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Non-R&D human capital and its effect(s) on product innovation

A RESEARCH ABOUT THE EFFECT(S) OF RBV INTELLECTUAL CAPITAL ON PRODUCT INNOVATION.

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Preface

In front of you lies the thesis 'Non-R&D human capital and its effect(s) on product innovation'. This thesis is written in context of the graduation from the master strategic management at the business administration department from Radboud University Nijmegen. The research has been conducted from February 2022 till June 2022.

In consultation with my supervisor Peter Vaessen, the research question was developed. To answer this research question, a quantitative analysis was carried out. Therefore, I would also like to thank the statistics lecturers of the strategic management master's programme for sharing their knowledge about IBM SPSS Statistics.

I also would like to thank my supervisor and 2nd examiner Stefan Breet for feedback and support. In addition would also like to express my appreciation to the fellow students from my thesis circle for their substantive feedback during the initial stages of the research process. Finally, I would like to thank my friends and family for their moral support during my graduation phase.

I wish you a lot of reading pleasure.

Sharif Tah

Nijmegen, June 13, 2022

Abstract

Innovation is an interesting topic, because firms try to adjust continuous to new developments within their market. A large number of organizations are innovative without having an own R&D-department, while many studies see R&D as the main source of innovation. Therefore, this thesis seeks to explain to what extent the resource-based view (RBV), intellectual capital drive product innovation. The criticism on linear thinking within innovation studies has led to an attempt within this research to investigate interaction effects between RBV intellectual capitals, in order to map whether these interaction effects have a reinforcing effect. Intending to answer the reasearch question, a quantitative study has been conducted. The quantitative analysis contains data from the 2015 European Manufacturing Survey, whereas the survey sample (used for this research) includes 179 Dutch companies from seven different industries. The results have made clear that (non-R&D) human capital has no direct relationship with product innovation, but strengthens the relationship between social capital and product innovation when interacting as a moderator. Moreover, it has been found that organizational capital has no direct relation with product innovation, which is also the case when (non-R&D) human capital is included as moderator. Finally, the research finds that R&D shows a correlation with technological product innovation, but not with non-technological product-service innovation. When (non-R&D) human capital interacts with these relationships, no relationship appears to be present in any of the cases. This research contributes to the knowledge about the relationship between RBV-elements and product innovation through which the innovation of companies without R&D can be partly explained. Follow-up studies are recommended to measure multiple aspects within the RBV intellectual capital and to focus on other interaction effects as not enough is known about this yet. In addition, a mixed-methods analysis would also be recommended, as this method allows to explain some inexplicable findings in the area of the resource-based view and product innovation.

Key words: resource-based view, intellectual capital, (non-R&D) human capital, social capital, organizational capital, R&D, product innovation

1. Introduction

1.1 Description of the problem

Innovation is an essential part of surviving in a dynamic environment, as it offers a competitive advantage despite the environmental change (Hoonsopon & Ruenrom, 2012). Much research has been done in the literature on R&D innovation, but little on non-R&D innovation (Arundel, Hollanders & Huang, 2010). Non-R&D innovation performing' refers to the development of innovation without formal internal or externally contracted R&D activities (Barge-Gil et al., 2011). A significant group of firms develops innovations without performing R&D activities as they do not have the resources to set up an R&D department (Arundel, 2007). Arundel et al (2008) found for example that in the European case about half of innovating firms do no use formal inhouse R&D. A brief look at the Dutch CBS-figures shows that in the Netherlands in 2018 out of 54.130 firms employing 10 or more employees 20.286 were technologically innovative (37%). However, only 10.555 firms (20%) had their own or hired R&D-employees (Centraal Bureau voor de Statistiek, 2020). Nevertheless, many studies use R&D related variables when analysing innovation, while non-R&D has received little attention (Xie et al., 2019). Given the many SMEs that appear to innovate without an R&D-department, the present investigation attempts to contribute to enriching the non-R&D innovation literature by focussing on the innovation potential of ordinary workers. A recent branch in de non-R&D innovation literature is the 'employee driven innovation' (EDI) approach, propelled by Kesting and Ulhøi (2010). This approach focusses on the innovation potential of ordinary employees. Furthermore, in order to move away from single-determinant-innovation-thinking and to broaden the range of potential innovation factors the present investigation makes use of the resource-based view theory (RBV). From this view alternative sources of innovation might be recognized next to or instead of the presence of an R&D-department in a firm. These are: non-R&D human resource capital of a firm as well as its social capital and organizational capital.

