Radboud Universiteit

Scientific versus commercial business networks, product innovation and academic spin-off growth

Master's thesis

Radboud University Nijmegen

School of Management

Master Innovation & Entrepreneurship

Author: Daav van Mil

Student number: 4795156

Supervisor: Dr. Peter Vaessen

2nd Reader: Dr. R.A.W. Kok

Date: 05 – 08 – 2020

Summary

This research examines the influence of scientific and commercial networks on growth within academic spin-offs, through product innovativeness. In the literature, there are conflicting views on this relationship. On the one hand, it is claimed that new knowledge from knowledge institutions within spin-offs makes it possible to come up with breakthrough innovation earlier, which results in faster spin-off growth. On the other hand, it is claimed that the use of one-sided knowledge networks causes too little use of the commercial network and that growth stagnates due to a lack of knowledge about needs from the market. This research, therefore, examines the influence of these networks on the growth of spin-offs through product innovativeness.

This is done by analyzing a survey sent to spin-offs from the Radboud University. The results are analyzed using a univariate-, a bivariate- and finally a multivariate analysis (regression analysis).

The results of this research show that the scientific network has a positive significant effect on product innovativeness within spin-offs. In addition, the commercial network has a positive but non-significant effect on product innovativeness. The interaction effect of both networks, on the other hand, has a negative but non-significant effect on product innovativeness within spin-offs.

Subsequently, the effect of the networks on growth is examined, which is divided into revenue- and employee growth. This shows that there is a positive indirect effect of the scientific network on both revenue and employee growth. When looking at the commercial network, it can be concluded that there is no effect on revenue- and employee growth. When analyzing the interaction effect, it must be concluded that there is also no effect on both revenue- and employee growth of the participating spin-offs.

Table of Contents

1. Introduction

In the future, it will become increasingly important that scientific knowledge can be turned into success for companies (Hayter, 2015). Converting scientific knowledge into commercial success can be done through university spin-offs (USOs). These are companies where activities / services are based on know-how gained at a university or college (Fontes, 2005). These companies can ensure that research results can be used more efficiently.

There are conflicting statements in the literature about the success of these university spin-offs. Some studies record a relatively large job-creating capacity (e.g. Czarnitzki, Rammer & Toole, 2014; Lawton Smith & Ho, 2006; Niosi, 2016; Roberts, 1991; Shane, 2004;). This is due to the fact that university spin-offs have earlier access to scientific knowledge than average companies. The earlier access to scientific knowledge networks ensures that a competitive advantage can be gained with breakthrough innovations, compared to companies that do not have early access to this scientific knowledge (Czarnitzki et al., 2014).

On the other hand, some studies claim that USO growth is scarce and that these companies not fully exploit their potential (Colombo & Piva, 2005; Gottschalk et al., 2007; Hayter, 2015). This would be because these companies depend on a one-sided scientific knowledge network. Because these USOs are descended from university know-how, they only have contact with scientific networks and therefore a lack of commercial networks. This lack of commercial networks could be a cause of the growth stagnation because the development of the innovations within the USO's is not in line with the demand from the market (Hayter, 2015).

Based on the literature, it can therefore be stated that USOs have high growth potential, but that this potential cannot be exploited due to a lack of commercial networks and the use of unilateral scientific networks (Colombo & Piva, 2005). The aim of the research is therefore to gain insight into the effect of scientific- and commercial networks on the growth of university spin-offs via the breakthrough innovations which spin-offs develop. The research question arises from this aim, namely: 'What is the direct effect of scientific and commercial networks on innovation within academic spin-offs, and therefore the indirect effect on the growth of these spin-offs?'

The study by Colombo & Piva (2005) suggests a follow-up study into the relationship between scientific and commercial networks and the growth of academic spin-offs, through product-innovation. This has not yet been implemented and provides a gap in the scientific knowledge

about the growth stagnation of USOs. By researching the effect of scientific- and commercial networks on growth, a contribution can be made to scientific knowledge on this subject.

In addition, businesses created by USOs, are important contributors to economic development. Think of converting scientific knowledge into new innovative products or services. Besides, the growth of these USOs leads to an increase in societal wealth, for example through the creation of new jobs (Cantner & Goethner, 2011). By using the results of this study, it can be determined where the growth stagnation within USOs comes from. When this is clear, the USOs can look at how they can achieve growth in the future. The growth of the USOs will therefore contribute to an increase in economic development and social wealth.

The preliminary thoughts, based on the literature (Czarnitzki et al., 2014; Colombo & Piva, 2005; Cantner & Goethner, 2011), will be that commercial networks have a positive influence on the growth of spin-offs, but that these networks are not strongly present within the bulk of the USOs. In addition, it is expected that scientific knowledge can be a competitive advantage for USOs, with which it can achieve growth. The comment that can be made here will be that different types of networks must be used to realize growth. It is therefore expected that the scientific network will have the greatest influence on innovation, and therefore growth within USOs. But that this effect can be even greater if commercial networks are also used.

To answer the main question, various steps will be taken. In chapter two, the theory of the most important concepts will be discussed. Chapter three will consist of the methodological framework. It is indicated how the research will be done and how the data will be analyzed. Chapter four presents the results of the study. The data is analyzed and interpreted with the help of SPSS analysis. Chapter five will consist of the conclusion of the investigation. First, the conclusion of the research will be discussed. Also, some recommendations for further research and practice will be discussed. The chapter will end with the limitations of the research.

2. Theoretical Background

2.1 Introduction

First of all an explanation of university spin-offs will be given and how they differ from other companies. Subsequently, the knowledge network of USOs is discussed, in which it is examined how they contribute to the innovativeness of the spin-offs and thereby to growth. The same is done for commercial networks of USOs. Subsequently, it will also be discussed what influence the interaction effect of scientific- and commercial network has on innovation, and what influence this interaction effect has on the growth of academic spin-offs. Hypotheses are drawn up based on this. The chapter concludes with the presentation of the conceptual model

2.2 Defining university spin-offs and how do they tend to differentiate from other firms

In the literature there are several definitions for university spin-offs (USO's). Walter, Parboteeah, Riesenhuber, & Hoegl (2011) define university spin-offs as: Business ventures, which (1) are founded by one or more academics that choose to work in the private sector, and (2) which transfer a technology or technology-based ideas developed within a university. Wright, Lockett, Clarysse, & Binks (2006) define university spin-offs as 'a start-up company whose formation is dependent on the formal transfer of intellectual property rights from the university'. Both definitions therefore show that spin-offs are companies that are descended from university academics, and use the knowledge from the universities to come to new insights. USOs therefore differentiate themselves in different ways from other companies.

First of all, USOs have more contacts with knowledge institutions compared to other companies. This contact makes it possible to exploit intellectual property within society, this intellectual property comes from universities. New knowledge from universities is therefore used within USOs to arrive at innovations (Czarnitzki et al., 2014). The knowledge that USOs use must therefore be up-to-date and this means frequent contact with knowledge institutions. The knowledge that comes from these institutions forms the basis for innovation within university spin-offs (Neves & Franco, 2016).

On the other hand, USOs have less contact with commercial networks because they often use unilateral knowledge networks from universities (Hayter, 2015). As a result, within USOs there is less industry-specific knowledge of competitive conditions, specific rules for the industrial sector of the spin-off, and also less experience with knowledge of goodwill with customers, suppliers and other stakeholders (Cantner & Goethner, 2011). Due to this lack of knowledge

about the market and therefore a lack of commercial network, USOs would not be able to exploit the growth potential (Piva & Colombo, 2005).

Finally, the degree of innovation within USOs differs compared to other companies. Within university spin-offs knowledge is thus used to come up with innovative ideas. These innovative ideas are important to achieve competitive advantages and survival of the company (Walter et al., 2011). Lejpras (2014) has conducted research into the innovativeness of spin-offs compared to differently designed companies. In this study, a survey was spread over 4,000 companies in Germany, including spin-offs and other companies. Firstly, this research shows that more R&D activities take place within spin-offs than in companies that have a different origin. In addition, it appears that cooperation within companies strengthens the innovativeness of these companies. The latest finding of this study is that close contact with research facilities enhances innovation. In addition, it is implied that business success in terms of innovation can be enhanced through close contacts with knowledge institutions and other forms of network, referring to both a knowledge and a commercial network. In addition, success can be enhanced by close collaboration within the organization (Lejpras, 2014).

2.3 USOs science networks, innovation and growth

There are different types of networks that companies use. One of these networks is the knowledge network. Knowledge networks are distinct from social networks; knowledge networks are the links between kernels of scientific and technological knowledge (Carnabuci & Bruggeman, 2009; Yayavaram & Ahuja, 2008). Elements of this knowledge are used to arrive at new innovations within companies, including USOs. Within university spin-offs, knowledge from the university in particular is used to come up with new ideas / innovations. Because this new knowledge is used, USOs have a head start on other companies and can gain a competitive advantage faster compared to other companies.

Sousa-Ginel, Franco-Leal, & Camelo-Ordaz (2017) investigated the knowledge conversion capability of USOs. Knowledge conversion capability is their capacity to transform scientific discoveries into products and goods that are efficiently commercialized to create value (Zahra et al., 2007). In other words, this means to what extent the USO is able to convert scientific knowledge into innovative products / services.

The study by Sousa-Ginel et al (2017) investigated the difference in knowledge conversion capability between USOs and non USOs. 555 technology based USOs participated in this study, which examined how the (knowledge) network had an impact on the knowledge conversion

capability within these USOs. This study shows that USO should maintain frequent contact with knowledge actors to facilitate the development of knowledge conversion capability. In addition, the focus should not be on a single source of knowledge, but it is recommended to use multiple sources of knowledge to gain new insights. Therefore, different knowledge networks need to be used for the benefit of realizing (product)innovation. Product innovativeness in turn is an important predictor of output growth (e.g. Roper 1997 Small Business Economics 9: 523–537, 1997) In contrast a number of research outcomes reveal that USOs have difficulty growing and that this has something to do with the characteristics of these knowledge networks. The knowledge networks of USOs are too one-sided because they are solely focused on knowledge from one university. These outcomes possibly might be related to the rather narrow definition of USOs applied in many investigations, i.e.. companies established for exploiting new technology or knowledge developed at a university or public research institution (e.g. Klofsten, M. & Jones-Evans. D. 2000; Löfsten & Lindelöf 2005; Shane 2004; Wright et al 2007, Zhang 2009). Consequently this type of definitions might cause "selection bias" regarding companies' networks from the perspective of investigators using a broad USO-definition as is the case in the current investigation (see section 2.2). Therefore we maintain the following hypotheses: .

H1: Other factors being equal, the larger the scientific network of academic spin-offs, the greater their product innovativeness.

H2: Other factors being equal, the larger the scientific network of academic spin-offs, the greater their product innovativeness, which leads to stronger growth

2.4 USOs commercial networks, innovation and growth

The commercial network is about the knowledge that a company possesses about the market such as customers, competitors, suppliers and so on. Customer orientation is important because you can identify the customer needs within the market. This gives you a better picture of the market demand, which means that it has a greater chance of eventual success (Maklan, Knox, & Ryals, 2008; Battor & Battor, 2010). Competitor Orientation is important because companies will benchmark and compare with competitors. The companies want to continue to surpass its competitors, so there is a continuous urge to continue to innovate. This urge ultimately leads to better and newer innovations (O'Dwyer & Gilmore, 2017, p. 35). Finally, suppliers are also added to the definition of the commercial network because the literature (Cai, Smart, & Liu, 2014) shows that different approaches must be used in managing suppliers depending on the type of innovation pursued and the type of innovation pursued. industries in which companies

serve (Cai, Smart, & Liu, 2014, p. 134). It is therefore implied that the success of innovations also depends on the suppliers that companies use.

Knowledge about customers, competitors and suppliers is thus necessary because they can be used to analyse the needs of the market. Commercial knowledge networks are therefore needed for new products to become successful (Czarnitzki et al., 2014).

Soltani et al., (2018) have investigated the influence of commercial networks on the success of companies. According to Soltani et al (2018), the commercial network mainly includes customer relationships and knowledge about competitors. They sent surveys among 155 companies, and received 150 valid surveys to analyse the impact of commercial network management on innovations and thus business success. This study shows that keeping the customer network up to date, and knowledge about competitors and the market, has a positive influence on the success of the new products that companies bring to the market. It is stated that by keeping track of customer relationships and competitor knowledge, it is possible to identify what the market demand is and that relevant products can be marketed that respond to customer demand. Bringing products that are tailored to customer demand on the market would then lead to a positive organization performance.

H3: Other factors being equal, the larger the commercial network of academic spin-offs, the greater their product innovativeness

H4: Other factors being equal, the larger the commercial network of academic spin-offs, the greater their product innovativeness, which leads to stronger growth

2.5 Scientific and Commercial Networks, innovation and growth

Finally, there is also literature that claims that a combination of scientific and commercial networks is necessary to achieve spin-off success. It states that in addition to new knowledge from academies, knowledge of the market is also required to successfully market innovations, which can subsequently lead to growth for companies (Gulati, 2000).

Mosey and Wright (2007) find that faculty entrepreneurs are often constrained by their own one-sided knowledge networks and are therefore unable to access individuals from industry important for the success of their spin-off. Mosey and Wright (2007) interviewed 44 entrepreneurs from academic spin-offs to find out how turning scientific knowledge into commercial success is a stumbling block for those companies. The research shows that less experienced spin-off entrepreneurs have structural holes with regard to industry-specific

knowledge. They lack knowledge to successfully market products / services. The following hypothesis has been compiled based on this literature. The above literature therefore suggests that USOs are more likely to have commercial success if industry-specific knowledge is available, in addition to scientific networks. In the initial phase of an academic spin-off, it is especially important that the company has access to customer networks, as these are the buyers of the products. When these are not present, it is difficult to grow as an organization. (Hackett & Dilts, 2004). Hayter (2015) has conducted research in America into the influence of scientific- and commercial networks on the growth of academic spin-offs. 104 entrepreneurs who started a spin-off between 1965 - 2011 took part in this study. As a result, there was a positive correlation between the size of a network and the growth of a company. However, this study showed that the relationship between growth and networks is mainly driven by the ability of entrepreneurs to break through their traditional knowledge networks and gain access to knowledge about new customers and competitors from the industry (Hayter, 2015). According to the literature, a combination of a scientific- and commercial network is therefore positively linked to the growth of an organization. Based on this research, the following hypotheses have been formulated:

H5: Other factors being equal, the larger the interaction of scientific and commercial networks of spin-offs, the greater their product innovativeness

H6: Other factors being equal, the larger the interaction of scientific and commercial networks, the greater their product innovativeness, which leads to stronger growth of this spin-off.

2.6 Conceptual Model

The research looks at what influence the scientific and commercial networks have on the growth of academic spin-offs. This is primarily done by looking at the influence of the scientific and commercial network on product innovativeness. The autonomous effects of the scientific and commercial network on product innovativeness are measured with H1 and H2 (blue arrow). The interaction effect of these networks on product innovativeness is measured with H3 (orange arrow).

Subsequently, the influence of scientific and commercial networks via product innovativeness on the growth of academic spin-offs is examined. The organizational growth is measured through revenue change, and the change in the number of employees of the companies. The autonomous effects of the scientific and commercial network on growth, via product innovativeness are measured with H4 and H5 (blue arrow). The interaction effect of these networks on growth via product innovativeness is measured with H6 (orange arrow). This is shown in the conceptual model below (Figure 1).

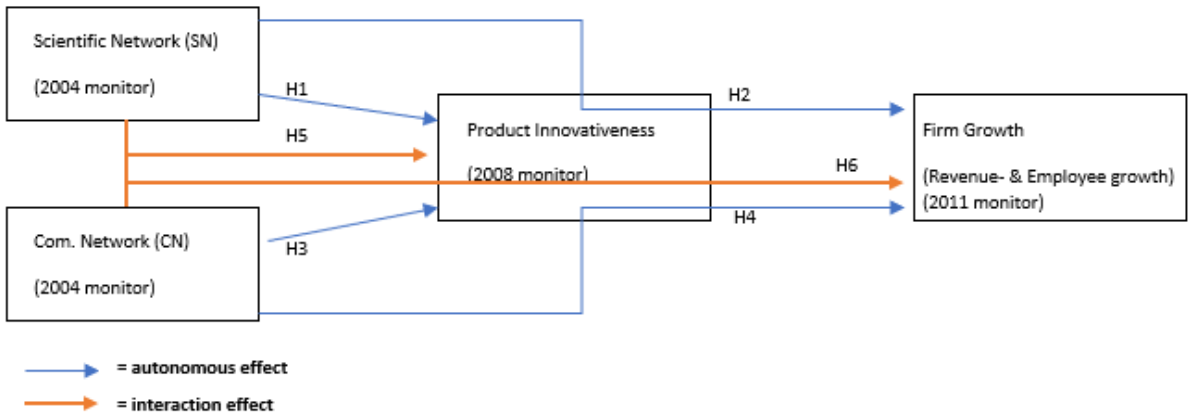


Figure 1: Conceptual Model

3. Methodology

3.1 Introduction

The planning of the research is discussed in this chapter. First of all, there will be indicated which research method will be used within this research. Then it will be indicated what the research unit consists of. Operationalization is made based on this. After the operationalization, it will be explained what has been done in the research to guarantee reliability and validity. Next, it is indicated which analysis methods are used within this study. Finally, the ethics section indicates how to deal with plagiarism and the analysis of data.

3.2 Research Method and Research Unit

3.2.1 Research method

The research that will be conducted is of quantitative nature. Quantitative research is based on a predefined theory or model that will then be tested against "empirical material". The research that will be conducted is therefore deductive. This means that a general theory will be taken as the starting point, then this general theory will be compared with a phenomenon from practice. The general (theory) looks at the specific (practice) (Vennix, 2016). The theory about scientific and commercial networks and innovativeness that are necessary for the growth of academic spin-offs will therefore be tested in practice. This will be done through a survey. In this survey questions are asked to find out whether the networks occur within the tested academic spin-offs, and if these networks lead to growth in combination with product innovativeness.

