapidly and globalization increases the pressure on companies to create unique competitive advantages and products. (Someshwar and Horsman, 2001) While all kinds of innovation are important for a company to stay competitive, radical innovations provide high financial incentives and are more likely to guarantee competitiveness in the long term. (Varadarajan, 2009) This research paper looked at the relationship between research and innovation. More specifically, it tried to investigate the relationship between basic research and radical innovation as well as applied research and incremental innovation.

Research results regarding the first hypotheses, which predicts that basic research has a positive effect on radical innovation, failed to produce a significant outcome. A slightly positive relationship existed in the model. It was however neither significant nor extensively explanatory of the variance in the dependent variable. This inability to prove a relationship can be caused by many factors. The innovation process in itself is highly complex. Various processes need to be aligned to produce commercially valuable products out of basic, working prototypes. A simple linear regression model between basic research and radical innovation fails to grasp the complexity of these activities.

It has been stated in the literature, that proving the economic value of basic research is nearly impossible. It needs to be considered as an iterative and complicated process, delivering value to the company in many more ways than only an economical end product. (David, Mowery, Steinmueller, 1994) That's why its ability to predict the radical innovation in a firm might be limited. An extensive literature review concerning the complete innovation process along with all relevant activities, may reveal important factors and variables to include in a statistical model, which can more accurately predict the role of basic research in the creation of radical innovation.

Nonetheless, firms should consider basic research as an investment opportunity with tremendous upside. Not only does it carry the potential for technological and scientific breakthrough, which may lead to radical products and new markets, it can increase firm productivity by enhancing capabilities in the innovation process such as applied research, absorptive capacity and transformation.

At the same time, the relationship between applied research and incremental innovation was analyzed. The significant, positive relationship that existed explained a portion of the variance in the dependent variable. Hence, we can draw from this that applied research, in this research setting and the sample analyzed, does positively influence incremental innovation. Implications are that future studies can use applied research as an independent variable in models to analyze other variables' effect on incremental innovation. Practically, it means that manufacturing firms should consider engaging in applied research activities if producing incremental innovations is the goal.

Likewise, more variance in the dependent variable can probably be explained by other factors and activities which play important roles in the innovation process, which were not included in the model.

Especially theories which deem basic research as crucial to their constructs might need to be reconsidered. Namely the Prospector strategy in the Miles and Snow framework, as well as the technology push methodology by Rothwell, appraise basic research as an instrumental part. Based on the results of this research, these approaches to innovation might not produce positive results and success as a strategy for companies, operating in the same context as the firms in this study. (Miles et al, 1978, Rothwell, 1994)

The closed innovation paradigm by Chensbrough also relies on internal research as an extensive and influential element in its reasoning. Applied research, performed internally, has explained a certain degree in the variance of incremental innovation. Closed innovation can therefore possibly lead to benefits in an environment similar to this one. (Chensbrough, 2003)

Firms conducting business under the same conditions as the ones in this study should take account of these findings and should not necessarily depend on research, especially basic research, as their main focus of creating successful innovations.

6. LIMITATIONS

First and foremost, the small sample size of 42 cases needs to be increased in order to receive more reliable and significant results. Especially normality has been lacking in the data which makes the results of the regression analysis inaccurate. Increasing the sample size, according to the central limit theorem, increases the likelihood of gathering normally distributed data. Additionally, a larger sample size decreases the effect of outliers and in general increases the reliability of a model.

Newer data needs to be collected in order to achieve more accurate and more importantly, more timely results. As an old dataset was used for this paper, the findings might be out of date and not apply to the activities of today's firms. The environment is ever changing and data from 4-5 years ago might not represent the landscape of the current economy and companies accurately.

Regarding the data used and the models created, a limitation can be identified in the measurement of the dependent variable. The independent variables were measured by 4 and 5 items respectively, but the dependent variable was only assessed by 2 items. The number needs to be increased in order to generate precise results. Besides that, more objective data needs to be collected. Asking an R&D Manager two questions concerning the innovation performance of his company does not truly represent the actual effectiveness and discharge of their innovative operations.

By combining subjective and objective data, another limitation of this study can be overcome. The common method bias occurs, when one is using the same method to measure the independent and dependent variable in a model. (Lindell and Whitney, 2001) Using different methods to measure the variables and using objective as well as subjective data makes the data and the conclusion drawn based upon it more reliable and accurate.

6.1 Direction for future research

Given the findings in this paper, a lot of opportunities arise for future studies. Most importantly, the research needs to eliminate the limitations of this one. A larger sample size is a requirement for more reliable results, as well as recent and up to date data which reflects the current situation more precisely.

Furthermore, more complete and relevant models need to be created, that can explain the variance in the dependent variable to a larger extent. Multiple regression analysis is probably more suitable in order to depict the actual situation in a model, as it can

resemble the complexity and variety of the innovation process better. As mentioned previously, combining different methods and different types of data allows to remove the biases.

Conducting the research in a different setting could bear interesting results. The research and innovation processes in the Netherlands might differ from the one in other countries, or even more so on other continents. Hence, a comparison could be achieved by researching the effects elsewhere.

Possibly, differences in industries exist as well. Other industries are more research intensive than others, which might create differences in the amount of research performed. Moreover, innovation processes can differ and might deliver different, yet interesting outcomes. Hence, research aside from the manufacturing industry should be performed.

7. CONCLUSION

As part of the Bachelor Thesis at the University of Twente, research was conducted, investigating the effects of research on innovation in private companies. A literature review showed the expected positive relationships between basic research and radical innovation as well as between applied research and incremental innovation. The data collected from Dutch companies was analyzed via SPSS. Reliability and validity tests showed positive results. The regression analysis was performed under sub-optimal circumstances, as the normality and linearity assumptions were not fulfilled. Basic research showed to have a tiny positive effect on radical innovation, the model was however weak in explaining the variance in the dependent variable and was on top of that not statistically significant. The second hypothesis delivered more promising results. Applied research positively influences incremental innovation and the created model explained a slight portion of the variance in the dependent variable, all while being statistically significant. Firms can therefore expect to perform rather well in incremental innovation when engaging in applied research. Also, ground for future research was laid out, as limitations concerning data and method were identified. In conclusion it can be stated that research positively influences innovation, although not all types of research were proven to have a significant impact in this study. Certain theories, which build upon a positive relationship between research and innovation, need to be reassessed and checked for compatibility and applicability for organizations working in similar surroundings.

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