A second but connected problem besides the neglect of non-R&D innovation that plagues innovation literature is the dominance of the so called 'linear model of innovation' (Salazar & Holbrook, 2004; Goding 2006): in a chain reaction an (initial) innovation factor autonomously and directly affects another innovation factor finally ending up with a new product. Rothwell (1992, p. 221) summarizes the oversimplification of the linear innovation process. According to Rothwell it was generally assumed that industrial technological innovation was a more or less linear process beginning with scientific discovery, passing through industrial R&D, engineering and manufacturing activities and ending with a marketable new product or process. Rothwell puts in place a different

model. This model developed by Rothwell and Zegveld (1985) is called the interactive model, which stand for a logically sequential, though not necessarily continuous process. This process can be divided into a series of functionally distinct but interacting and interdependent stages. The innovation process can be described as complex net of communication paths, linking together various in-house functions and linking the organization to the broader scientific & technological community and to the marketplace. The interactive model builds on the critique of single-determinant-innovation-thinking by viewing innovation as a process in which different in-house activities interact to create innovation.

1.2 Why RBV as a possible replacement driver for innovation?

The role of human capital on innovation is essential in this research. This variable was chosen because this element stems from the resource-based view theory (RBV). Research has shown that RBV intellectual capital is positively related to product innovation, but there still is a need of exploration of this impact (Subramaniam and Youndt, 2005). There is a knowledge gap, which could be minimized by conducting future research including measuring the separate and interaction impacts of intellectual capital elements on generation and adaption of innovation (Pérez-Luno et al., 2014). Intellectual capital refers to the area of accumulating and exploiting knowledge. The term is also explained as intangible or knowledge assets an organisation can possess (Stewart, 1991). According to Martín-de-Castro et al. (2006), intellectual capital can be divided into: human capital, technological capital, organizational capital, business capital and social capital. It was decided not to include technological capital and business capital, as several studies do not classify these two forms of capital under intellectual capital (Davenport & Prusak, 1998; Nahapiet & Ghoshal, 1998; Schultz, 1961). Another reason for leaving business capital out of consideration is that many elements of it recur within social capital. The omission of technological capital in this study also has to do with the fact that this capital is not just about technology, but also concerns the knowledge that is involved in the techniques. This knowledge is unique and not directly 'buyable' (Teece, 1997). Because of the knowledge element within the capital, a comparison is visible with the human capital element.

The aim of this paper is to analyse exactly what effect the elements of intellectual capital have on product innovation. In addition to the autonomous relationship, it will also be analysed to what extent human capital has an interaction effect on the relationship between possible innovation-stimulating resources and product innovation. The independent variables will consist of human capital, social capital, organizational capital and R&D activities. The first three mentioned stem from the RBV intellectual capital component (Martín-de-Castro et al., 2006). Finally, the R&D variable was chosen as it has already been shown in the existing literature that this has a positive relationship with product innovation (Fonseca, 2014). By selecting the variable, this research could clarify whether the

hiring of R&D staff is sufficient to optimise product innovation or whether the alignment/integration between R&D and non-R&D staff significantly enhances the innovation effect of the department.

1.3 How does the linear thinking criticism manifest itself in the relationship between (non-RD) human capital and innovation?

It is known to this day that companies without an R&D department know how to innovate in their own way. This research will shed light on how non-R&D human capital has an effect on the product innovation in an organization. Product innovation can be interpreted as the introduction of goods and services that are new or significantly improved from their specifications or intended uses (Mothe and Thuc Uyen, 2012). Previous research has been done into the effect of generic training/courses on product innovation. This is an important premise because (generic) training increases human capital according to Vidal Salazar et al. (2017), as these trainings help increase the educational level and experience of its employees and managers. Educating staff may improve their ability to absorb and understand new knowledge in the future, which could be used to develop innovation (Luo et al., 2009). This could be a possible explanation for the positive relationship between human capital and innovation which was found by Subramaniam and Youndt (2005).