3.2.2. Research Unit

The population consists of all companies (co) founded by (graduate) former or still undergoing students of Radboud University. Or by former or still employed employees of Radboud University. Not included in the population are general practices, hospital practices of medical specialists, dental practices, and pure law firms. Offices where the legal profession is combined with "legal advice are included as a" spin-off ". The addresses are from the Who-is-Who guides issued by the Alumni Office. The Who-is-Who guides were address guides for the benefit of the reunion organizations of the Radboud University and were updated and re-published every two years.

3.3 Operationalisation

In this section, the theoretical central concepts from the hypotheses are converted into empirically observable terms. The operationalization can be seen in figure 2.

Variable Type	**Variable name**	**Item**	**Min**	**Max**	**Measurement level**	**Question number (See Appendix 1)**
Dependent	Revenue change (2008 – 2010)	Revenue	-1	1	Ratio	14 (2011 survey)
	Employee Change (2008 – 2010)	Employees	-1	1	Ratio	15 (2011 survey)
Independent	Scientific Networks (2001 – 2003)	Knowledge Contacts	0	3	Ordinal	10 (2011 survey)
	Commercial Networks (2001 – 2003)	Market Contacts (customer, competitor, supplier)	1	4	Ordinal	11 (2011 survey)
Mediator	Innovativeness (2005 – 2007)	New products/ Services	1	3	Nominal	8 (2011 survey)
Control	Employee size 2003	Number of Employees	0	80	Ratio	21d(2003 survey)
	R&D activity	R&D	1	2	Nominal	7c (2011 survey)

Figure 2: Operationalisation central concepts.

The dependent variables of the research are the change in revenue and the change in the number of employees. The first item is the revenue change. The revenue change of the companies can be filled in the survey (question 14). The outcome of this question can be compared with the results of the 2008 and 2004 questionnaires, so that it can be deduced whether this has increased / decreased. The second item is the number of employees (question 15), and can also be compared to the numbers of the 2008 and 2004 questionnaires. (See Appendix 1).

There are two explanatory variables within the research, namely 'scientific networks' and 'commercial networks'. The first explanatory variable concerns the scientific networks of the academic spin-offs. It is therefore necessary to examine which knowledge contacts relate to academic spin-offs. This compares with whether there is a difference in this area between strong and less strong spin-off growth. This is reflected in question 10 of the 2011 survey (see Appendix 1).

The second explanatory variable concerns the commercial networks of the academic spin-offs. Commercial networks therefore mainly deal with customer and collaborative networks of companies such as suppliers and competitors (Hayter, 2015). This is reflected in question 11 of the 2011 survey (see Appendix 1).

These variables are also aggregated to view the interaction effect of these variables on product innovativeness, and subsequently through product innovativeness on growth. The explanatory variables from 2001 - 2003 are used to see what influence they have had on product innovativeness in 2005 - 2007. Finally, it is examined how this product innovativeness has had on business growth between 2008 and 2010.

In addition, a mediator variable is added to the research, namely ' product innovativeness'. This static variable explains the relationship between scientific- and commercial networks and growth. Product innovation is question 8 of the 2011 survey (see Appendix 1).

Finally, two control variables were included in the study. This was done because the results were not biased because a certain category of companies was over- or under-represented in terms of age. The number of employees can be found in question 21d of the 2003 survey. This is done because the size of the network can depend on the number of employees. The more employees, the more contacts and thus the chance of a larger network. In addition, it must be checked whether the spin-off practiced R&D activities or not, this can be found in item 7c of the 2011 survey.

3.4 Validity and Reliability

The validity and reliability are important factors in scientific research. A distinction can be made between two types of validity. With internal validity, you check whether you measure what you want to measure, with external validity you check whether the results can be generalized to a larger population. In principle, reliability is about whether the same results are obtained when a measurement is repeated (Vennix, 2016).

The survey used in the study has been conducted over several years. The survey was conducted in 2011, 2008 and 2004 among academic spin-offs from Radboud University Nijmegen. The data from both data are linked, making longitudinal research possible. It is therefore possible to look at what has changed at the companies over the years. So there are different measuring moments, which makes it possible to check whether the results largely correspond to the earlier measuring moment. It can be examined whether the results can be compared with each other when the research is repeated. This improves the reliability of the research.

Triangulation was also used in the study. In fact, different data sources were used in the preparation of the theory. As a result, the validity of the theory is high. This has made operationalization more accurate, which increases the likelihood that the measuring instrument is also valid, because it is easier to measure what you actually want to measure.

3.5 Method of analysis and ethics

In the statistical analysis it is necessary to convert the empirical data into a dataset. The analysis can be performed with this dataset. The data was entered into the analysis program SPSS.

First, univariate analysis will be performed to see how the variables are distributed within the study. This is done by analyzing the 'descriptive table' of the variables in SPSS. It is examined whether striking scores can be found among the variables.

Then a bivariate analysis will be performed to see which variables correlate with each other. This will be done by means of a correlation table. It will be examined whether there is multicollinearity, and which variables correlate significantly with each other. In addition, other notable scores will be mentioned.

Finally, multiple regression analysis is used because the dependent variables are metric in nature. Using the linear regression analysis, we predict the value of organizational growth, broken down into a change in revenue, and change in employees (dependent variables). This will be done by first looking at the effect of scientific- & commercial networks on product innovativeness, including the interaction effect. After this, the indirect effect of scientific and commercial networks on growth will be measured by means of a regression analysis with a mediator (via Hayes, Process).

The survey used in this study has been conducted over several years. This makes a longitudinal analysis possible. This means that the variables have been measured over different times and can therefore be used in the analysis. This analysis assumes that contacts with the scientific and

commercial network between 2001 - 2003 (2004 monitor) will lead to product innovations in the period 2005 - 2007 (2008 monitor), which in turn will lead to firm growth in 2008 - 2010 (2011 monitor).

Before discussing the results of the analysis, it is wise to consider the ethical justification of the research. It is important that the collected data from this research are treated ethically. Participants put time and effort into participating, but may also be harmed by participating in a study (Derry & Green, 1989).

4. Results

4.1 Introduction

In this chapter the findings of the SPSS analysis will be discussed. First, the response of the analysis will be discussed. The variables of the study are discussed below, and it is indicated how the variables are composed based on the data. The analysis are then discussed. First of all, an univariate analysis will be held in which the descriptives table is shown with any remarkable scores. Then a bivariate analysis will be performed using a correlation table. Finally, a multivariate analysis will be conducted using regression tables. The hypotheses are also tested. A brief conclusion of the analysis will be given at the end of this chapter.

4.2 Response

This study is based on three written surveys under spin-offs from Radboud University. The measurements were carried out in successive 2004, 2008 and 2011. In 2004, a questionnaire was drawn up under spin-offs from RU on behalf of the municipality of Nijmegen. In total, 287 questionnaires were sent. 139 validly completed questionnaires were received (49 percent).

In 2008 and 2011, questionnaires were again sent to spin-offs from RU. Both survey rounds were part of one agreement with the management of Mercator Incubator (MI) / Mercator Science Park (MSP). The net 'population' of the 2008 survey consisted of 506 addresses. 188 questionnaires were received, six of which were filled in invalid. The response is therefore (182/506) x 100 = 36 percent.

We had the names of 793 persons available for the 2011 questionnaires. The shipping file ultimately consisted of 703 valid addresses. Of these, 194 completed questionnaires were received. The net response for the 2011 questionnaire was therefore (194/703) x100 = 27.5 percent.

Figure 3 shows how many spin-offs participated in the surveys in the various years.

Year of Monitoring			Nr. of spin-offs
2004	2008	2011	
+	—	—	42
+	+	—	10
+	+	+	16
+	—	+	4
—	+	—	33
—	+	+	38
—	—	+	48
			191

Explanation: + = participated; — = not participated

Figure 3: Participation in Spin-Off surveys.

4.3 Variable construction

The variables that are central to this research are: scientific networks, commercial networks, product innovativeness and growth of spin-offs. Within the analysis, growth is split into two variables, namely: growth in revenue and growth in the number of employees. In addition, the study uses two control variable, namely number of employees and R&D activity.

4.3.1 Scientific networks

Within the survey, there are a number of variables that have been combined to arrive at the variable scientific networks. These variables are taken from question 10 of the 2004 survey (see Appendix 1). The variables that have been combined are: v10a (contact with RU Nijmegen), v10b (contact with other universities) and v10c (contact with other knowledge institutions).First of all, a reliability analysis was carried out to see whether these variables are sufficiently related. The results are shown in Appendix 2.1.

The results of Appendix 2.1 show that the aggregated variables have a Cronbach's alpha of 0.701, which means that the Cronbachs are quite good. When removing a variable, the Cronbach's alpha cannot be raised, so it was decided to merge these three variables into a new variable. The variables have been combined using the count function into the variable ‘Wet_kennis04’, labelled as ' use of scientific networks in 2004 '.

4.3.2. Commercial networks

The definition is based on the knowledge that a spin-off can have about the market. It is therefore examined from which sources the spin-off can obtain relevant knowledge that they

can use to strengthen their position. With this item you therefore collect information from the customers, together with the information from the supplier, and information from the competitor. Information from suppliers applies because they come up with new products that may be relevant to the innovations within the spin-off, direct competitors apply because they can be used as an 'example' when, for example, a new innovation has been implemented at a competitor . With this definition you take v11b_04 (information from the customer), together with v11c_04 (information from suppliers) and v11d_04 (information about competitors).

The results of the reliability analysis show that the aggregated variables have a Cronbach's alpha of 0.442 (see Appendix 2.2). This is under 0.6 which means that the Cronbachs is not very strong. That is why it was decided in this study to include the variables separately in the analysis, to see what effect they have on product innovativeness and thus growth. From these separate effects, a conclusion about the commercial network can be drawn up. These variables are examined for the influence they have individually on product innovativeness, only the variables with added value are included in the follow-up analysis.

4.3.3. Interaction effect Scientific- and Commercial Networks

The interaction effect between scientific and commercial networks must also be included in the analysis. This examines the impact of the variables on product innovativeness and ultimately the growth of spin-offs.

This variable will only be used in the mediation analysis. It has therefore been compiled on the basis of the results of the univariate, bivariate and first regression analysis with regard to product innovativeness. The scientific network is therefore multiplied by the 'consumer network'. This was done because previous analysis showed that both the competitor and the supplier network had no added value in the research.

The individual variables of scientific and consumer networks are first of all centred. This means that the mean is taken from the total score. The mean was searched via the frequency function and removed from the original variable via compute. Then these centred variables are merged via compute: Wet_cen * consumer network. The interaction variable that came out of this is v11b_h04.

4.3.4. Product Innovation

Product innovativeness within spin-offs is used with the variables of question 8 of the spin-off surveys. It looked at which new products / services the spin-offs brought to the market. In

addition, this question also examines whether there have been new products / services that are new / improved for the spin-off's market.

Item v8a_08 (new products / services spin-off) and item v8b_08 (new products / services market) were used for these variables. The variables have been combined using the count function into the variable ‘pi_08’, labelled as ‘product innovation 2005-2007’. This means that we look at product innovativeness in the period 2005 - 2007, so that we monitored in 2008 (declared '08' in the variable name). These are two variables that do not try to measure the same with a slightly different question, which you try to determine with a reliability analysis. A reliability analysis is therefore not necessary, and the variables can be put together.

4.3.5. Revenue growth

Spin-off growth is measured by two variables, the first of which is revenue growth. Sales growth was measured in question 13 of the 2011 survey (see Appendix 1). The revenue is therefore available from 2008 - 2011.

The revenue of 2008-2010 have been combined to form the variable "omz08_10". This was done via "compute variable". The Nummeric Expression used here is ((v13_10 / v13_08) * 100) -100.

4.3.6. Employee growth

The spin-off growth is thus measured by two variables, the second of which is the growth in the number of employees. The growth in the number of employees was measured in question 2011 in question 15 (see Appendix 1). This survey shows the revenue for the years 2008 - 2010.

The number of employees from 2008-2010 have been combined to form the variable "wzp08_10". This was done via "compute variable". The Nummeric Expression used here is ((v15a10 / v15a08) * 100) -100.

4.3.7. Control Variables

The control variables are intended not to present a distorted picture of the results. This is because the control variables affect the dependent and independent variables, without any special attention being paid to this (Vennix, 2016). The control variables chosen in this study are Number of employees and R&D activity. These variables are stand-alone items in the data file and does not need to be merged or changed for analysis. Number of employees is item 21d in the 2003 survey, R&D is item v7c in the 2011 survey.

4.4 Univariate Analysis

In this section the values of the individual variables are discussed. It will be examined whether there are striking scores for the variables, and what could be the cause of this. This is done through the "descriptives" table in SPSS. This can be found in figure 4.

						Skewness		Kurtosis	
	N Statistic	Minimum Statistic	Maximum Statistic	Mean Statistic	Std.Deviation Statistic	Statistic	Std.Error	Statistic	Std.Error
Change revenue 2008- 2010	112	1,00	5,00	3,1518	1,35041	-,281	,228	-,936	,453
Change wzp 2008- 2010	157	-1,00	1,00	,1210	,62378	-,089	,194	-,452	,385
Scientific Knowledge 2001 - 2003	136	1,00	3,50	1,5037	,65968	1,067	,208	,176	,413
Customer information 2001 - 2003	136	1,00	4	2,60	1,071	-,198	,208	-1,198	,413
Competitor Information 2001 - 2003	137	1,00	4	1,97	,866	,402	,207	-,800	,411
Supplier information 2001 - 2003	134	1,00	4	1,60	,893	1,320	,209	,680	,416
Product innovation 2005 - 2007	133	1	3	1,9549	,88647	,089	,210	-1.732	,417
Nr. of employees	148	,40	80	6,8905	12,66519	3,261	,199	12,032	,396
R&D	136	1	2	1,29	,457	,914	,208	-1,183	,413
Valid N	26								

Figure 4: Summary Univariate Analysis

One dependent variable is central to the research, namely growth of the spin-off. Earlier in this study it was stated that the growth of a spin-off is measured by the growth in revenue and the growth in the number of employees. On the basis of the descriptive table, it can be concluded that the participating spin-offs have a reasonably high percentage that realize growth. When the score was 1 there was no growth, at a score of 5 there was a high degree of growth. The average of this variable is 3.15, which means that on average there is reasonable revenue growth at the participating spin-offs. When looking at employee growth, something else has to be concluded. The average employee growth for a range between -1 and 1 is 0.12. This means that the number of employees of the spin-offs remains almost the same, on average there is a slight increase in the number of employees.

When looking at the independent variables, a number of things also stand out. The scientific networks look at how often the spin-offs have contact with scientific networks such as universities. This is measured by scores of 0 = no contact to 3 = very often. The average is 0.7850, which means that there is incidental contact between spin-offs and the scientific network. This is remarkable because spin-offs use the knowledge from these networks to come up with innovations, so it is expected that this would involve regular contact.
Looking at the commercial network, there is actually nothing very noticeable. This is measured from 1 slightly important to 4 very important. When looking at information from the customers, it can be seen that the mean is at 2.6, which means that the customers are important as a source of information. When looking at the competitors this is 1.97 which means that they are somewhat important. For suppliers as a source of information this is 1.60, which means that they are not - somewhat important.

This study also includes a mediator variable, namely product innovativeness. The range here is as follows, 1 = no product innovation, 2 = product is only new to the company and 3 = product is also new to the market. The average for this variable is 1.95, which means that on average product innovations certainly occur within the spin-offs. It should be noted that this is mainly because 55 companies indicate that they do not implement product innovation, and 49 companies come up with products that are new to the company as well as to the market. There are only 29 companies with products that are new to the company (see figure 5). This means that a large part of the companies do not implement product innovations, and that another large part of the spin-offs come up with products that are new to the company and the market.

		Frequency	**Percent**
Valid	No product innovation	55	11,8
	Product innovation new to company	29	6,2
	Product innovation new to company and market	49	10,5
	Total	133	28,5
Missing	System	333	71,5
Total		466	100

Figure 5: Descriptives Product innovation variable

4.5 Bivariate Analysis

This section deals with the relationship between the different variables. This is done using a correlation table in SPSS. When analysing the correlation table, it is examined whether striking scores occur and what could be the cause of this. We also look at which variables are significantly related.

		1	2	3	4	5	6	7	8	9
1. Revenue Growth (2008 – 2010)	**Correlation**	1	,444**	,190	-,099	-,259	-,166	,193	-,180	-,247
	Nr of cases		107	31	31	31	31	56	36	31
2. Employee growth (2008 – 2010)	**Correlation**		1	,125	,189	-,008	-,055	,267*	-,283	-,012
	Nr of cases			42	42	42	42	82	48	42
3. Scientific Network (2001 – 2003)	**Correlation**			1	,200*	,297**	,186*	,493**	,102	,359**
	Nr of cases				135	136	134	46	135	134
4. Consumer information (2001 – 2003)	**Correlation**				1	,194*	,170*	,225	,159	,104
	Nr of cases					136	133	46	135	134
5. Competitor Information (2001 – 2003)	**Correlation**					1	,257**	,114	,217*	,211*
	Nr of cases						134	46	136	135
6. Supplier Information (2001 – 2003)	**Correlation**						1	,125	,193*	,131
	Nr of cases							45	133	132
7. Product Innovation (2005 – 2007)	**Correlation**							1	,141	,250
	Nr of cases								54	46
8. Nr. of employees	**Correlation**								1	,171*
	Nr of cases									135
9. R&D	**Correlation**									1
	Nr of cases									

*= Correlation is significant at the 0.01 level

**= Correlation is significant at the 0.05 level

Figure 6: Bivariate Analysis table

First of all, it is necessary to check in the above model whether there is no multicollinearity within the study. Multicollinearity occurs when the R-value (correlation) of the variables exceeds .85. The highest R-value that occurs in this study is .493. This is still far below 0.85, so it can be stated that there is no multicollinearity within the study. It can therefore be said to

be an acceptable analysis, since low levels of multicollinearity mean that there is no risk to the estimated values of the model.