However relevant studies show that the results on the relationship between human capital and innovation can be regarded as inconclusive (Vidal Salazar et al., 2017). For example, there have been researchers who have found a positive relationship between training and product innovation (eg, Laursen and Foss, 2003; Shipton et al., 2006; Walsworth and Verma, 2007), but also researchers who were unable to discover a relationship in their analysis (eg, Caloghirou et al., 2004; Sung and Choi, 2014). In addition, there is, for example, the research by Beugelsdijk (2008) that explains that the positive relationship between the two variables is only present during incremental innovations. Moreover, research has also been carried out by Da Saá-Perez (2012), which indicates that a negative effect has even been found between training and innovation performance of small and medium-sized firms. Only in situations where the trainings interact with the knowledge assets of the firm, the researchers found a positive relationship instead of negative. This finding inspires the development of the approach for this study. While apart from testing the autonomous innovation effects of non-R&D human capital, there will also be examined to what extent non-R&D human capital moderates the impact of several organizational resources that possibly may contribute to product innovation autonomously, if not bringing dormant innovation factors to life as it were. By using such a more integrative approach to organizational innovation capabilities, the present study seeks to contribute to unravelling the knowledge problem of mixed findings when it comes to testing the innovation impact of non-R&D workers.

Why this problem deserves research can be seen in the management of organizations. Merely emphasizing R&D innovation can demotivate non-R&D innovation. Due to the lack of knowledge and the little attention it receives, management may think that non-R&D innovation involves an extremely costly and uncertain process that demands large and specific investments (Hervas-Oliver, Garrigos & Gil-Pechuan, 2011). The results of this research may indicate to what extent non-R&D human capital plays a role in innovation-stimulating activities, which were previously thought to be separate from each other. If management has this knowledge, the organization may be better able to value the contribution of this group of employees. In addition, by examining interaction effects, it will become clear how non-R&D can best be used to increase effectiveness in the area of product innovation. Highly educated people usually cost more in wages (Centraal Bureau voor de Statistiek, 2011), therefore it is important for organizations to know in which cases their involvement leads to higher efficiency (in terms of product innovation) and in which cases it does not. Finally, it may motivate organizations to stimulate the development of non-R&D human capital within the organization in order to increase the degree of innovation within the organization.

1.4 How is the problem framed in academic literature?

As has become clear from the previous section, there is no unambiguous result about the influence of non-R&D human capital on (product) innovation. The dominance of the linear model has already been mentioned as the reason why research to date has focused only on the autonomous and direct correlation between R&D (variables) and innovation. The quality of this model can be strongly questioned as there are many companies that manage to innovate without R&D personnel. Within the Employee Driven Innovation (EDI) perspective there is also an idea that certain non-R&D activities result in innovation. Thus, the linear thinking model is also used here with other assumptions. This research wants to distance itself from the linear thinking since practice shows that there are several innovation stimulating factors that are also related to each other (Dost et al., 2016). In order to achieve this, system theory will be used. This holistic way of thinking makes it possible to study phenomena across a range of disciplines. Thus, according to Teece (1997) the theory is necessary: *'.. a proper understanding of a system cannot be reached by studying its components in isolation from one another (reduction)..'*. The system theory therefore focuses on the complementarities among elements, their integration and the outcomes resulting from their interactions (Teece, 1997). In this research, system thinking will be used by not only examining the autonomous relationships but also the interaction (moderation) effects. If the results of this research confirm that linear thinking has had an influence on the different research outcomes and that the new approach (examining interaction effects for the drivers of non-R&D innovation) can explain this, the research may have great scientific relevance. Besides explaining the ambiguity that still exists in the current literature about the relation between RBV elements and innovation, this may motivate future studies to delve into interaction (indirect) effects when studying non-R&D innovation and thus build on the criticism of the dominance of the linear model.

This section will briefly explain what is known about the investigated relationship between potential innovation stimulating factors and product innovation (also while moderated by human capital). These innovation stimulating factors include social- & organizational capital (which stem from the discussed RBV intellectual capital perspective) and R&D activities. Therefore, in this paragraph it will become clear how this research can contribute to the existing literature. For more substantive information about the relationships, see the theoretical framework in Chapter 2.

Non-R&D human capital and product innovation

As the introduction made clear, the studies on (non-R&D) human capital and innovation are not unambiguous. For example, result from research that investigated data from the World Bank's China private manufacturing organization questionnaire survey, indicate that experience is positively related to process innovation, while the educational level has a significantly positive effect on product innovation (Fu et al., 2020). Other research has also shown that human capital elements such as the level of education, experience of key employees, investment in HC have a positive effect on innovation engagement in an organization (Mariz-Perez et al., 2012).