After the multicollinearity of the model has been checked, you can already see which relationships emerge when viewing the bivariate analysis. The pearson correlation can be used to see to what extent there is an effect between variables. This means that the higher the R value, the greater the effect between the variables. Based on Field (2014), values of + -. 1 = small effect, + -. 3 = medium effect and + -. 5 is a large effect. Based on this rule of thumb, you can already see what the bivariate analysis says about the hypotheses.

Hypothesis 1 examines the influence of scientific networks on product innovativeness within spin-offs. When looking at this relationship in the correlation table, you can see that there is an R value of .493. That is> .5, which means that it can be said that there is a major effect of scientific knowledge on product innovativeness within spin-offs.

Hypothesis 3 examines the influence of commercial networks on product innovativeness within spin-offs. Within this research, the commercial network is investigated by 3 variables. Knowledge from the customer has an R-value of. 225, which means a medium effect. Knowledge from the competitor has an R-value of .114 which reflects a small effect. Knowledge from the supplier has an R-value of .125, which also means a small effect

About hypotheses 2, 4, 5 and 6: the indirect effect of scientific and commercial networks on growth (via product innovativeness) is not yet clear via the correlation table. However, the correlation table shows that product innovativeness has a positive effect on both revenue and employee growth of academic spin-offs. In employee growth, the influence of product innovativeness is even significant P = 0.15 <0.05. This is not significant for revenue growth.

Finally, it can be seen that there are large differences in the nr or cases of the variables. This is because there is a longitudinal analysis. There must therefore be a valid variable value at multiple points in time to be included in the analysis.

4.6 Multivariate Analysis

In this chapter linear regression analysis are given. First, the direct influences of the dependent variables on product innovativeness are examined, this is done by means of a regression analysis. The indirect effects of the dependent variables are then measured on the independent variable, via the mediator. This effect is measured by means of a mediation analysis via Hayes, Process. The hypotheses are then tested and then the chapter end with a conclusion.

4.6.1. Scientific- and commercial networks on product innovativeness

First of all, the relationship between scientific and commercial networks and the mediator 'product innovativeness‘ will be examined. This is done by entering scientific networks, and the narrow and broad form of commercial networks as independent variables, and the mediator is dependent variable.

4.6.1.1. Model assumptions

First, the model assumptions of the dependent variable "pi_08" are discussed. The first assumption that must be met is the assumption of linearity, for this it is checked whether the scatter plot does not contain a clear pattern. Appendix 4.1.1 shows that the scatter plot does not contain a pattern and so this assumption is met. The second assumption is homoscedasticity, in which the scatter plot must be checked to see whether there is no form, this is not the case and so this assumption is also met. The third assumption concerns the independent errors. In appendix 4.1.2. you can see that under the heading ’Std. Predicted value’ the mean equals 0, and the standard deviation equals 1. This is good, so it can be said that this assumption is met. The last assumption is that the variables are normally distributed. This can be done by looking at whether the histogram and the individual p-plots are normal and do not deviate. In appendix 4.1.3. it can be seen that there are no remarkable shapes in these figures, so that it can be stated that these assumptions are met.

4.6.1.2. Model Statistics

This analysis is done on the basis of two models. In the first model, the interaction term is not included because autonomous effects are difficult to interpret when the interaction term is included. The interaction effect is included in the second model. The observations of both models are at 53, which is quite low, but this is because a longitudinal analysis is used, so information from the same companies is needed at different time points.

		Product Innovation (2005 – 2007)	
Covariate		b (SE)	b (SE)
1.	R&D	.074 (.241)	.006(.235)
2.	Nr of Employees 2003	.195 (.082)*	.182(.078)*
Explanatory variables			
3.	Scientific Network (2001 – 2003)	.540(.172)**	.560(.172)**
4.	Customer network (2001-2003)	.131 (.102)	.121(.092)
5.	Competitor Network (2001 – 2003)	-.115(.132)	-.123(.153)
6.	Supplier Network (2001 – 2003)	-.001 (.136)	.096(.163)
7.	Scientific & Commercial Network (2001-2003)		-.092(.163)
Model information			
	F-waarde	3.443**	4.916**
	R^2	.344	.334
	Adjusted R^2	.244	.266
	N	53	53
Explanation: *p< ,10 ** p<0,05 p<,01			

Figure 7: Longitudinal product innovation effects from scientific and customer business networks

Figure 7 also shows that the significance level of the scientific network relative to product innovativeness is 0.000. This is significant at a significance level of p <0.01, which means that the scientific network has a significant effect on product innovativeness within spin-offs.

The significance level for commercial networks compared to product innovativeness is for consumer network .206. This is not significant at a significance level of p <0.01, which means that consumer networks have no significant effect on product innovativeness within the spin-offs. For the competitor network it is .38 and for supplier network it is .991, which means that these variables have little added value in the follow-up analysis. Based on this, it is decided to continue the 'consumer network' for commercial network, because it is the only one of relevant value.

In the interaction effect between scientific and commercial networks it can be stated that p = .577. This is not significant, which means that the interaction effect between scientific and commercial networks does not affect the product innovativeness of academic spin-offs.

4.6.1.3 Hypothesis testing

The hypotheses below relate to the dependent variable "product innovation" of the above analysis.

H1: Other factors being equal, the larger the scientific network of academic spin-offs, the greater their product innovativeness.

The analysis above shows that the scientific network has a significant influence on product innovativeness within academic spin-offs. This is in line with the literature. The knowledge that is used within the spin-offs from the universities forms the basis for product innovativeness within spin-offs (Neves & Franco, 2016). Based on this conclusion, it was expected that scientific research within this research would be positively related to product innovativeness. The linear regression analysis above shows that the scientific network is indeed positively related to product innovativeness. Hypothesis 1 is supported within this study.

H3: Other factors being equal, the larger the commercial network of academic spin-offs, the greater their product innovativeness.

The analysis above shows that the commercial network has no significant influence on product innovativeness within academic spin-offs. This is therefore contradictory to the literature of Solatani et al (2018), in which it was claimed that knowledge about customer relations and competitor knowledge has a positive influence on the innovations that companies bring to the market. The linear regression shows that within the participating spin-offs there is no significant input from the consumer, competitor or supplier network on the product innovativeness within these spin-offs. There could be a number of reasons for this. In the literature from chapter 2 it has already been noticed that many spin-offs only use a scientific network and not a commercial network. So it could be that the spin-offs in this analysis are indeed the case. Literature in chapter 2 states that the commercial network is necessary for growth. In addition, it can be seen that there is a positive effect on product innovativeness, but none significant. A cause could be the small number of cases because there is an effect but not significant when using a low number of cases. So, this is an opportunity for follow-up research. Hypothesis 3 is not supported in this study. Since Consumer network is the only variable relevant to the study, it was decided to include it as the only variable in the following analyses. The above analysis showed that neither competitor nor supplier network have any effect on product innovation and therefore the rest of the research.

H5: Other factors being equal, the larger the interaction of scientific and commercial networks of spin-offs, the greater their product innovativeness

The literature in chapter 2 indicates that an interaction between scientific and commercial networks is required to achieve product innovativeness and thus growth within spin-offs. However, the above analysis shows something completely different, namely that an interaction of both networks within the analysed spin-offs has a negative effect on product innovativeness. First of all, this could be because the research by Hayter (2015) is mainly focused on regional growth and to a lesser extent the effect of product innovativeness is included in the analysis. In addition, it could be that there are few cases in the analysis, and that the cases used are characterized by a relatively high frequency of companies that do not implement product innovativeness. So, this is a suggestion for a follow-up study. Within this research, it must be concluded that an interaction effect of scientific and commercial networks has no influence on product innovativeness within the participating spin-offs.

4.6.2. Indirect effect of science networks on growth

This section discusses the indirect effect of the scientific network on growth. This is done by means of a mediation analysis to look at the influence of the scientific network on growth, through product innovativeness. This is done by including the variables in a mediation analysis, including the control variable nr of employees. When looking at the growth in the number of employees, control variable v1a is also included. That is whether it has been a team start-up or a solo starter. By definition, a team start-up has one more employee, so this is also checked.

4.6.2.1 Model assumptions

First, the model assumptions of the dependent variable "omz08_10" are discussed. The first assumption that must be met is the assumption of linearity, for this it is checked whether the scatter plot does not contain a clear pattern. Appendix 4.2.1 shows that the points are completely random distributed over the graph, so it can be stated that this assumption is met. The second assumption is homoscedasticity, in which the scatter plot must be checked to see whether there is no form, this is not the case and so this assumption is also met. The third assumption concerns the independent errors. In appendix 4.2.2. you can see that under the heading 'Std. Predicted value' the mean equals 0, and the standard deviation equals 1. This is good, so it can be said that this assumption is met. The last assumption is that the variables are normally distributed. This can be done by looking at whether the histogram and the individual p-plots are normal and do not deviate. In appendix 4.2.3. it can be seen that there are no remarkable shapes in the

histogram, and that the p-plot deviates a little from the middle line. A cause for this can be the relatively little amount of cases within the analysis.

Now the model assumptions of the other dependent variable "wzp08_10" will be discussed. First of all, it must again be examined whether the assumption of linearity and homoscedasticity is met. In Appendix 4.2.4. it can be seen that the points are again randomly distributed over the graph, so that it can be stated that both the assumption of linearity and that of homoscedasticity are satisfied. As a third assumption, it is again examined whether the independent errors within the analysis see correctly. In Appendix 4.2.5. it can be seen that the mean here is also 0, and the median 1, so that this assumption is met. Finally, it must be checked again whether the points are normally distributed within the analysis. When the histogram in Appendix 4.2.6. it can be seen that they are normally distributed. However, the P-Plot of this variable looks a bit different, because it contains a number of horizontal lines, which is normally the intention of an analysis. Only because a small number of cases are used within this research can this form be caused by this, so that it will not have a major influence on the validity of the research results.

4.6.2.2. Model statistics

The model statistics of the mediation analysis are now discussed. First of all, an analysis is again given of the influence of scientific networks on revenue growth. Subsequently, the influence of scientific networks on employee growth is discussed.

Figure 8 shows the mediation analysis with the effect of the scientific network on revenue and employee growth, through product innovativeness. First of all, we look at the influence on revenue growth. The check shows that the scientific network has a positive influence on product innovativeness within academic spin-offs. In addition, it can be seen that there is a negative direct effect of scientific network contacts 2001-2003 on revenue growth in 2008-2010. This can be explained by the fact that there is a long period in between and therefore there is no direct connection between this variable. In addition, it can be seen that product innovativeness in 2005-2007 has a positive effect on the revenue growth of academic spin-offs in 2008 - 2010. In addition, figure 8 also shows that there is a positive indirect effect of the scientific network on revenue growth. , when the mediator product innovativeness is included (b=1.08; SE=.38; 95% BI: 0.52 – 2,01). It can therefore be stated that the use of scientific networks in 2001-2003 provides product innovativeness in the period 2005 - 2007, which in turn leads to a growth in revenue in the period 2008 - 2010. In addition, the model information of the analysis can be

where it can be stated that these factors explain 43% of the variance of revenue growth. There were 31 valid cases used in this analysis.

Now we are looking at the influence on employee growth. Once again, the analysis shows that the positive significant effect of the scientific network on product innovativeness is present. In addition, there is also a positive direct effect of both scientific network and product innovativeness on the growth of the number of employees. This is not significant, but this could also be due to the low number of cases (N = 42). As a result, there is also a positive indirect effect of scientific networks 2001 - 2003, via product innovativeness 2005 - 2007, on employee growth 2008 - 2010 (b=.18; SE=.10; 95% BI: 0.04 – .45) . Finally, it can be seen that this model shows 16% of the variance of employee growth.

	Product innovation 2005-2007 **b (SE)**	**Revenue Growth 2008 – 2010** **b (SE)**	**Product innovation 2005-2007** **b (SE)**	**Employee Growth 2008 – 2010** **b (SE)**
Explanatory variable				
Scientific Network 2001 -2003	,75 (,18)***	-,28 (,49)	,58 (,20)***	-,05 (,19)
Mediator variable				
Product innovation	n.a.	1,44 (,40)***	n.a.	,32 (,15)**
Control variables				
R&D	,26(,28)	-1,72 (,60)***	-,04 (,29)	,01 (,26)
Firm size 2003 (ln)	,12 (,10)	-,09 (,22)	,24 (,09) **	-,17 (,09) *
Effect	Indirect positive effect from use scientific network 2001-2003 on revenue growth 2008-2010; b=1.08; SE=.38; 95% BI: 0.52 – 2,01		Indirect positive effect from use scientific network 2001-2003 on revenue growth 2008-2010; b=.18; SE=.10; 95% BI: 0.04 – .45	
Model Information				
F	9,59***	5,97***	5,90***	1,73
R^2	,52	,43	,32	,16
N	31	31	42	42
Explanation: (*)p <,15 *p <,10; **p <,05; ***p <,01 N.A.: Not Applicable				

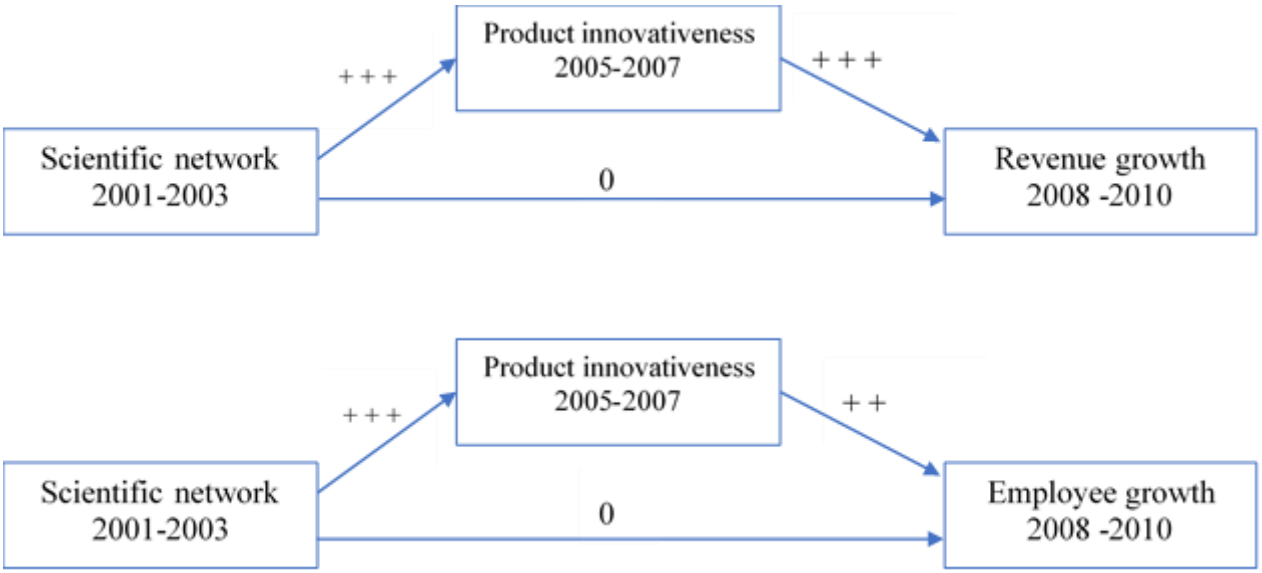
Figure 8: Mediation statistics scientific network on revenue- and employee growth

4.6.2.3. Hypothese testing

The above models tests the hypothesis:

H2: Other factors being equal, the larger the scientific network of academic spin-offs, the greater their product innovativeness, which leads to stronger growth

On the basis of the above analysis, it can be stated that contact with scientific knowledge institutions in the period 2001 - 2003 led to product innovations in the period 2005 - 2007 (significant). In addition, it can be stated that this product innovativeness has a positive effect on both the revenue- and employee growth within the participating spin-offs in the period 2008 - 2010 (significant). Finally, it can be stated that there is a positive indirect effect of the scientific network on both revenue growth (1.08; SE=.38; 95% BI: 0.52 – 2,01) and on employee growth (b=.18; SE=.10; 95% BI: 0.04 – .45). An overview of the effects of the above analysis is shown in Figure 9.



Explanation

+ + +	− − −	Strong positive/negative relationship (p<.01)
+ +	− −	Fairly strong positive/negative relationship (p<.05)
+	−	Positive/negative relationship(p<.10)
	0	No relationship (p≥,10

Figure 9: Long term effect of scientific network on growth

4.6.3. Indirect effect of commercial networks on growth

This section examines the indirect effect of commercial networks on growth, with product innovativeness as a mediator. Again, growth in this analysis is again split into growth in revenue and growth in the number of employees.

4.6.3.1. Model assumptions

First, the model assumptions of the analysis are discussed again. These can be seen in Appendix 4.3.1 to 4.3.6. The model assumptions show that for both the variable "revenue growth" and the variable "employee growth" the points are randomly distributed over the scatter plot, so that it can be stated that the assumption of linearity and homoscedasticity is met. In addition, the table of independent errors for both variables also shows that the mean is 0, and the median 1 which means that this assumption is also met. The histograms and P-Plots of both variables are examined below. The variable revenue shows that the histogram is normally distributed, and that in the P-Plot the points are close to the diagonal line. The assumptions are therefore also met with this variable. This is slightly different with the variable employee. Here you can see that in the histogram there is an outlier that makes the P-Plot seem a bit flat. In addition, the P-Plot also shows some horizontal lines, which means that this variable may not be distributed normally. An explanation for this could be that use is made of invalid cases within the analysis, so that he deviates somewhat.