Nevertheless, there are also studies that have not been able to demonstrate a relationship between human capital and innovation (eg, Caloghirou et al., 2004; Sung and Choi, 2014). In addition, there is also research that did not find an autonomous relationship but found correlation only in cases with interaction (effects) between training/courses and the knowledge assets of a firm (Da Saá-Perez, 2012).

First, it will be analysed to what extent an autonomous relationship exists, since the literature cannot offer an unambiguous prediction on this. Then, this report will try to explain the lack of unambiguousness within the literature. As stated before, this will be done by analysing the extent to which interaction effects are determining the correlation within the relationship between non-R&D human capital and the innovation rate. The starting point for this comparison is logically the correlation in autonomous relationship between non-RD human capital and innovation.

Non-R&D human capital, social capital & product innovation

the variable social capital in this study concerns cooperation with external partners (for explanation of operationalisation, see chapter 3). Researchers have indicated that collaboration with external parties has a positive effect on innovation (Brettel & Cleven, 2011). According to research by Cordón-Pozo et al (2017), it can be stated that innovation training courses provided by employers lead to more innovation if there is collaboration with external parties. The combination effect of the three variables is greater than the autonomous relationship between innovation training and innovation (Cordón-Pozo et al., (2017). Based on the discussed data, it could be hypothesised that human capital has a positive effect as moderator on the relationship between collaboration with external partners and product innovation. Yet it is unknown to what extent human capital actually moderates the relationship.

It is reported by other researchers that future studies should be done to point down the effect of the cognitive process on the relationship between collaboration with external parties and innovation (Temel et al., 2021). By means of this research, an attempt will be made to map out to what extent non-R&D human capital moderates this relationship.

Non-R&D human capital, organizational capital & product innovation

The literature shows that there is a positive relationship between organizational capital and innovation (Dost et al., 2016). In addition, it has been shown that the intellectual capital element, social capital, as an interaction effect strengthens the relationship between organizational capital and innovation (Dost et al., 2016). This while human capital in turn increases social capital (Ottósson & Klyver, 2010). It may therefore also be possible that human capital as a moderator itself can strengthen the relationship between organisational capital and innovation.

Until now there is no available information in the existing literature about the interaction effect of the other intellectual capital element, human capital, on the relationship between organizational capital and innovation.

Non-R&D human capital, R&D & product innovation

As it is generally known, R&D activities focus on innovation development. Research shows that R&D activities are an important driver of product innovation, but much less so for process innovation (Hervas-oliver et al., 2021). According to Blackburn et al., (2000) their research it has become clear that R&D activity is driven by human capital accumulation. When human capital grows, the amount of R&D activity increases. In addition, higher human capital also improves the efficiency of manufacturing and expands the possibilities for innovation activities. Literature therefore shows that human capital has a positive effect on R&D activities, while R&D activities have a positive effect on product innovation. It is therefore possible to assume from the literature that there is an indirect positive relationship between human capital and product innovation, but it is not yet clear to what extent human capital had a moderation effect on the relationship between R&D and product innovation. Therefore, this research can contribute to the existing knowledge in this field.

1.5 Objective and research question

Objective

The aim of this research is to develop more clarification on the role of non-R&D human capital in product innovation within companies. The difference in autonomous versus interaction-effect (moderating) will be investigated, therefore an attempt will be made to see whether non-R&D human capital strengthens the relationship between innovation-oriented factors/activities and the actual (technological and non-technological) product innovation degree.

Research question: *To what extent does non-R&D human capital add value to different types of organizational assets for enhancing product innovation in addition to the independent innovation impact of non-R&D human capital?*

Sub questions:

1. To what extent does non-R&D human capital affect product innovation autonomously?

2. To what extent does the intellectual capability of a firm's non-R&D human workforce affect the company's innovation potential from its social network, i.e. social capital?

3. To what extent does the interaction with non-R&D human capital influence the relationship between organizational capital and product innovation?

4. To what extend does the intellectual capability of a firm's non-R&D human workforce affect the product innovation generated by R&D department?

1.6 Outline of the thesis

In the next chapter important theoretical concepts from scientific publications are defined and explained. In addition, based on the acquired knowledge, a hypothesis will also be drawn up, which will be clarified by means of a conceptual model.