4.6.3.2. Model statistics

The model statistics of the mediation analysis are now discussed. First of all, an analysis is again given of the influence of commercial networks on revenue growth. Subsequently, the influence of commercial networks on employee growth is discussed.

Figure 10 shows the mediation analysis, looking at the influence of contact with the commercial network (2001 - 2003) on revenue- and employee growth (2008 - 2010), through product innovativeness (2005 - 2007). First of all, we look at the influence on revenue growth. It is again stated that the commercial network has a slightly positive effect on product innovativeness, but that this effect is not significant. In addition, it can be seen that the influence of product innovativeness (2005 - 2007) on revenue growth (2008 - 2010) is positive and significant. In addition, it can also be seen that the direct effect of the commercial network on revenue growth is negative. An explanation for this is that the knowledge from the commercial network in 2001 – 2003 is outdated, when using this knowledge in 2008 – 2010. Based on the

mediation analysis, it can be established that there is no indirect effect of the commercial network on revenue growth because it has no significant influence on product innovation, through product innovativeness (b=.20; SE=.17; 95% BI:- .09 – ,57) It can be seen that this model has an explanatory power of 46%, and that 31 valid cases were used. Finally, it can also be seen that R&D has a significant influence on the revenue growth of the participating spin-offs. It can therefore be established that R&D activities within the spin-offs lead to higher revenue growth.

The influence on employee growth is now being discussed. Again, it can be seen that the commercial network has a positive influence on product innovativeness within the participating spin-offs, this is not a significant effect. In addition, it can be seen that product innovativeness itself has a positive influence on the employee growth of the spin-offs, but this effect is also not significant. As a result, it can be stated that the parts do have a slightly positive effect on each other, but that there is no mention of an indirect effect of the commercial network on employee growth, because this effect is very little positive (b=.04; SE=.04; 95% BI: 0.01 – .18). In addition, Figure 10 shows that the direct effect of the commercial network on employee growth, the same as with revenue growth, is negative. The explanation that can be given for this is the same as for revenue growth, namely that outdated market knowledge in the period 2001 - 2003 no longer leads to employee growth in 2008 - 2010. Finally, the model information shows that this analysis can explain 17% and that 42 valid cases have been used.

	Product innovation 2005-2007 b (SE)	Revenue Growth 2008 – 2010 b (SE)	Product innovation 2005-2007 b (SE)	Employee Growth 2008 – 2010 b (SE)
Explanatory variable				
Consumer Network 2001 - 2003	,14 (,13)	-,28 (,21)	,16 (,11)	,07 (,09)
Mediator variable				
Product innovation	n.a.	1,39 (,32)***	n.a.	,28 (,13)**
Control variables				
R&D	,62 (,33)*	-1,71 (,58)***	,29 (,28)	-,02 (,23)
Firm size 2003 (ln)	,10 (,13)	-,10 (,21)	,20 (,10)*	-,15 (,09)*
Effect	Indirect positive effect from use scientific network 2001-2003 on revenue growth 2008-2010; b=.20; SE=.17; 95% BI:- .09 – ,57		Indirect positive effect from use scientific network 2001-2003 on revenue growth 2008-2010; b=.04; SE=.04; 95% BI: 0.01 – .18	
Model Information				
F	2,96**	5,65**	3,33**	1,88
R^2	,25	,46	,21	,17
N	31	31	42	42
Explanation: (*)p <,15 *p <,10; **p <,05; ***p <,01 N.A.: Not Applicable				

Figure 10: Mediation statistics commercial network on revenue- and employee growth

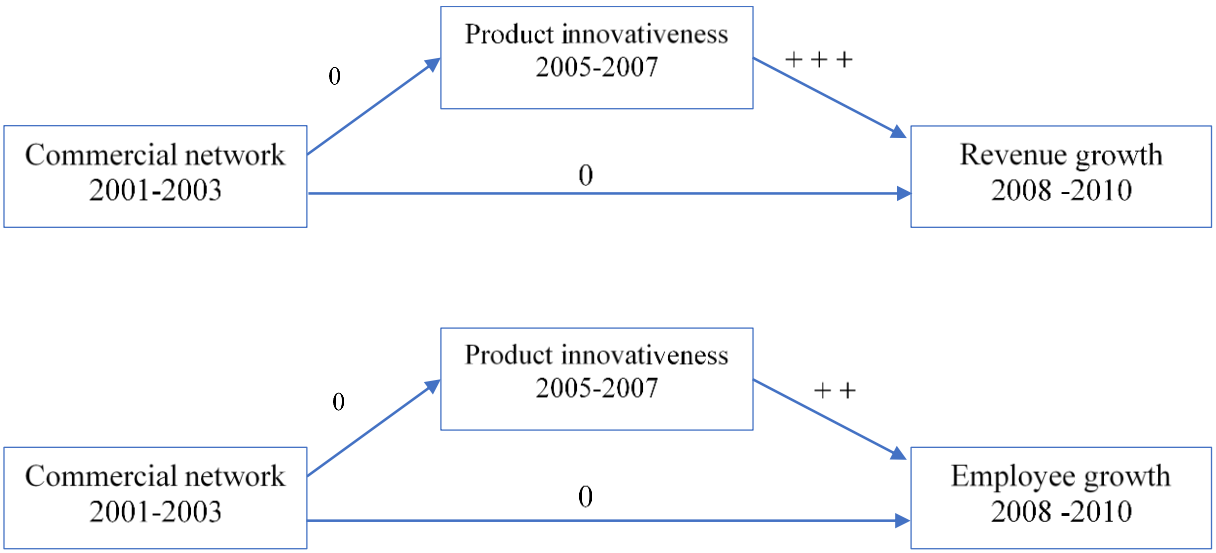
4.6.3.3. Hypothese testing

The above models tests the hypothesis:

H4: Other factors being equal, the larger the commercial network of academic spin-offs, the greater their product innovativeness, which leads to stronger growth.

On the basis of the above analysis, it can be stated that contact with commercial network in the period 2001 – 2003 don't led to product innovativeness in the period 2005 – 2007. In addition, it can be stated that product innovativeness has a positive effect on revenue- and employee growth of academic spin- in the period 2008 - 2010). On the basis of the above analysis, it can

therefore be concluded that the commercial network (2001 - 2003) has no indirect effect on the revenue growth (2008 - 2010) of academic spin-offs. In addition, it can be stated that the commercial network (2001 - 2003) also has no indirect effect on the employee growth (2008 - 2010) of these spin-offs. An overview of the effects of the above analysis is shown in Figure 11.



+ + +	− − −	Strong positive/negative relationship (p<.01)
+ +	− −	Fairly strong positive/negative relationship (p<.05)
+	−	Positive/negative relationship(p<.10)
	0	No relationship (p≥,10

Figure 11: Long term effect of commercial network on growth

4.6.4. Indirect effect of interaction between scientific- and commercial networks on growth

This section examines the indirect effect of an interaction between scientific- and commercial networks on growth, with product innovativeness as a mediator. Growth is split up again into growth in revenue and growth in the number of employees. Again, in the growth in the number of employees, ‘number of founder’ has been added as a covariate.

4.6.4.1. Model assumptions

As with the other analyses, the model assumptions are discussed first. For this analysis, these can be found in appendix 4.4.1 to 4.4.6. For the variable revenue it can be seen that the points are again randomly distributed over the graph, so that it can be stated that the assumptions of linearity and homoscedasticity are met for this variable. The table with independent errors also

states that the mean is "0" and the median is "1", which means that these assumptions are also met. Finally, for the variable "revenue" we look at the histogram and the scatter plot. The histogram is normally distributed, when looking at the P-plot the dots are slightly further from the line, but the reason for this is again the number of valid cases. Then the variable "employees" is analysed. Here it can also be seen that the points are randomly distributed on the scatter plot graph and do not tend to centre to one point. The mean and the median also show the correct numbers, which means that this assumption is also met. Finally, there is again a flat shape in the histogram and horizontal lines within the P-Plot, but here again this is shifted to the low number of cases.

4.6.4.2. Model statistics

Figure 12 shows the model statistics of the mediation analysis. This mediation analysis examines the influence of the interaction effect between scientific and commercial networks (2001 - 2003) on revenue- and employee growth (2008 - 2010), through product innovativeness (2005 - 2007). First of all, the effect on revenue growth will be discussed. The table shows that the interaction effect between scientific and commercial networks has a negative effect on product innovativeness within spin-offs. When the items are used separately, they ensure product innovativeness, but when the variables are combined, it can be seen that they are not very compatible. In addition, it can be seen that product innovativeness itself has a positive significant impact on the revenue growth of the participating spin-offs. In addition, it can be seen that the interaction effect between scientific and commercial networks does have a direct neagtive influence on revenue growth, but this is far from significant. On the basis of the analysis it can be stated that there is no indirect effect of the interaction between scientific and commercial networks and revenue growth (b=-.23; SE=.31; 95% BI:-1 .02 – ,32). Finally, it can be seen that the model has an explanatory power of 49% and 31 valid cases.

Now the influence on employee growth will be discussed. First of all, the table shows that the interaction effect between scientific and commercial networks has a positive effect on product innovativeness within spin-offs, but it’s far from significant. When the items are used separately, they ensure product innovativeness, but when the variables are combined, it can be seen that they are not very compatible. In addition, it can be seen that product innovativeness itself has a positive significant impact on the employee growth of the participating spin-offs. In addition, it can be seen that the interaction effect between scientific and commercial networks has a negative effect on employee growth. On the basis of the analysis it can be stated that there is no indirect effect of the interaction between scientific and commercial networks and

employee growth (b=.003; SE=.07; 95% BI:- 0.17 – .13). Finally, it can be seen that the model has an explanatory power of 22% and 42 valid cases.

	Product innovation 2005-2007 **b (SE)**	**Revenue Growth 2008 – 2010** **b (SE)**	**Product innovation 2005-2007** **b (SE)**	**Employee Growth 2008 – 2010** **b (SE)**
Explanatory variable				
Scientific*Consumer Network 2001 - 2003	-,15 (,18)	-,29 (,38)	,01 (,19)	-,23 (,17)
Mediator variable				
Product innovation	n.a.	1,51 (,42)***	n.a.	,30 (,15)*
Control variables				
R&D	,23 (,29)	-1,58 (,60)	-,06 (,29)	,02 (,25)
Firm size 2003 (ln)	,13 (,10)	-,13 (,22)	,24 (,09)	-,17 (,09)*
Effect	Indirect positive effect from use scientific network 2001-2003 on revenue growth 2008-2010; b=-.23; SE=.31; 95% BI:-1 .02 – ,32		Indirect positive effect from use scientific network 2001-2003 on revenue growth 2008-2010; b=.003; SE=.07; 95% BI:- 0.17 – .13	
Model Information				
F	6,13***	3,80***	3,88***	1,63
R^2	,55	,49	,35	,22
N	31	31	42	42

Explanation: (*)p <,15 *p <,10; **p <,05; ***p <,01

N.A.: Not Applicable

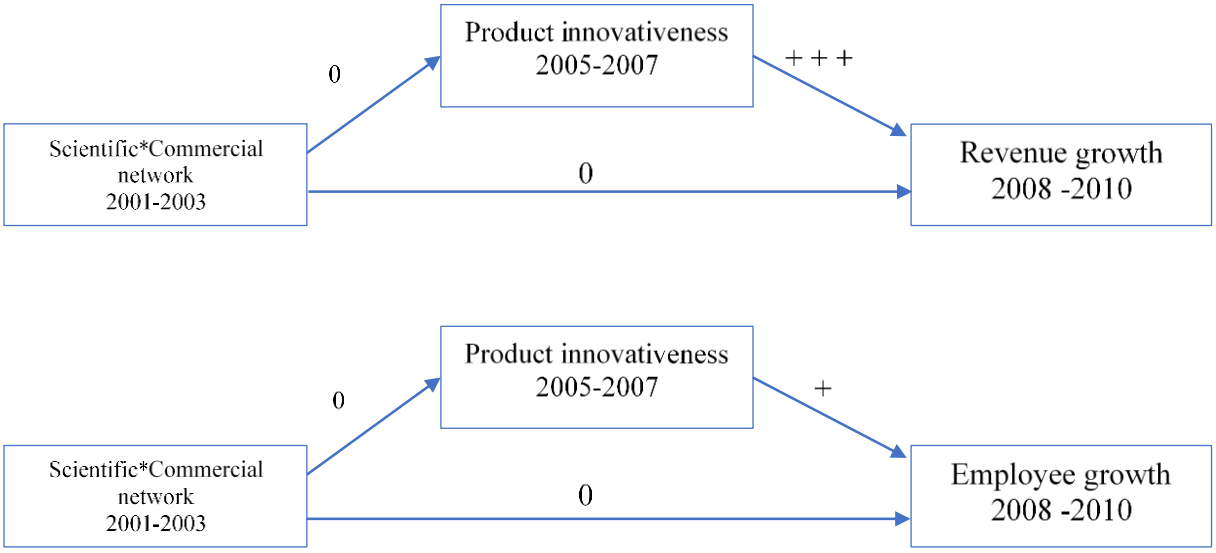
Figure 12: Mediation statistics interaction scientific- and commercial network on revenue- and employee growth

4.6.4.3. Hypothese testing

The above models tests the hypothesis:

H6: Other factors being equal, the larger the interaction of scientific and commercial networks, the greater their product innovativeness, which leads to stronger growth of this spin-off

On the basis of the above analysis, it can be stated that the interaction-effect between scientific- and commercial knowledge in the period 2001 - 2003 had no effect on product innovativeness in the period 2005 - 2007. In addition, it can be stated that product innovativeness has a positive effect on revenue- and employee growth of academic spin-offs but in the period 2008 - 2010 (significant). But since the interaction effect has no impact on product innovativeness, it can be said that there is no indirect effect of the interaction between scientific and commercial networks, on revenue and employee growth, through product innovativeness. An overview of the effects of the above analysis is shown in Figure 13.



+ + +	− − −	Strong positive/negative relationship (p<.01)
+ +	− −	Fairly strong positive/negative relationship (p<.05)
+	−	Positive/negative relationship(p<.10)
	0	No relationship (p≥,10

Figure 13: Long term effect of scientific*commercial network on growth

4.7 Conclusion

First of all, this chapter looked at the influence of scientific and commercial networks on product innovativeness within the spin-offs. After testing these hypotheses, it appears that scientific networks have a significant effect on product innovativeness within USOs. In addition, testing the hypotheses shows that commercial networks do have a positive effect on product innovativeness within spin-offs, but that this effect is not significant. Finally, the interaction effect is discussed. This shows that an interaction effect between scientific and commercial networks has a negative effect on product innovativeness within spin-offs (not significant).

Subsequently, the indirect effect of scientific networks on growth was examined. First, the analysis once again shows that the scientific network has a positive effect on product innovativeness. In addition, it appears that there is a positive (not significant) effect of the scientific network for both revenue- and employee growth. For hypothesis 2, it must therefore be concluded that there is an indirect positive effect of the scientific network on growth within spin-offs.

T

he effect of commercial networks on growth within spin-offs is examined. This analysis showed that product innovativeness has a positive significant effect on revenue growth within USOs. It is significant in revenue growth, but there is no significant effect of commercial networks on product innovativeness. It can be stated that the use of commercial new brands has no indirect positive effect on revenue growth within spin-offs. When looking at employee growth, there is no significant effect on product innovativeness or growth, so it is stated here that there is no effect of a commercial network on employee growth.

Finally, the interaction effect of scientific and commercial networks on growth is examined. As has already emerged in hypothesis 5, there is a negative influence of the interaction effect on product innovativeness within spin-offs, but not significant. Product innovativeness itself has a positive effect on both revenue- and employee growth. As a result, the analysis also shows that there is no indirect effect of the interaction effect of scientific and commercial networks on growth.

5. Research completion

5.1 Introduction

This chapter focuses on the completion of the research. First, a short summary of the research is given. Then answers are given to the questions that are central to the research. The answers to these questions are then linked to the theory. Based on this link, recommendations are written for possible follow-up research. Finally, the limitations are discussed in this chapter.

5.2 Research summary

This research examines the influence of scientific and commercial networks on growth within academic spin-offs, through product innovativeness. In the literature, there are conflicting views on this relationship. On the one hand, it is claimed that new knowledge from knowledge institutions within spin-offs makes it possible to come up with breakthrough innovation earlier, which results in faster spin-off growth. On the other hand, it is claimed that the use of one-sided knowledge networks causes too little use of the commercial network and that growth stagnates due to a lack of knowledge about needs from the market. This research, therefore, examines the influence of these networks on the growth of spin-offs through product innovativeness.

This is done by analyzing a survey sent to spin-offs from the Radboud University. The results are analyzed using a univariate-, a bivariate- and finally a multivariate analysis (regression analysis).

The results of this research show that the scientific network has a positive significant effect on product innovativeness within spin-offs. In addition, the commercial network has a positive but non-significant effect on product innovativeness. The interaction effect of both networks, on the other hand, has a negative but non-significant effect on product innovativeness within spin-offs.

Subsequently, the effect of the networks on growth is examined, which is divided into revenue- and employee growth. This shows that there is a positive indirect effect of the scientific network on both revenue and employee growth. When looking at the commercial network, it can be concluded that there is no effect on revenue- and employee growth. When analyzing the interaction effect, it must be concluded that there is also no effect on both revenue- and employee growth of the participating spin-offs.

5.3 Answering Research Questions

In this section, answers are given to the research questions that have been drawn up based on the literature.

H1: Other factors being equal, the larger the scientific network of academic spin-offs, the greater their product innovativeness.

This hypothesis is supported in this study. Based on the analysis it can be stated that scientific networks have a positive significant influence on product innovativeness within academic spin-offs.

H2: Other factors being equal, the larger the scientific network of academic spin-offs, the greater their product innovativeness, which leads to stronger growth

This hypothesis is also supported in this study. Based on the analysis, it can be stated that scientific networks have a positive indirect effect on both revenue and employee growth, through product innovativeness.

H3: Other factors being equal, the larger the commercial network of academic spin-offs, the greater their product innovativeness

The study shows that commercial networks have a positive influence on product innovativeness, but this effect is not significant within the study. So this hypothesis is not supported within this study

H4: Other factors being equal, the larger the commercial network of academic spin-offs, the greater their product innovativeness, which leads to stronger growth

This hypothesis is not supported in this research. The analysis shows that commercial networks have no influence on revenue- and employee growth.

H5: Other factors being equal, the larger the interaction of scientific and commercial networks of spin-offs, the greater their product innovativeness

This hypothesis is not supported in this study. The interaction effect between scientific and commercial networks has a negative non-significant effect on product innovativeness within academic spin-offs.

H6: Other factors being equal, the larger the interaction of scientific and commercial networks, the greater their product innovativeness, which leads to stronger growth of this spin-off

This hypothesis is also not supported in this study. The interaction effect between scientific and commercial networks has no effect on product innovativeness, as well as on revenue and employee growth within academic spin-offs.

5.4 Linking results and theory

The literature claims that the use of network contacts leads to the development of product innovativeness within spin-offs. This product innovativeness in turn lead to the growth of these spin-offs.

Spin-offs are companies that use knowledge from knowledge institutions, which gives them earlier access to new knowledge. This access to new knowledge can ultimately lead to breakthrough innovations and thus growth (Czarnitzki et al., 2014). Sousa-Ginel, Franco-Leal, & Camelo-Ordaz (2017) investigated the influence of knowledge networks on product innovativeness, and subsequently the growth of academic spin-offs. They claim that there must be regular contact with knowledge institutions to keep the knowledge up to date. In addition, it is also concluded that no one-sided network should be used, but that various knowledge contacts should be created. Based on these claims in the literature, the hypotheses of this study have been formulated. This study shows that contacts with a knowledge network did indeed lead significantly to product innovativeness within the spin-offs that participated in the survey. A large proportion of the participating spin-offs have thus created innovations that were both new to the company and new to the market. The link with breakthrough innovations is therefore also made within the research. In addition, this research also shows that the implementation of product innovativeness, in turn, has a positive effect on both the revenue and employee growth of the participating spin-offs. So, there is a positive indirect effect of the scientific network on the growth of spin-offs. It can therefore be concluded that the earlier access to new knowledge of the participating spin-offs (2001 - 2003) led to product innovativeness in the period 2005 - 2007, which in turn led to growth of the companies in the period 2008 - 2010.

On the other hand, it is claimed that many spin-offs remain relatively small and thus fail to exploit the growth potential. According to the literature (Piva & Colombo, 2015), this is because spin-offs are too focused on the scientific network, so that the commercial network is not considered. Research by Soltani et al., (2018) shows that maintaining customer relationships, and gaining knowledge about competitors, leads to better identification of market needs. This outline of market needs can then lead to opportunities for product innovativeness. This successful depth of customer needs then leads to growth. The above research shows that the

commercial network of the participating spin-offs indeed has a positive influence on product innovativeness, but this is not significant. The reason for this can be that the participating spin-offs are indeed too focused on the scientific network and therefore have not expanded the commercial network. In addition, the indirect effect of the commercial network on the growth of spin-offs is being examined. The analysis shows that of the participating spin-offs, the commercial network nevertheless has a no indirect impact on revenue growth and employee growth. The influence of the commercial network of the participating spin-offs was not expected to have a significant impact on product innovativeness. This is also true, but it does show that there is indeed a positive effect, so that when expanding this network it is expected that a significant effect will be possible.

Finally, it is claimed in the literature (Mosey & Wright, 2007) that in addition to scientific knowledge, commercial knowledge is also required to achieve growth within spin-offs. There would therefore be an interaction effect of scientific and commercial knowledge, which leads to product innovativeness and thus growth. Research has been conducted into this interaction effect within this study and a conflicting conclusion can be drawn from this. The literature suggests that the interaction between the two networks provides complementary knowledge and thus a greater chance of product innovativeness and thus growth. However, the research conducted shows that the interaction effect has a negative influence on product innovativeness (not significant), and that it has no indirect effect on growth. It can therefore be concluded from this that companies must either use scientific knowledge to achieve greater product innovativeness and thus growth. Commercial knowledge, and a combination of scientific and commercial knowledge together is not very compatible in this area.

5.5 Recommendations

The recommendations are split into recommendations for follow-up research, and recommendations for companies in practice.

First, the recommendations for follow-up studies are discussed. First, it should be noted that the intention was to publish a new survey this year among spin-offs from the Radboud University. This survey could have asked questions that went deeper into the scientific and commercial networks of the spin-offs. This would also produce a longitudinal analysis that was more relevant than the one currently used (with outdated data). Unfortunately, this could not continue due to the outbreak of COVID-19, because companies had to deal with other more important things, which is of course understandable. A suggestion for follow-up research could therefore

be to carry out such an analysis in the future, with a newly conducted survey. This makes it easier to generalize the results to the present. In addition, spin-offs from other universities or knowledge institutes could also participate in a new study. This compares whether the results for spin-offs from other knowledge institutions show comparable results.

The recommendations for practice indicate the significance of the results of this research for spin-offs. The analysis thus shows that the regularity with which spin-offs have contact with knowledge institutes has a positive significant impact on product innovativeness and thus the growth of these spin-offs. As a recommendation for practice, you could therefore say that spin-offs should keep in regular contact with knowledge institutions to keep their knowledge up to date. With this new knowledge, innovations can be implemented, which in their turn ensure the revenue and employee growth of spin-offs. The claims in the literature stating that there is no influence of the scientific network on growth can be rejected with the above research. In addition, the analysis shows that the commercial network also has a positive influence on product innovativeness, but this effect is not significant. There is, however, a positive effect, so it will be interesting to see whether a significant effect can be found with a more extensive commercial network. Based on this research, there is also something not recommended for the spin-offs, namely the use of scientific and commercial contacts at the same time. The research shows that interaction of these networks has a negative non-significant effect on product innovativeness and both forms of growth. As a recommendation, it can therefore be stated that the spin-offs can best invest in the scientific network, since they have a significant influence on product innovativeness and thus growth. Using the commercial network separately, or using a combination of a scientific and commercial network has no effect on product innovativeness and thus both forms of growth within academic spin-offs.

5.6 Limitations

The reader should take into account that this research is based on spin-offs that originated from Radboud University, Nijmegen. This means that the research is based on spin-offs from a single knowledge institution, so that the external validity to the total population of spin-offs is somewhat lower.

When reading this study, it must also be considered that a questionnaire from previous research by dhr. Vaessen has been used. This means that the measurement of the variables "scientific and commercial networks" is not as specific as planned. The intention was to generate a new

questionnaire that went deeper into these concepts. However, this was not possible due to the COVID-19 pandemic.

In addition, the number of cases for the analysis are not very high. The results show that for revenue change N =31 and for employee change N = 42. This means that not many observations have been included in the analysis. This means that an undisputed conclusion cannot be reached.

Finally, the survey only included spin-offs that have remained viable. Several spin-offs have also gone bankrupt over the years, these have not been included in the investigation. In these companies, revenue and the number of employees have obviously fallen sharply, but they have not been included in the survey. The conclusion of this study can therefore give a distorted picture because only companies that have remained viable have participated.

References

Battor, M., & Battor, M. (2010). The impact of customer relationship management capability on innovation and performance advantages: testing a mediated model. Journal of Marketing Management, 26(9–10), 842–857. https://doi.org/10.1080/02672570903498843

Cai, J., Smart, A. U., & Liu, X. (2014). Innovation exploitation, exploration and supplier relationship management. International Journal of Technology Management, 66(2/3), 134. https://doi.org/10.1504/ijtm.2014.064589

Cantner, U., & Goethner, M. (2011). Performance differences between academic spin-offs and non-academic start-ups: A comparative analysis using a non-parametric matching approach . The Economics of Innovative Change, 1–50.

Carnabuci, G., & Bruggeman, J. 2009. Knowledge specialization, knowledge brokerage and the uneven growth of technology domains. Social Forces, 88: 607–641.

Czarnitzki, D., Rammer, C., & Toole, A. A. (2014). University spin-offs and the "performance premium". Small Business Economics, 43(2), 309–326. https://doi.org/10.1007/s11187-013-9538-0

Derry, R., & Green, R. (1989). Ethical Theory in Business Ethics: A Critical Assessment. Journal of Business Ethics, 8, 521–533. Consulted from: https://link-springer-com.ru.idm.oclc.org/content/pdf/10.1007%2FBF00382928.pdf

Field, A. (2014). *Discovering Statistics using IBM SPSS Statistics.* London: SAGE Publications Ltd.

Fontes, M. (2005). The process of transformation of scientific and technological knowledge into economic value conducted by biotechnology spin-offs. Technovation, 2005(25), 339–347

Gottschalk, P., & Khandelwal, V. K. (2017). Global Comparison of Stages of Growth Based on Critical Success Factors. Journal of Global Information Management, 10(2), 40–49. https://doi.org/10.4018/jgim.2002040104

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. Strategic Management Journal, 21, 203-215

Hackett, S.M., Dilts, D.M., (2004). A real option-driven theory of business incubation. Journal of Technology Transfer 29, 41–54

Han, X., & Niosi, J. (2016). Star scientists in PV technology and the limits of academic entrepreneurship. Journal of Business Research, 69(5), 1707–1711. https://doi.org/10.1016/j.jbusres.2015.10.042

Hayter, C. (2015). Social Networks and the Success of University Spin-offs: Toward an Agenda for Regional Growth. Economic Development Quarterly, 29(1), 3–13.

Klofsten, M., & Jones-Evans, D. (2000). Comparing Academic Entrepreneurship in Europe - The Case of Sweden and Ireland. Small Business Economics, 14(4), 299–309. https://doi.org/10.1023/a:1008184601282

Lawton Smith, H., & Ho, K. (2006). Measuring the performance of Oxford University, Oxford Brookes University and the government laboratories' spin-off companies. Research Policy, 35(10), 1554–1568. https://doi.org/10.1016/j.respol.2006.09.022

Lejpras, A. (2014). How innovative are spin-offs at later stages of development? Comparing innovativeness of established research spin-offs and otherwise created firms. Small Business Economics, 43(2), 327–351. https://doi.org/10.1007/s11187-013-9534-4

Lindelof, P., & Lofsten, H. (2005). Academic versus corporate new technology-based firms in Swedish science parks: an analysis of performance, business networks and financing. International Journal of Technology Management, 31(3/4), 334. https://doi.org/10.1504/ijtm.2005.006638

Maklan, S., Knox, S., & Ryals, L. (2008). New Trends in Innovation and Customer Relationship Management: A Challenge for Market Researchers. International Journal of Market Research, 50(2), 221–240. https://doi.org/10.1177/147078530805000206

Mosey, S., & Wright, M. (2007). From human capital to social capital: A longitudinal study of technology-based academic entrepreneurs. Entrepreneurship Theory and Practice, 31, 909-935

Mustar, P., Wright, M., Clarysse, B., 2008. University spin-off firms: lessons from ten years of experience in Europe. Sci. Public Policy 35 (2), 67–80

Neves, M., & Franco, M. (2016). Academic spin-off creation: barriers and how to overcome them. R&D Management, 48(5), 505–518. https://doi.org/10.1111/radm.12231

O'Dwyer, M., & Gilmore, A. (2017). Competitor orientation in successful SMEs: an exploration of the impact on innovation. Journal of Strategic Marketing, 27(1), 21–37. https://doi.org/10.1080/0965254x.2017.1384040

Piva, E. & Colombo, M.G. (2005). Academic start-ups and new technology-based firms: a matched pair comparison. Paper presented at the 5th Triple Helix conference. Turin, May

Roberts, E. (1991). Entrepreneurs in high technology. Lessons from MIT and beyond. New York: Oxford University Press.

Roper, S. (1997). Product Innovation and Small Business Growth: A Comparison of the Strategies of German, U.K. and Irish Companies. Small Business Economics, 523–537. Geraadpleegd van https://link.springer.com/article/10.1023/A:1007963604397

Shane, S. (2004). Academic Entrepreneurship: University Spin-Offs and Wealth Creation. Edward Elgar, Northampton, MA

Soltani, Z., Zareie, B., Milani, F. S., & Navimipour, N. J. (2018). The impact of the customer relationship management on the organization performance. Journal of High Technology Management Research, 29, 237–246.

Sousa-Ginel, E., Franco-Leal, N., & Camelo-Ordaz, C. (2017). The influence of networks on the knowledge conversion capability of academic spin-offs. Industrial and Corporate Change, 26(6), 1125–1144. https://doi.org/10.1093/icc/dtx013

Tornatzky, L., Waugaman, P., Casson, L., Crowell, S., Spahr, C., Wong, F. (1995). Benchmarking best practices for university-industry technology transfer: Working with start-up companies. Atlanta, GA: Southern Technology Council

Vennix, J. A. M. (2016). Onderzoeks- en interventiemethodologie. Benelux: Pearson

Walter, A., Parboteeah, K. P., Riesenhuber, F., & Hoegl, M. (2011). Championship Behaviors and Innovations Success: An Empirical Investigation of University Spin-Offs*. Journal of Product Innovation Management, 28(4), 586–598. https://doi.org/10.1111/j.1540-5885.2011.00826.x

Wright, M., Lockett, A., Clarysse, B., & Binks, M. (2006). University spin-out companies and venture capital. Research Policy, 35(4), 481–501. https://doi.org/10.1016/j.respol.2006.01.005

Yayavaram, S., & Ahuja, G. 2008. Decomposability in knowledge structures and its impact on the usefulness of inventions and knowledge-base malleability. Administrative Science Quarterly, 53: 333–362.

Zahra, S. A., E. Van de Velde and B. Larraneta (2007), 'Knowledge conversion capability and the performance of corporate and university spin-offs,' Industrial and Corporate Change, 16, 569–608.

Zhang, J. (2008). The performance of university spin-offs: an exploratory analysis using venture capital data. The Journal of Technology Transfer, 34(3), 255–285. https://doi.org/10.1007/s10961-008-9088-9

Appendix

Appendix 1: Questionnaire 2011 / 21D 2003

1. De start

V1a_11 1a. Bent u oprichter of betrokken geweest bij de oprichting van het op het voorblad ingevulde bedrijf?

- [1] nee
- [2] ja, en ik was enige oprichter
- [3] ja, tezamen met nog V1aa_11 andere oprichters (aantal)

1b. In welk jaar is het bedrijf opgericht? V1b_11 oprichtingsjaar

V2_11 **2. De huidige status van het door u opgerichte bedrijf** *(kruis het antwoord aan dat het meest van toepassing is)*

- [1] Het bedrijf is overgenomen door of gefuseerd met een andere onderneming of organisatie } *ga door naar vraag 4*
- [2] Het bedrijf is geheel zelfstandig en volledig operationeel
- [3] De bedrijfsactiviteiten zijn sterk verminderd en het bedrijf is (nagenoeg) inactief } *ga door naar vraag 3*
- [4] Het bedrijf is inmiddels opgeheven in V2b_11 jaar van opheffing → V4a

3. Inactieve en opgeheven bedrijven

In welke jaar was het bedrijf nog operationeel? V3_11 → V4a jaar

Beantwoord a.u.b. in elk geval de vragen 4, 5, 12, 15 en 16 (voor de laatste operationele jaren)

4. De activiteiten en aard van het bedrijf

V4a_11 4a. Betreft uw bedrijf een:

- [1] bedrijf of onderneming
- [2] praktijk in het kader van de vrije beroepsbeoefening, zoals (huis)artsen, advocaten, notarissen, psychotherapeuten e.a.
- [3] anders, namelijk: V4a3_11

V4b_11 4b. Wilt u de kernactiviteit(en) van uw bedrijf hieronder zo concreet mogelijk omschrijven.

V5a_11 **5. Financiering**

5a. Hoeveel euro bedroeg het startkapitaal van dit bedrijf?

- [1] < 10.000
- [2] 10.000 - 25.000
- [3] 25.000 - 50.000
- [4] 50.000 - 100.000
- [5] ≥ 100.000

5b. Door wie is het startkapitaal van dit bedrijf gefinancierd? *(meerdere antwoorden mogelijk)*

V5b_11

[1] de oprichter(s)
[2] externe financiers, namelijk: → [1] bank V5ba_1_11
[3] n.v.t. (*geen startkapitaal*) [2] participatie-/venturefonds V5ba_2_11
[3] familie/kennissen V5ba_3_11
[4] anders, namelijk .....

V5c_11

5c. Heeft u later, ná de startfase, gebruik gemaakt van externe financiers voor continuering of groei van het bedrijf?

[1] nee
[2] ~~ja, namelijk:~~ → [1] bank V5c2_1_11
[2] participatie-/venturefonds V5c2_2_11
[3] familie/kennissen V5c2_3_11
V5c2_4_11 [4] anders, namelijk .....

5d. In welke mate heeft u het bijeenbrengen van voldoende financiële middelen als een probleem ervaren bij...

	in zeer geringe mate	in geringe mate	in grote mate	in zeer grote mate
V5d1_11 ....de start van uw bedrijf?	[1]	[2]	[3]	[4]
V5d2_11 ... de groei en ontwikkeling van uw bedrijf?	[1]	[2]	[3]	[4]

V6_11

6. **Groeiplannen**
Hoe groot is het streven van uw bedrijf om in de komende jaren te groeien?