The methodology will be discussed in the third chapter of this report. Here is described how the quantitative research was structured, based on sample size, variable construction, various statistical analyses, etc. In the fourth chapter, the execution of the quantitative research will be discussed. The main results will be mapped there, after which a conclusion will be formulated in chapter five based on the obtained research results. This will ultimately result in answering the research question. Chapter six will consider the reflection on the theoretical framework, practical and managerial recommendations, and the limitations of the research. Finally, a bibliography and several appendices will follow (see table of contents for overview).

2. Theoretical framework

The first section of this chapter describes product innovation (dependent variable), while the second section describes the independent variables of RBV. This is followed by an explanatory section 2.3 which focuses on the relationship between RBV and product innovation. Hence, several sections will follow focusing on the findings from the literature regarding the relationship between explanatory factors (independent variables) and the dependent variable product innovation. In addition, it will become clear how the moderator non-R&D human capital may influence these relationships. Based on this information, appropriate hypotheses* will be drawn up, which will finally be visualized by means of a conceptual model.

* *A large proportion of the studies used as literature in this chapter limit their research to innovation in general within an organisation. Hypotheses will therefore be drawn from this data that assume that the innovation findings discussed apply to both technological product innovation and non-technological product innovation, i.e. products-services innovation. The amount of literature that focuses on the relationship between a specific form of product innovation is not sufficient to base a prediction on.*

2.1 Product innovation: different types within the broader innovation landscape

According to Kinkel, Lay and Wengel (2004) there are four types of innovation within organisations. A distinction can be made between technical and non-technical innovation (see figure 1). Schramm (2017) gives more insight about this distinction as he states that technological innovation focusses on the conversion of ideas & knowledge into commercially new and successful products, services and processes. Within the non-technical type, an attempt is made to develop new business methods or new organizational concepts (Schmidt & Rammer, 2007). As discussed in the previous chapter, within this research the focus will be on product level while both technical and non-technical product innovation will be considered as dependent variable. Vandermerwe and Rada (1988, p.314) define non-technical product innovation (product-service innovation) as the increased offering of more complete market packages/bundles based on customer-specific combinations of products, service, support and knowledge. This differs from technical product innovation which deals with the development of new products, new services or new technologies (Armbruster, Kirner and Lay, 2006). According to the same study, product innovation is related to products, while product-service innovation focuses on new or improved

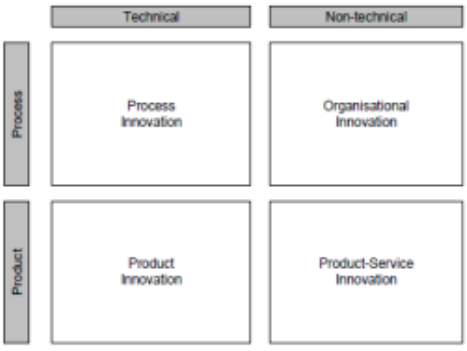

Figure 1: Types of innovation (Armbruster, Kirner, & Lay, 2006), based on Kinkel, Lay and Wengel (2004)

services. A somewhat deeper meaning is given by Mothe and Thuc Uyen (2012), as they define the concept as the introduction of goods and services that are new or significantly improved with respect to their specifications or intended uses. They thus conclude that novelty is not the only requirement for labelling as product innovation.

2.2 Organizational resources: a typological description

Three types of resources determine the firm's capacity to innovate: financial resources, technical resources and intangible resources (Martín-de-Castro et al., 2006). The intangible resources are known for their big impact on strategic value and contain of three components: human capital, social capital, organizational capital (Wright, Dunford, & Snell, 2001; Reed, Lubatkin, & Srinivasan, 2003; Subramaniam & Youndt, 2005). These three forms of capital are the elements of intellectual capital within the RBV, as became clear earlier (Davenport & Prusak, 1998; Nahapiet & Ghoshal, 1998; Schultz, 1961). First will be explained what the intellectual capital terms human capital, social capital and organizational capital mean. Following this, it will be explained what the existing literature says about the autonomous relationship between the intellectual capital elements and innovation.