[1] ons streven is om de grootste speler worden
[2] ons streven is om *sterk* te groeien
[3] ons streven is groei
[4] ons streven is een gezonde bedrijfsvoering, eventueel met groei
[5] we streven niet naar groei

7. **Hoger opgeleiden, octrooien en R&D**

7a. Welk deel van de medewerkers van uw bedrijf heeft onderwijs op HBO- of WO-niveau genoten

V7a_11 ..... % van het totaal aantal medewerkers (u zelf inbegrepen)

7b. Beschikt uw bedrijf over één of meerdere geregistreerde octrooien (incl. lopende octrooiaanvragen)?

V7b_11

[1] nee
[2] ja, namelijk V7b_2_11 (aantal)

V7c_11 7c. Zijn in uw bedrijf bepaalde medewerkers (u zelf inclusief) specifiek belast met het ontwikkelen van nieuwe of het verbeteren van bestaande producten en processen (R&D)?

[1] nee
[2] ja ⟶ Indien ja, hoeveel arbeidsjaren* zijn daarmee gemoeid?

Aantal R&D-arbeidsjaren V7c_ja_11

* *een voltijdmedewerker die alle werktijd besteedt aan R&D telt voor één arbeidsjaar. Een medewerker die in deeltijd werkt of niet alle werktijd besteedt aan R&D slechts meetellen voor een gedeelte van een arbeidsjaar. Bijvoorbeeld een medewerker die twee dagen per week besteedt aan R&D telt voor 0,4 arbeidsjaar.*

8. Nieuwe en/of verbeterde producten/diensten

V8a_11 8a. **Nieuw voor uw bedrijf:** Heeft uw bedrijf **de laatste** drie jaar nieuwe of verbeterde producten of diensten op de markt gebracht?

[1] nee
[2] ja ⟶ V8a2_11 % van de omzet uit nieuwe of verbeterde producten of diensten

8b. **Nieuw voor uw afzetmarkt:** Heeft uw bedrijf de laatste drie jaar producten/diensten verkocht die voor uw afzetmarkt nieuw of duidelijk verbeterd waren?
(d.w.z. niet eerder door concurrenten op de markt gebracht!)

V8b_11 [1] nee
[2] ja ⟶ V8b2_11 % van de omzet uit producten of diensten nieuw voor de markt

Ig_11 **9. Marktverbreding**

Heeft u in de laatste drie jaar producten of diensten geïntroduceerd op afzetmarkten die nieuw waren voor uw bedrijf?	niet	in geringe mate	in redelijk sterke mate	in sterke mate
	[1]	[2]	[3]	[4]

10. Contacten met kennisinstellingen
Hoe vaak zijn er in de laatste drie jaar op enigerlei wijze contacten* geweest tussen uw bedrijf en:

	geen contact	incidenteel	regelmatig	zeer vaak
V10a_11 a. de Radboud Universiteit Nijmegen/UMC St. Radboud?	[1]	[2]	[3]	[4]
V10b_11 b. andere universiteiten?	[1]	[2]	[3]	[4]
V10c_11 c. andere onderzoeksinstellingen?	[1]	[2]	[3]	[4]

* *'contacten' zo breed mogelijk opvatten (lezingen, gebruik faciliteiten, stagiaires, contacten met medewerkers, in dienst nemen van afgestudeerden, bibliotheekgebruik e.a.)*

11. Informatiebronnen
Hoe belangrijk waren de laatste drie jaar de volgende informatiebron voor de innovatie-activiteiten van uw bedrijf?

	bron gebruikt en was: enigszins belangrijk	belangrijk	zeer belangrijk	*bron niet gebruikt*
a. Interne bronnen binnen uw bedrijf of concern	1	2	3	4
b. Afnemers	1	2	3	4
c. Leveranciers van apparatuur, materialen, componenten of software	1	2	3	4
d. Concurrent of andere bedrijven in uw bedrijfstak	1	2	3	4
e. Radboud Universiteit Nijmegen/UMC St Radboud	1	2	3	4
f. Andere universiteit(en)	1	2	3	4
g. Andere onderzoeksinstelling(en) (TNO, RIVM e.a.)	1	2	3	4
h. HBO-instellingen	1	2	3	4
i. Consultants, commerciële R&D-instituten of laboratoria	1	2	3	4
j. Conferenties, beurzen of exposities	1	2	3	4
k. Wetenschappelijke tijdschriften en vak-/technische publicaties	1	2	3	4
l. Beroeps- en brancheverenigingen	1	2	3	4
m. Internet	1	2	3	4

12. Knelpunten

Geef aan of uw bedrijf de laatste drie jaar ten aanzien van de volgende bedrijfsaspecten knelpunten heeft ervaren

	Knelpunt? nee	ja enigszins	ja aanzienlijk
a. Opstellen goed businessplan	1	2	3
b. Geschikt contactennetwerk	1	2	3
c. Verwerven naamsbekendheid/ pr/ communicatie	1	2	3
d. Inzicht in wensen van (mogelijke) klanten (marktkennis)	1	2	3
e. Geschiktheid vestigingspunt/bedrijfsruimte	1	2	3
f. Medewerking van de bank, financiers	1	2	3
g. Verkrijgen subsidies	1	2	3
h. (financiële) administratie	1	2	3
i. Veel concurrentie	1	2	3
j. Aantrekken geschikt personeel	1	2	3
k. Liquiditeitspositie	1	2	3
l. (Verbetering) rendement van het bedrijf	1	2	3
m. Regels en wetten (bv. arbeidsregelgeving, milieuwetgeving)	1	2	3
n. Andere belangrijke knelpunten nl:		2	3

13. Omzet

	Jaar 2008	Jaar 2009	Jaar 2010
a. Geef aan hoeveel de totale omzet van uw bedrijf bedroeg over de jaren 2008, 2009 en 2010 (exclusief btw)	€	€	€
b. n.v.t. we hadden nog geen omzet	1	2	3

21. Omvang en performance

a. Geef aan hoeveel de totale omzet van uw bedrijf bedroeg over de jaren 2003 en 2002 (exclusief btw).

Jaar 2003	Jaar 2002
☐ < € 10.000	☐ < € 10.000
☐ € 10.000 - € 25.000	☐ € 10.000 - € 25.000
☐ € 25.000 - € 50.000	☐ € 25.000 - € 50.000
☐ € 75.000 - € 100.000	☐ € 75.000 - € 100.000
☐ € 100.000 - € 150.000	☐ € 100.000 - € 150.000
☐ € 150.000 - € 250.000	☐ € 150.000 - € 250.000
☒ € 250.000 - € 500.000	☐ € 250.000 - € 500.000
☐ € 500.000 - € 1.000.000	☐ € 500.000 - € 1.000.000
☐ ≥ € 1.000.000, nl:	☐ ≥ € 1.000.000, nl:
€	€ .....
☒ n.v.t. we hadden nog geen omzet	☒ n.v.t. we hadden nog geen omzet

b. Ten opzichte van 2001 is onze omzet in 2003…
☐ gestegen met ..... %
☐ gelijk gebleven
☐ gedaald met ..... %

c. Maakte uw bedrijf in **2003** winst of verlies?
☐ verlies ☐ quitte ☒ winst ☐ n.v.t.

Maakte uw bedrijf in **2002** winst of verlies?
☐ verlies ☐ quitte ☐ winst ☐ n.v.t.

d. Geef aan hoeveel medewerkers in uw bedrijf werkzaam waren in achtereenvolgens de jaren 2003 en 2002.

	Jaar 2003	Jaar 2002
Totaal aantal medewerkers	4	.....
Aantal medewerkers op basis van fulltime eenheden	4 fte	.....

14. **Netto bedrijfsresultaat**

	Jaar 2008	Jaar 2009	Jaar 2010
negatief	1	2	3
break even	1	2	3
positief	1	2	3
n.v.t.	1	2	3

15. **Medewerkers** *(u zelf inbegrepen)*

Geef het gemiddelde aantal medewerkers in uw bedrijf in achtereenvolgens de jaren 2008, 2009 en 2010 *(uzelf inclusief)*

	Jaar 2008	Jaar 2009	Jaar 2010
a. Totaal aantal medewerkers			
b. Aantal medewerkers op basis van fulltime eenheden			
c. **n.v.t.** het bedrijf was nog niet opgericht	1	2	3

16. **Persoonsgegevens en achtergrond ondernemer**

16a. Wat is uw geboortedatum? .....

16b. Wat is uw geslacht?

1 vrouw
2 man

16c. Bent u student aan de RU Nijmegen/UMC St. Radboud of bent u dat in het verleden geweest?

1 nee, nooit geweest
2 ja, geweest → afgestudeerd in: ..... (laatste studiejaar) ..... faculteit (naam)
3 ja, nog → ..... faculteit (naam)

17. **Bent u na beëindiging van uw studie in loondienst werkzaam geweest?**

1 nee → nee *(ga door naar vraag 20)*
2 ja

18. **Werkgevers**

Vermeld per bedrijf of organisatie waar u na beëindiging van uw opleiding aan RU/UMC werkzaam bent geweest.

Naam organisatie/werkgever	Plaats	Jaartal in dienst	Jaartal uit dienst *(mits van toepassing)*	type organisatie	
				profit	non-profit
				1	2
				1	2
				1	2
				1	2
				1	2
				1	2

19 **Bent u medewerker van de RU Nijmegen/UMC St. Radboud of bent u dat in het verleden geweest? Zo ja bij welke faculteit/dienst?**

V19_U

[1] nee
[2] ja ⟶ bij faculteit/dienst V19b_U (naam)

20 **Fulltime of parttime ondernemer**

V20_U

Bent u in uw eigen bedrijf fulltime werkzaam of parttime?

[1] fulltime
[2] parttime

21. **Kansen voor contacten met Radboud Universiteit:**
De Radboud Universiteit wil de relatie versterken met ondernemers met een verleden aan RU/UMC. Kruis aan of uw bedrijf **in de toekomst** gebruik wil maken van onderstaande diensten.

		nee	ja
V21a_U	a. Contacten met onderzoekers van RU/UMC.	1	2
V21b_U	b. Informatie over research op uw vakgebied.	1	2
V21c_U	c. Vakgerichte master classes en workshops.	1	2
V21d_U	d. Workshops ondernemen en management.	1	2
V21e_U	e. Netwerk met andere spin-off ondernemers.	1	2
V21f_U	f. Rol als mentor/coach voor jonge start ups.	1	2
V21g_U	g. Stageplaatsen bij uw bedrijf voor studenten.	1	2
V21h_U	h. Onderzoek/advies door RU-wetenschappers.	1	2
V21i_U	i. Gebruik van faciliteiten, zoals laboratoria.	1	2
V21j_U	j. Locatie op campus: Universitair Bedrijvencentrum (UBC)/Mercator Science Park.	1	2

Appendix 2: Output variables composition

2.1 Scientific Networks

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	155	33,3
	Excluded[a]	311	66,7
	Total	466	100,0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
,701	3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
v7a Hoe vaak zijn er in de laatste drie jaar op enigerlei wijze contacten geweest tussen uw bedrijf en a de Radboud Univ	1,67	2,014	,467	,700
v7b andere universiteiten?	2,08	2,163	,637	,471
v7c andere onderzoeksinstellingen?	1,97	2,499	,478	,659

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
2,86	4,356	2,087	3

Appendix 3: Univariate Analysis

3.1 Descriptive Statistics all variables

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
omz08_10 Ontwikkeling omzet tussen 2008 en 2010	112	1,00	5,00	3,1518	1,35041	-,281	,228	-,936	,453
wzp08_10 Ontwikkeling wzp tussen 2008 en 2010	157	-1,00	1,00	,1210	,62378	-,089	,194	-,452	,385
v11e_h04 gebruik van wetenschappelijke kennisbronnen in 2004	136	1,00	3,50	1,5037	,65968	1,067	,208	,176	,413
v11b_04 informatiebron afnemer	136	1	4	2,60	1,071	-,198	,208	-1,198	,413
v11d_04 informatiebron concurrent	137	1	4	1,97	,866	,402	,207	-,800	,411
v11c_04 informatiebron leverancier	134	1	4	1,60	,893	1,320	,209	,680	,416
pi_08 productinnovatie 2005-2007	133	1,00	3,00	1,9549	,88647	,089	,210	-1,732	,417
v15a03 totaal aantal mdwers 2003	148	,40	80,00	6,8905	12,66519	3,261	,199	12,032	,396
v7c_04 r&d	136	1	2	1,29	,457	,914	,208	-1,183	,413
Valid N (listwise)	26								

3.2 Descriptive Statistics Product innovativeness

Statistics

productinnovatie 2005-2007

N	Valid	133
	Missing	333
Mode		1,00
Range		2,00
Minimum		1,00
Maximum		3,00

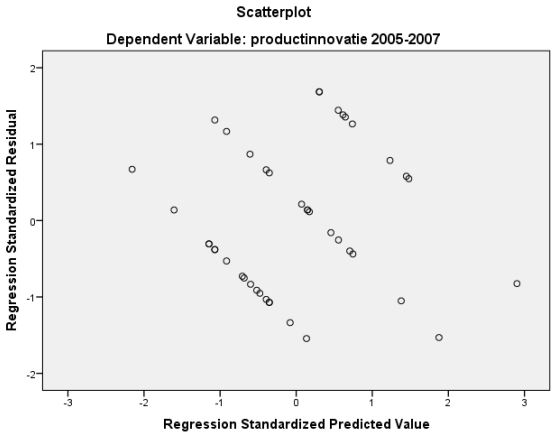
productinnovatie 2005-2007

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	geen productinnovatie	55	11,8	41,4	41,4
	productinnovatie alleen nieuw voor het bedrijf	29	6,2	21,8	63,2
	productinnovatie ook nieuw voor de markt	49	10,5	36,8	100,0
	Total	133	28,5	100,0	
Missing	System	333	71,5		
Total		466	100,0		

Appendix 4: Multivariate Analysis

4.1 Relation scientific- and commercial networks with product innovativeness

4.1.1. Linearity and homoscedasticity



4.1.2 Independent errors

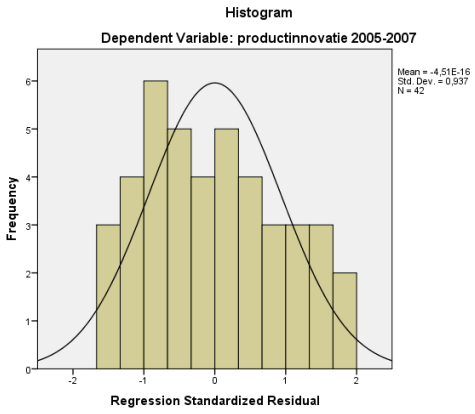
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	,6043	3,4869	1,8333	,56983	42
Residual	-,91063	,99451	,00000	,55261	42
Std. Predicted Value	-2,157	2,902	,000	1,000	42
Std. Residual	-1,544	1,686	,000	,937	42

a. Dependent Variable: productinnovatie 2005-2007

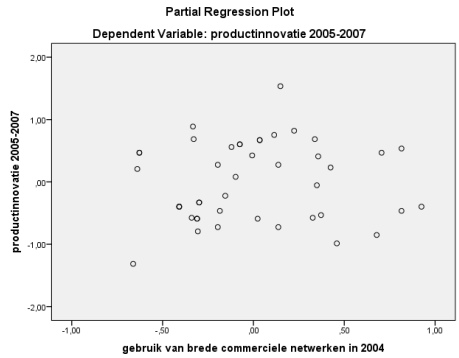
4.1.3. Normally distributed errors

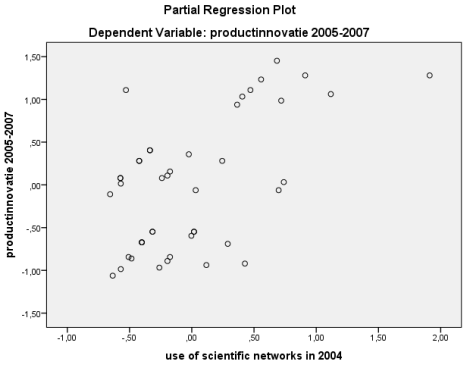
Histogram



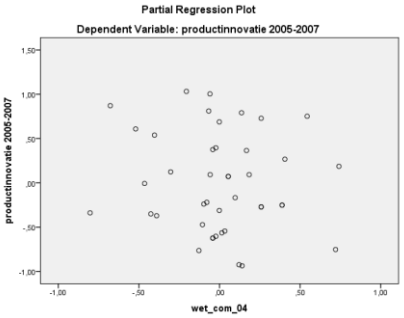
Scientific Network

Commercial Network (narrow)





Scientific*Commercial Network



4.1.4. Model statistics

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.507	4	3.127	6.150	.000[b]
	Residual	25.420	50	.508		
	Total	37.927	54			
2	Regression	12.669	5	2.534	4.916	.001[c]
	Residual	25.258	49	.515		
	Total	37.927	54			

a. Dependent Variable: productinnovatie 2005-2007

b. Predictors: (Constant), number of employees in 2003 (founder(s) included, informatiebron afnemer, gebruik van wetenschappelijke kennisbronnen in 2004, r&d

c. Predictors: (Constant), number of employees in 2003 (founder(s) included, informatiebron afnemer, gebruik van wetenschappelijke kennisbronnen in 2004, r&d, interaction term v11b_04 v11e_h04

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.598	.386		1.551	.127
	r&d	.032	.229	.017	.138	.891
	informatiebron afnemer	.125	.091	.162	1.379	.174
	gebruik van wetenschappelijke kennisbronnen in 2004	.535	.165	.394	3.248	.002
	number of employees in 2003 (founder(s) included	.178	.077	.285	2.322	.024
2	(Constant)	.608	.389		1.564	.124
	r&d	.006	.235	.003	.025	.980
	informatiebron afnemer	.121	.092	.157	1.320	.193
	gebruik van wetenschappelijke kennisbronnen in 2004	.560	.172	.413	3.261	.002
	number of employees in 2003 (founder(s) included	.182	.078	.291	2.346	.023
	interaction term v11b_04 v11e_h04	-.092	.163	-.069	-.561	.577

a. Dependent Variable: productinnovatie 2005-2007

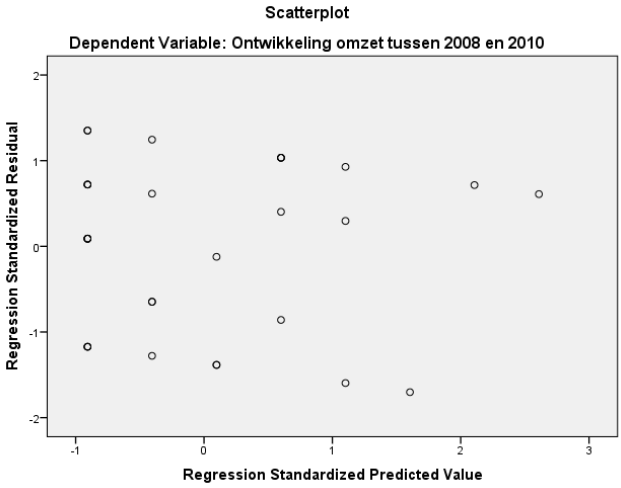
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.845	.450		1.878	.067
	r&d	.074	.241	.041	.305	.762
	informatiebron afnemer	.131	.102	.172	1.283	.206
	informatiebron leverancier	-.001	.136	-.001	-.011	.991
	informatiebron concurrent	-.115	.132	-.116	-.872	.388
	informariebron consultant	-.070	.144	-.064	-.483	.631
	gebruik van wetenschappelijke kennisbronnen in 2004	.540	.172	.401	3.145	.003
	number of employees in 2003 (founder(s) included	.195	.082	.315	2.364	.022

a. Dependent Variable: productinnovatie 2005-2007

4.2 Indirect effect of science networks on growth

4.2.1 Linearity and Homoscedasticity ‘omz08_10’



4.2.2 Independent errors ‘omz08_10’

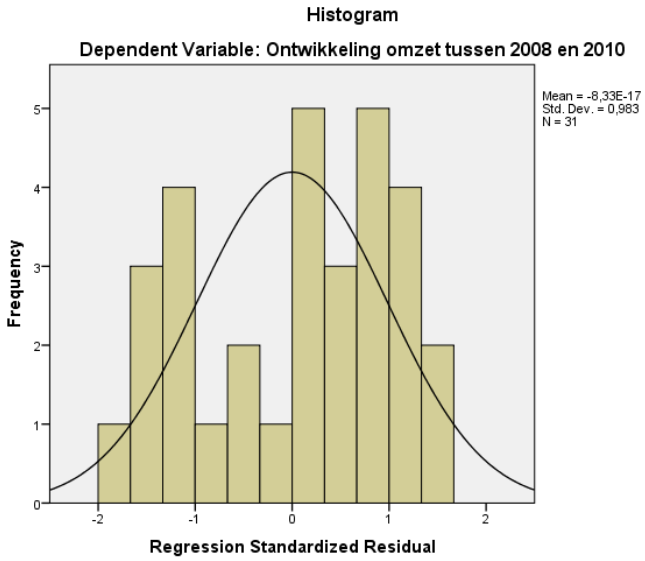
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2,8578	4,0339	3,1613	,33442	31
Residual	-2,69788	2,14224	,00000	1,55819	31
Std. Predicted Value	-,908	2,609	,000	1,000	31
Std. Residual	-1,702	1,352	,000	,983	31

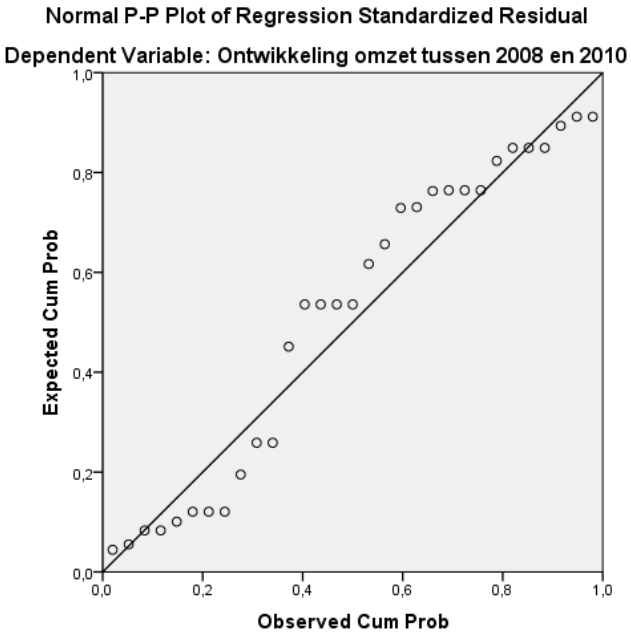
a. Dependent Variable: Ontwikkeling omzet tussen 2008 en 2010

4.2.3. Normally distributed errors ‘omz08_10’

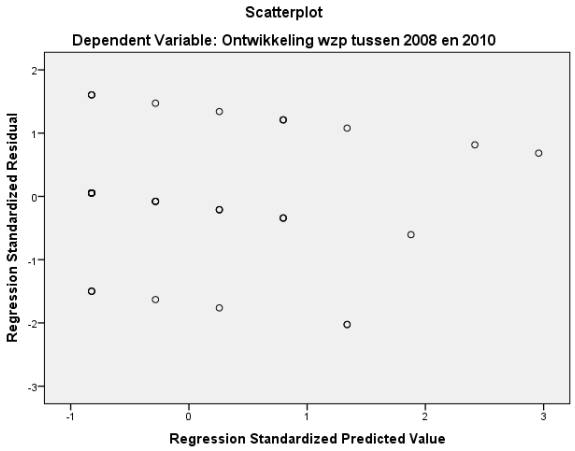
Histogram



P-Plot



4.2.4 Linearity and homoscedasticity 'wzp08_10'



4.2.5 Independent errors 'wzp08_10'

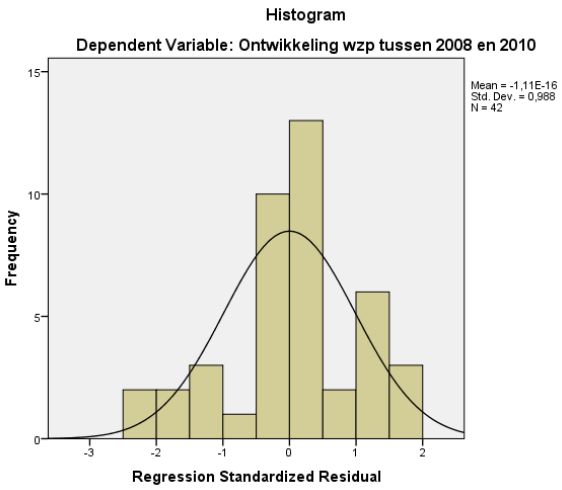
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-,0339	,5593	,0952	,15687	42
Residual	-1,30508	1,03390	,00000	,63650	42
Std. Predicted Value	-,823	2,958	,000	1,000	42
Std. Residual	-2,025	1,604	,000	,988	42

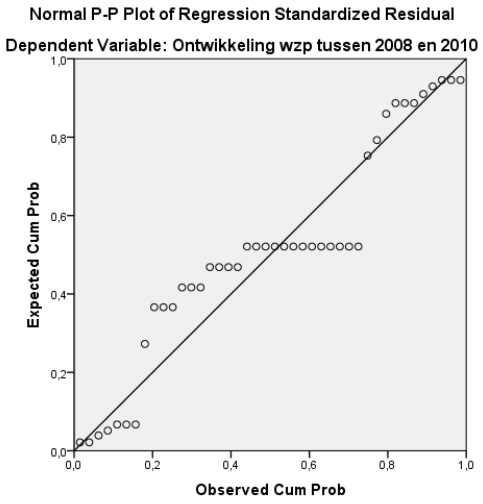
a. Dependent Variable: Ontwikkeling wzp tussen 2008 en 2010

4.2.6 Normally distributed errors 'wzp08_10'

Histogram



P-Plot



4.2.7. Process Output 'omz08_10'

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Release 2.13 ***************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = omz08_10
    X = v11e_h04
    M = pi_08
```

```
Statistical Controls:
CONTROL= v7c_04   v15a03ln

Sample size
         31

**************************************************************************
Outcome: pi_08

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,7183      ,5159      ,3759     9,5913     3,0000    27,0000
,0002

Model
              coeff         se          t          p       LLCI       ULCI
constant      ,2845      ,3697      ,7694      ,4483     -,4742     1,0431
v11e_h04      ,7531      ,1827     4,1221      ,0003      ,3782     1,1279
v7c_04        ,2556      ,2823      ,9053      ,3733     -,3237      ,8349
v15a03ln      ,1228      ,1021     1,2028      ,2395     -,0867      ,3324

**************************************************************************
Outcome: omz08_10

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,6586      ,4338     1,6594     4,9792     4,0000    26,0000
,0041

Model
              coeff         se          t          p       LLCI       ULCI
constant     3,1484      ,7852     4,0096      ,0005     1,5343     4,7625
pi_08        1,4406      ,4043     3,5630      ,0014      ,6095     2,2718
v11e_h04     -,2827      ,4899     -,5769      ,5690    -1,2898      ,7245
v7c_04      -1,7167      ,6021    -2,8512      ,0084    -2,9544     -,4791
v15a03ln     -,0861      ,2202     -,3911      ,6989     -,5388      ,3666

****************** DIRECT AND INDIRECT EFFECTS ************************

Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
     -,2827      ,4899     -,5769      ,5690    -1,2898      ,7245

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
pi_08     1,0849      ,3826      ,5128     2,0050

****************** ANALYSIS NOTES AND WARNINGS ************************

Number of bootstrap samples for bias corrected bootstrap confidence
intervals:
     1000

Level of confidence for all confidence intervals in output:
    95,00

NOTE: Some cases were deleted due to missing data.  The number of such
cases was:
  301
```

```
------ END MATRIX -----
```

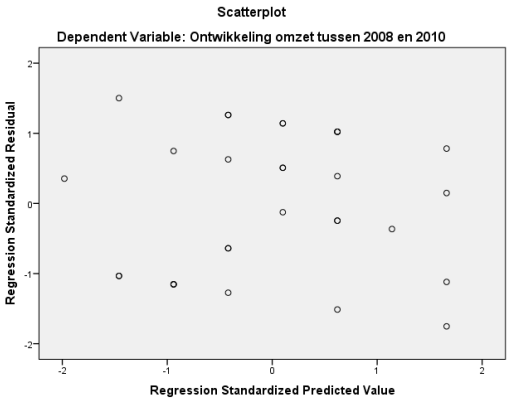
4.2.8. Process Output 'wzp08_10'

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Release 2.13 ***************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = wzp08_10
    X = v11e_h04
    M = pi_08

Statistical Controls:
CONTROL= v7c_04   v15a03ln

Sample size
         42

**************************************************************************
Outcome: pi_08

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,5636      ,3176      ,5011     5,8952     3,0000    38,0000
,0021

Model
              coeff         se          t          p       LLCI       ULCI
constant      ,9421      ,3618     2,6038      ,0131      ,2096     1,6745
v11e_h04      ,5761      ,1967     2,9292      ,0057      ,1779      ,9742
v7c_04       -,0382      ,2862     -,1334      ,8946     -,6176      ,5413
v15a03ln      ,2384      ,0926     2,5759      ,0140      ,0510      ,4258

**************************************************************************
Outcome: wzp08_10

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,3969      ,1575      ,4012     1,7294     4,0000    37,0000
,1643

Model
              coeff         se          t          p       LLCI       ULCI
constant     -,2825      ,3514     -,8038      ,4267     -,9945      ,4296
pi_08         ,3189      ,1451     2,1971      ,0344      ,0248      ,6130
v11e_h04     -,0514      ,1948     -,2636      ,7935     -,4461      ,3434
v7c_04        ,0103      ,2562      ,0401      ,9682     -,5088      ,5293
v15a03ln     -,1667      ,0898    -1,8571      ,0713     -,3485      ,0152

****************** DIRECT AND INDIRECT EFFECTS *************************
```

```
Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
     -,0514      ,1948     -,2636      ,7935     -,4461      ,3434

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
pi_08      ,1837      ,1005      ,0355      ,4523

******************** ANALYSIS NOTES AND WARNINGS *************************

Number of bootstrap samples for bias corrected bootstrap confidence
intervals:
     1000

Level of confidence for all confidence intervals in output:
    95,00

NOTE: Some cases were deleted due to missing data.  The number of such
cases was:
  290

------ END MATRIX -----
```

4.3 Indirect effect of commercial networks on growth

4.3.1. Linearity and Homoscedasticity 'omz08_10'



4.3.2. Independent errors 'omz08_10'

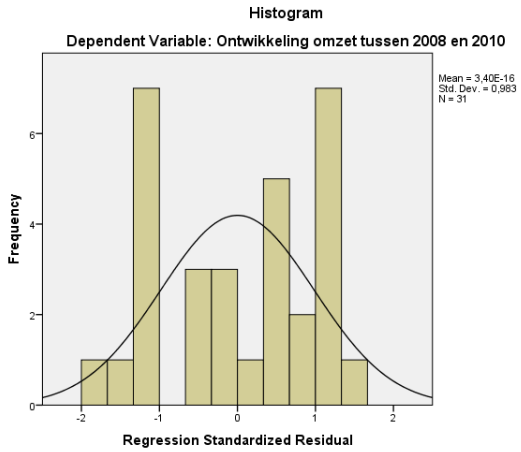
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2,4412	3,7654	3,1613	,36362	31
Residual	-2,76542	2,36962	,00000	1,55163	31
Std. Predicted Value	-1,980	1,661	,000	1,000	31
Std. Residual	-1,752	1,502	,000	,983	31

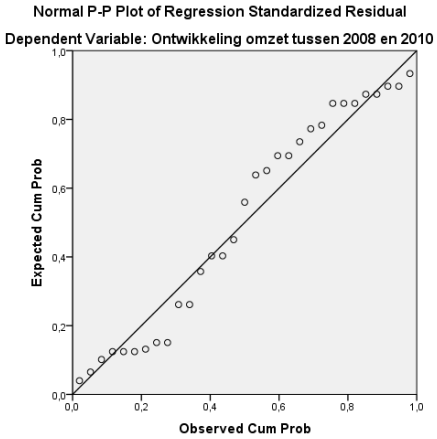
a. Dependent Variable: Ontwikkeling omzet tussen 2008 en 2010

4.3.3. Normally distributed errors ‘omz08_10’

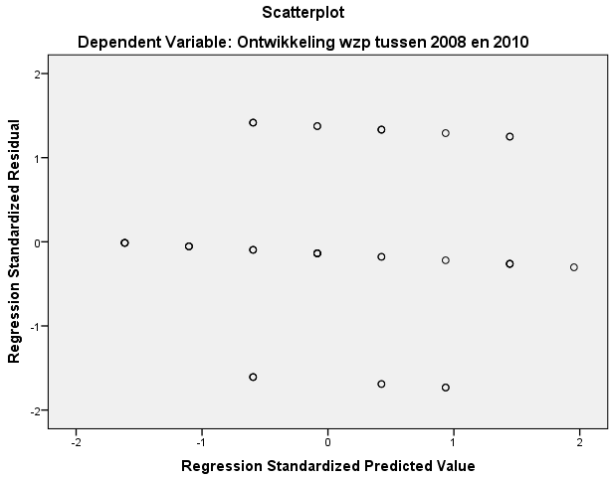
Histogram



P-Plot



4.3.4. Linearity and Homoscedasticity ‘wzp08_10’



4.3.5. Independent errors 'wzp08_10'

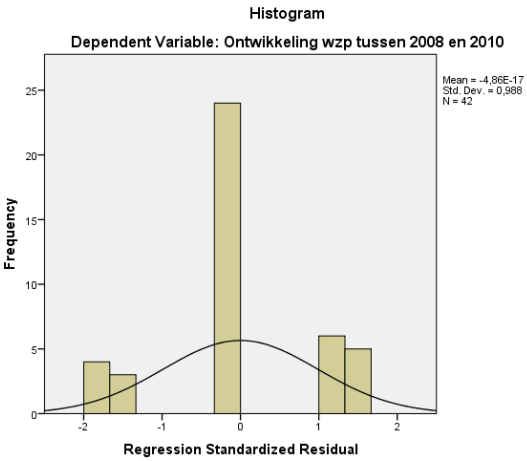
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	,0083	,2005	,0952	,05387	42
Residual	-1,14557	,93679	,00000	,65332	42
Std. Predicted Value	-1,614	1,954	,000	1,000	42
Std. Residual	-1,732	1,416	,000	,988	42

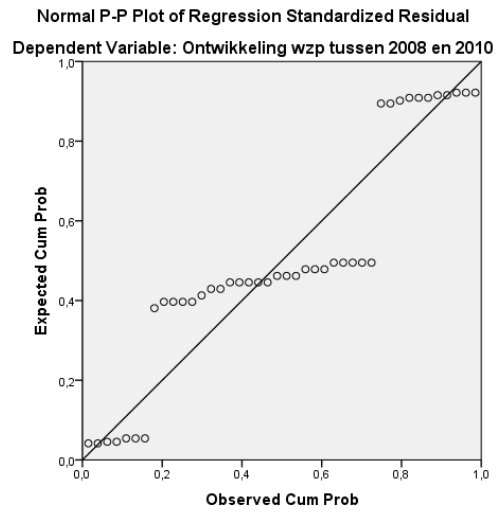
a. Dependent Variable: Ontwikkeling wzp tussen 2008 en 2010