Human capital plays an essential role in this research. Human capital is understood to mean: the educational level, training, and experience of its employees and managers (Hitt et al., 2001). This capital includes competences and knowledge, which could be explicit or tacit (Bueno et al., 2006). Tacit knowledge is merely based on insights and intuitions, while explicit knowledge is often codified and digitized. Another distinguishing which could be made in human capital is social knowledge and individual knowledge (Bueno et al., 2006). The first one is about the collection of knowledge by society, whereas individual knowledge is about the knowledge collection of an individual. Therefore, individual knowledge is bounded by time. Some research indicates that highly skilled and experienced employees are an important prerequisite in high-level innovative activities because they generate new knowledge and absorb existing knowledge (Luo et al., 2009). The author states that employees who bring in valuable human capital are better able to execute the different phases in the process of absorbing knowledge. According to the literature, there are three main stages that occur in absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2002; Todorova & Durisin, 2007). The first is the recognition stage, where an organization tries to identify valuable external information. This is followed by the assimilation phase, which is concerned with understanding the knowledge and integrating it with the existing knowledge. Finally, there is the phase of exploitation, where it must be able to apply the internalized knowledge commercially, such as by innovating product or services. Successful absorption of knowledge is only achieved once all three phases have been completed. The problem formulation (section 1.2) shows that there is no unambiguous result about the relationship between (non-D&D) human capital and product innovation. Nevertheless,

more studies in the literature appear to claim a positive relationship than a negative or absent relationship. More information about the relationship between human capital and innovation and the possible moderation effect of human capital on innovation-stimulating activities can be found in the following paragraphs.

The second capital element that comes from the RBV is *social capital*. This resource could be described as the value of relationships which are maintained with other social agents and its surrounding (Martín-de-Castro et al., 2006). According to the resource-based view theory not only must a company create knowledge within their boundaries, but they also must try to expose themselves to new ideas and information from their external environment in order to prevent rigidity, to encourage innovative behaviour and to compare their technological developments against those of competitors (Leonard-Barton, 1995). The information that organization subtracts from these relationships enhance the development of product innovation (Carmona-Lavado et al., 2010). Within social capital, two categories can be distinguished (Nahapiet & Ghoshal, 1998). Firstly, structural embeddedness relates to whom and how relationships are established. Secondly, relational embeddedness that describes the type of relationship that people have developed after the history of interactions. Distinguishing between the two categories is important, because both contribute in their own way to the stimulation of innovation. In section 2.4 there is more explanation about the relationship between collaboration with external parties (social capital) and innovation, in addition it will also become clear what effect the literature predicts when human capital is involved as a moderator.

Finally, *organizational capital* is concerned with organizational practices or routines that enable renewal and reorganization of resources, so that changes can be anticipated (Adner and Helfat, 2003; Labrouche, 2014). According to the literature, organizational capability can be divided into two forms: dynamic capabilities and operational capabilities. Zahra (2009) argues that dynamic capability is an essential part of organizational capital. This concept is described by Teece et al. (1997) as the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments. Therefore, dynamic capabilities of an organization determine the organization’s ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions (Leonard-Barton, 1992). Operational capabilities (also referred to as ‘ordinary’) concern the performance of administrative, operational, and governance-related functions, which are needed to accomplish tasks. In addition, Teece (2014) states *'Dynamic capabilities involve higher-level activities that can enable an enterprise to direct its ordinary activities toward high-payoff endeavors. This requires managing, or "orchestrating," the firm's resources to address and shape rapidly changing business environment.’.* The importance of organizational

capability also lies in the fact that organizations can distinguish themselves from competitors on the basis of routines, skills, and complementary assets. With organizational competences, capabilities and routines, imitation is a normally complex (Teece, 1997). The main components/indicators of organizational capital can be described as (Martín-de-Castro et al., 2006): culture, structure, and organizational learning. Organizational culture is defined as the set of beliefs, values, assumptions and symbols that define the business. The organizational structure is the set of means and processes devoted to the formal organization of the company (CIC, 2003). The traditional form of an organization is based on structures focused to control, designed with the goal to improve the use of physical resources (Chandler, 1962).

Furthermore, organizational learning represents the ability of the organization to acquire new knowledge and competencies with the goal of using this to successfully react to change dynamics and organizational development (CIC, 2003). Organizational learning is used to manage and mobilize the firm's resources in a competitive response (Jashapara, 1993). It can therefore be concluded that organizational learning is necessary for the use of dynamic capabilities. Organizational resources are more valuable when the components of the company fit to the environment through knowledge acquisition, information distribution and organizational memory (Huber, 1991). Thus, based on the information discussed, it can be summarised that the essence of organisational capital lies in the organisational practices or routines that enable renewal or reorganisation of resources (Adner and Helfat, 2003; Labrouche, 2014). These organisational practices or routines are necessary to respond to trends and, according to the RBV perspective, have a positive impact on innovation, yet it is unclear what this impact looks like exactly (Subramaniam and Youndt, 2005).