4.3.6. Normally distributed errors 'wzp08_10'

Histogram



P-Plot



4.3.7. Process output 'omz08_10'

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Release 2.13 ***************
```

```
          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = omz08_10
    X = v11b_04
    M = pi_08

Statistical Controls:
CONTROL= v7c_04   v15a03ln

Sample size
         31

**************************************************************************
Outcome: pi_08

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,4973      ,2473      ,5845     2,9574     3,0000    27,0000
,0502

Model
              coeff         se          t          p       LLCI       ULCI
constant      ,6418      ,4971     1,2912      ,2076     -,3781     1,6618
v11b_04       ,1422      ,1250     1,1375      ,2653     -,1143      ,3986
v7c_04        ,6260      ,3315     1,8881      ,0698     -,0543     1,3062
v15a03ln      ,1010      ,1278      ,7906      ,4361     -,1612      ,3633

**************************************************************************
Outcome: omz08_10

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,6818      ,4648     1,5684     5,6453     4,0000    26,0000
,0021

Model
              coeff         se          t          p       LLCI       ULCI
constant     3,5768      ,8390     4,2630      ,0002     1,8521     5,3015
pi_08        1,3876      ,3152     4,4017      ,0002      ,7396     2,0356
v11b_04      -,2859      ,2096    -1,3641      ,1842     -,7167      ,1449
v7c_04      -1,7086      ,5778    -2,9571      ,0065    -2,8964     -,5209
v15a03ln     -,1039      ,2117     -,4908      ,6277     -,5392      ,3313

******************** DIRECT AND INDIRECT EFFECTS ************************

Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
     -,2859      ,2096    -1,3641      ,1842     -,7167      ,1449

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
pi_08      ,1973      ,1660     -,0955      ,5678

******************** ANALYSIS NOTES AND WARNINGS ************************
```

```
Number of bootstrap samples for bias corrected bootstrap confidence
intervals:
     1000

Level of confidence for all confidence intervals in output:
    95,00

NOTE: Some cases were deleted due to missing data.  The number of such
cases was:
  301

------ END MATRIX -----
```

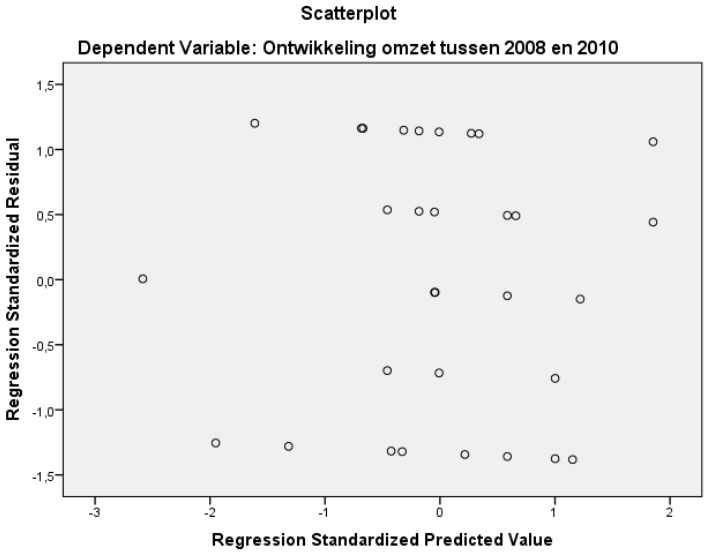
4.3.8. Process output 'wzp08_10'

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Release 2.13 ***************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = wzp08_10
    X = v11b_04
    M = pi_08

Statistical Controls:
CONTROL= v7c_04   v15a03ln

Sample size
         42

**************************************************************************
Outcome: pi_08

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,4565      ,2084      ,5813     3,3339     3,0000    38,0000
,0294

Model
              coeff         se          t          p       LLCI       ULCI
constant     1,0121      ,4344     2,3299      ,0252      ,1327     1,8916
v11b_04       ,1587      ,1081     1,4673      ,1505     -,0602      ,3776
v7c_04        ,2914      ,2787     1,0459      ,3022     -,2727      ,8555
v15a03ln      ,1951      ,0984     1,9833      ,0546     -,0040      ,3943

**************************************************************************
Outcome: wzp08_10

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,4106      ,1686      ,3959     1,8762     4,0000    37,0000
,1352
```

```
Model
              coeff         se          t          p       LLCI       ULCI
constant     -,4264      ,3832    -1,1126      ,2731    -1,2029      ,3501
pi_08         ,2792      ,1339     2,0855      ,0440      ,0079      ,5504
v11b_04       ,0689      ,0917      ,7517      ,4570     -,1169      ,2548
v7c_04       -,0244      ,2332     -,1047      ,9172     -,4970      ,4482
v15a03ln     -,1548      ,0853    -1,8153      ,0776     -,3276      ,0180

****************** DIRECT AND INDIRECT EFFECTS *************************

Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
      ,0689      ,0917      ,7517      ,4570     -,1169      ,2548

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
pi_08      ,0443      ,0447     -,0088      ,1838

****************** ANALYSIS NOTES AND WARNINGS *************************

Number of bootstrap samples for bias corrected bootstrap confidence
intervals:
     1000

Level of confidence for all confidence intervals in output:
    95,00

NOTE: Some cases were deleted due to missing data.  The number of such
cases was:
  290

------ END MATRIX -----
```

4.4 Indirect effect of interaction between scientific- and commercial networks on growth

4.4.1. Linearity and Homoscedasticity 'omz08_10'



4.4.2. Independent errors 'omz08_10'

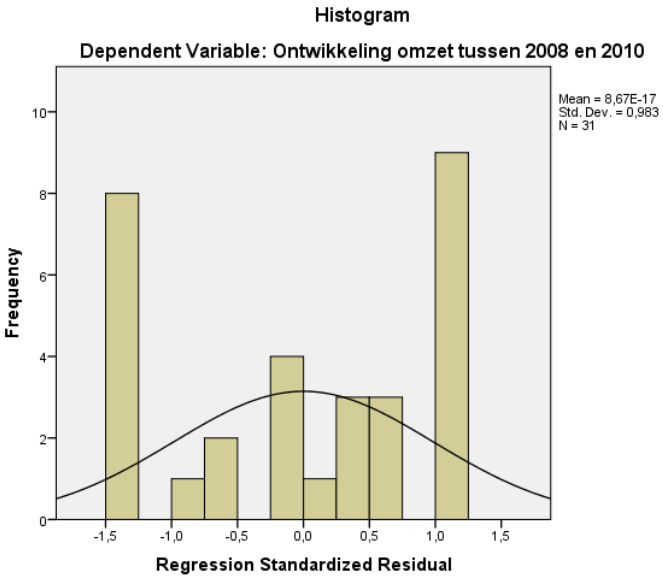
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2,9896	3,2844	3,1613	,06642	31
Residual	-2,23787	1,94570	,00000	1,59229	31
Std. Predicted Value	-2,585	1,853	,000	1,000	31
Std. Residual	-1,382	1,201	,000	,983	31

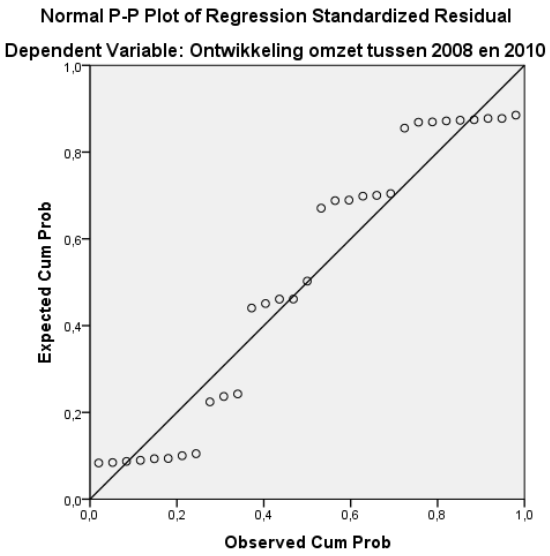
a. Dependent Variable: Ontwikkeling omzet tussen 2008 en 2010

4.4.3. Normally distributed errors ‘omz08_10’

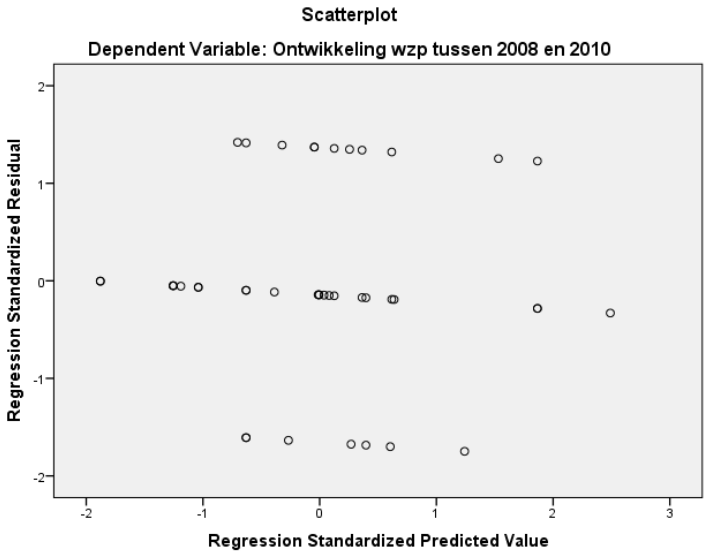
Histogram



P-Plot



4.4.4. Linearity and Homoscedasticity ‘wzp08_10’



4.4.5. Independent errors ‘wzp08_10’

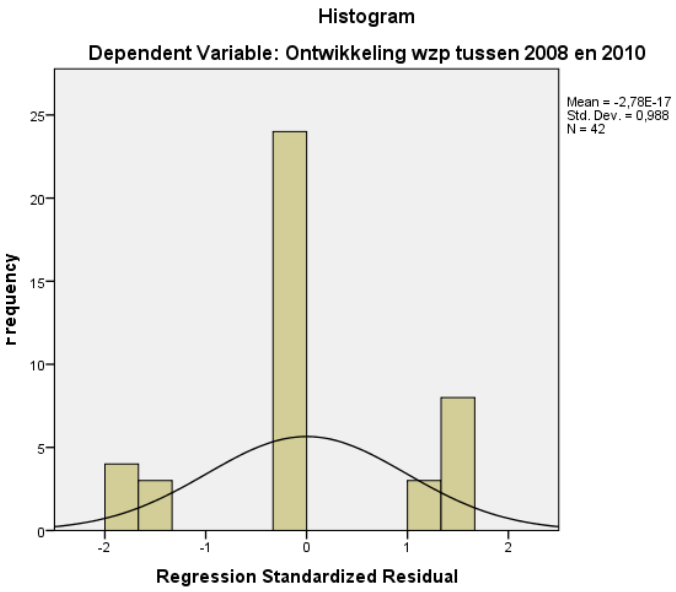
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	,0023	,2184	,0952	,04945	42
Residual	-1,15663	,93954	,00000	,65367	42
Std. Predicted Value	-1,879	2,490	,000	1,000	42
Std. Residual	-1,748	1,420	,000	,988	42

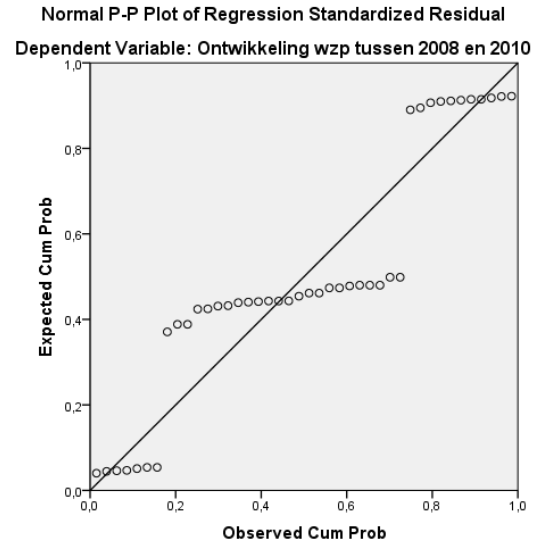
a. Dependent Variable: Ontwikkeling wzp tussen 2008 en 2010

4.4.6. Normally distributed errors ‘wzp08_10’

Histogram



P-Plot



4.4.7. Process output 'omz08_10'

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Release 2.13 ***************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = omz08_10
    X = v11b_h04
    M = pi_08

Statistical Controls:
CONTROL= v7c_04   v15a03ln v11b_04  v11e_h04

Sample size
         31

**************************************************************************
Outcome: pi_08

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,7421      ,5507      ,3768     6,1281     5,0000    25,0000
,0008

Model
              coeff         se          t          p       LLCI       ULCI
constant      ,0540      ,4252      ,1270      ,8999     -,8217      ,9297
v11b_h04     -,1507      ,1793     -,8405      ,4086     -,5200      ,2186
v7c_04        ,2339      ,2867      ,8159      ,4222     -,3565      ,8244
v15a03ln      ,1344      ,1030     1,3042      ,2040     -,0778      ,3466
v11b_04       ,1093      ,1007     1,0853      ,2881     -,0981      ,3166
v11e_h04      ,7335      ,1835     3,9971      ,0005      ,3555     1,1114

**************************************************************************
Outcome: omz08_10

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,6980      ,4873     1,6278     3,8011     6,0000    24,0000
,0084

Model
              coeff         se          t          p       LLCI       ULCI
constant     3,7365      ,8840     4,2269      ,0003     1,9119     5,5610
pi_08        1,5095      ,4157     3,6313      ,0013      ,6515     2,3674
v11b_h04     -,2882      ,3779     -,7628      ,4530    -1,0681      ,4917
v7c_04      -1,5769      ,6037    -2,6120      ,0153    -2,8229     -,3308
v15a03ln     -,1346      ,2213     -,6084      ,5486     -,5914      ,3221
v11b_04      -,2954      ,2141    -1,3795      ,1804     -,7373      ,1465
v11e_h04     -,3024      ,4883     -,6194      ,5415    -1,3102      ,7054

****************** DIRECT AND INDIRECT EFFECTS ************************

Direct effect of X on Y
```

```
     Effect         SE          t          p       LLCI       ULCI
     -,2882      ,3779     -,7628      ,4530    -1,0681      ,4917

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
pi_08     -,2275      ,3129    -1,0241      ,3248

******************** ANALYSIS NOTES AND WARNINGS ************************

Number of bootstrap samples for bias corrected bootstrap confidence
intervals:
     1000

Level of confidence for all confidence intervals in output:
    95,00

NOTE: Some cases were deleted due to missing data.  The number of such
cases was:
  301

NOTE: Some bootstrap samples had to be replaced.  The number of such
replacements was:
  1

------ END MATRIX -----
```

4.4.8. Process output 'wzp08_10'

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Release 2.13 ***************

          Written by Andrew F. Hayes, Ph.D.       www.afhayes.com
    Documentation available in Hayes (2013). www.guilford.com/p/hayes3

**************************************************************************
Model = 4
    Y = wzp08_10
    X = v11b_h04
    M = pi_08

Statistical Controls:
CONTROL= v7c_04   v15a03ln v11b_04  v11e_h04

Sample size
         42

**************************************************************************
Outcome: pi_08

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,5919      ,3504      ,5036     3,8831     5,0000    36,0000
,0065

Model
              coeff         se          t          p       LLCI       ULCI
constant      ,6404      ,4276     1,4975      ,1430     -,2269     1,5077
v11b_h04      ,0130      ,1872      ,0694      ,9451     -,3666      ,3926
v7c_04       -,0553      ,2874     -,1925      ,8484     -,6383      ,5276
```

```
v15a03ln      ,2379      ,0933     2,5509      ,0151      ,0487      ,4270
v11b_04       ,1366      ,1016     1,3451      ,1870     -,0694      ,3427
v11e_h04      ,5550      ,1978     2,8052      ,0081      ,1537      ,9562

**************************************************************************
Outcome: wzp08_10

Model Summary
          R       R-sq        MSE          F        df1        df2
p
      ,4668      ,2179      ,3937     1,6250     6,0000    35,0000
,1695

Model
              coeff         se          t          p       LLCI       ULCI
constant     -,3521      ,3897     -,9033      ,3725    -1,1433      ,4391
pi_08         ,2973      ,1474     2,0171      ,0514     -,0019      ,5965
v11b_h04     -,2422      ,1655    -1,4634      ,1523     -,5782      ,0938
v7c_04        ,0171      ,2543      ,0671      ,9469     -,4992      ,5333
v15a03ln     -,1742      ,0896    -1,9440      ,0600     -,3561      ,0077
v11b_04       ,0537      ,0921      ,5829      ,5637     -,1332      ,2405
v11e_h04     -,0558      ,1931     -,2891      ,7742     -,4479      ,3362

****************** DIRECT AND INDIRECT EFFECTS *************************

Direct effect of X on Y
     Effect         SE          t          p       LLCI       ULCI
     -,2422      ,1655    -1,4634      ,1523     -,5782      ,0938

Indirect effect of X on Y
          Effect    Boot SE   BootLLCI   BootULCI
pi_08      ,0039      ,0705     -,1735      ,1321

****************** ANALYSIS NOTES AND WARNINGS *************************

Number of bootstrap samples for bias corrected bootstrap confidence
intervals:
     1000

Level of confidence for all confidence intervals in output:
    95,00

NOTE: Some cases were deleted due to missing data.  The number of such
cases was:
  290

------ END MATRIX -----
```