This section has clarified what the elements of RBV (intellectual capital) entail. In addition, limited information has been given on the autonomous relationship between human capital, social capital, organizational capital and product innovation. The descriptive definition is necessary to understand and demarcate the concepts. It is also necessary to guarantee unambiguity in terms of meanings.

2.3 Organizational resources: RBV and its link to innovation

The resource-based view theory (RBV) argues that resources endowments are heterogeneously divided among firms which explains the different firm performances of competitors. In addition, the theory states that owning or controlling superior resources allows the firm to sustain competitive advantage (Martín-de-Castro et al., 2006). An important condition for this advantage is that firms' resources and capabilities are characterized by the fact that they are hard to imitate, while market failure exist (Lipmann & Rumelt, 1982; Barney, 1986, 1991; Grant, 1991; Peteraf, 1993; Priem & Butler, 2001). Barney (1991) distinguished different resources, firstly there are resources which are rare and valuable and therefore lead to competitive advantage. Secondly there are resources which are similar but hard to imitate, irreplaceable and difficult to transfer, which provide a sustainable competitive advantage. Besides to the well-known relationship with sustainable competitive advantage, research has shown that RBV is also related to innovation. Several studies have shown that there is a direct positive relationship between RBV and innovation (Martín-de-Castro et al., 2006). Do et al. (2022) recently concluded that developing internal resources (elements from the RBV) are positively related to organizational resilience, which in turn has a stimulating effect on innovation (Do et al., 2022). This means that RBV has both direct and indirect influence on the innovation rate of an organization. However, there are also voices within the same research area that could not demonstrate a correlation (eg, Caloghirou et al., 2004; Sung and Choi, 2014). A possible reason for this is that certain interaction effects have such a significant influence on the stimulation of innovation, while these influences have often not been taken into account within studies in the field. Thus, the current RBV literature could be enriched by the use of holistic thinking through system theory. Therefore, the lack of clarity within the literature will be attempted to be clarified by contrasting interaction effects between various RBV intellectual capital with the autonomous relationship between human capital and product innovation.

2.3.1 Is human capital (autonomous) really the driver for more product innovation?

According to Subramaniam and Youndt (2005), R&D human capital can be understood to mean: knowledge, skills and abilities residing and used by individuals. Within this study, individuals are defined as Resource & Development department employees. The opposite will therefore be the meaning for non-R&D human capital: knowledge, skills and abilities residing and used by employees who are not active in the Resource & Development department.

Schultz (1961) and Becker (1964) developed the human capital theory where they suggest that education enhances a person's skill and therefore it increases their human capital. Also, the level of human capital determines the production capacity according to their theory. The literature not

only points to an increase in productivity, research by Romer (1990) also shows that innovations are generated by human capital stock. Blackburn et al. (2000) state that it is very important to maximize the accumulation of skills and knowledge, since in its absence there is a greater competition for the fixed stock of human capital, resulting in disappearing incentives that stimulate innovation.

However, several studies claim that in order to stimulate innovation development organisations should invest in highly educated workforce and experienced managers (Becker 1994; Vinding 2006), but also in strategic human resource (HR) practices aimed at developing human capital by increasing employees' firm-specific technical skills and competences (Youndt and Snell 2004; Subramaniam and Youndt 2005). The main finding of Capozza & Divella (2018) is that education level does have a positive effect on product innovation development, but not on process innovation. In addition, they point out that HR practices that aim at fostering employees' learning and autonomy within the organization is more important than the educational attainment of workers. Only when all these factors are present will there be a significant increase in the degree of innovation within an organisation. This shows once again that the linear model non-R&D human capital -> innovation engagement, does not hold.

The researchers Nazarov & Akhmedjonov (2012) found and important addition to the current literature about human capital and an increase in the innovation engagement within organisations. They firstly state that training provided by firms (on-the-job-learning) is a stronger driving force for innovation than formal higher (university) education. Secondly they conclude that an increase in the fraction of labour force with tertiary education in a given country does not translate into a significant increase in participation in the majority of innovation activities (Nazarov & Akhmedjonov, 2012). Unfortunately, the study does not provide a substantive explanation for the research findings.

Based on the criticism of the linear thinking model, the expectation is that non-R&D human capital (autonomous) does not provide a strong explanatory power for product innovation. This requires interaction between multiple innovation-enhancing variables. Taken in to account the discussed literature, the following hypotheses were formulated.

Hypothesis 1: The level of a company's non-R&D human capital has no direct correlation with the engagement in technological product innovation.

Hypothesis 2: The level of a company's non-R&D human capital has no direct correlation with the engagement in non-technological product innovation, i.e. products-services innovation

2.3.2 Social capital and product innovation while moderated by non-R&D human capital

Moran (2005) has researched the effect of social capital on innovation. He concludes, for example, that the relational embeddedness element of social capital ensures that people within an organization encourage each other's innovation ideas. As a result, the innovation-covering actor gains the necessary confidence to continue the innovation. Nijssen and frambach (2000) have the same claim as Cooper & Kleinschmidt (1991) that interaction between different departments is a determinant factor of product innovation. Despite critics from a systems perspective upon the autonomous effect of perceived single innovators, some interesting findings have been found in the existing literature, which report that social capital influences firms' innovation by supporting creativity and inspiring new knowledge and ideas (Aragón-Correa, García-Morales, & Crodón-Pozo, 2007; Calantone , Cavusgil, & Zhao, 2002; Hult, 2002; Hult, Hurley, & Knight, 2004; Lu & Shyan, 2004; Song & Thieme, 2006).

R&D human capital plays an important role in innovation novelty through partially mediating the relationship between alliance partner and firm innovation performance (Garcia Martinez et al., 2017). Researchers Vavra, Sein & Vohralik (2020) make it clear that countries from Central and Eastern Europe are more likely to achieve less innovation as a result of collaboration because they are often burdened by insufficient absorption capacity. According to previous research of Najafi-Tavani, et al., (2018) absorptive capacity determines the success of using collaborative innovation network to develop product innovation capability. Their research investigated 258 respondents from Iranian high and medium tech manufacturing industries. They found out that absorptive capacity plays an essential role in collaborations that purpose the goal of innovation. The results of the research of Najafi-Tavani, et al., (2018) indicate that an organization needs to have managers that have developed the capacity to scan and acquire external knowledge. Besides that, the research shows that in presence of absorptive capacity, product innovation capabilities are only stimulated by cooperating with research organizations and competitors, while for process innovation capability cooperation with research organizations and suppliers are needed.

Also, according to several other studies, it can be concluded that absorptive capacity is an important dynamic capability that makes it possible for organizations to successfully use externally obtained knowledge for innovation purposes (Cohen & Levinthal, 1990; Zahra & George, 2002; Lane, Koka, & Pathak, 2006). Zahra & George (2002) state that external information sources are better utilised by absorptive capacity, because this capacity ensures that potential information acquisition is transformed more effectively, thereby increasing exploitation. The value of the information obtained

is thus higher, which has a positive effect on both strategic flexibility and innovation within an organisation. As stated earlier Luo et al (2009) explains that human capital stimulates absorptive capacity, which seems to be an important determinant for successfully using collaboration with external partners to develop product innovation. Therefore, based on the mentioned literature the following hypotheses are formulated:

Hypothesis 3: The greater the non-R&D human capital of an organization, the greater the contribution of its collaboration partners to technological product innovation.

Hypothesis 4: The greater the non-R&D human capital of an organization, the greater the contribution of its collaboration partners to non-technological product innovation.

2.3.3 Organizational capital and product innovation while moderated by non-R&D human capital

From the second section of this chapter, it has become clear that multiple research claim that dynamic capability (organisational capital element) has a positive relationship with innovation (Leonard-Barton, 1992). Also mentioned earlier, organisational learning is an important precondition for dynamic capability (Jashapara, 1993). The presence of human capital means that there are highly educated people employed. To be highly educated, you need to have a certain ability to learn. Based on this, the assumption is made that human capital will strengthen the relationship between dynamic capabilities (organizational capital) and innovation when the variable is present as interaction effect.

There are studies that support the critique on the linear thinking and claim there is no relationship between the variable's organizational capital and product innovation. For example, research by Carmona-Lavado et al. (2010) has shown that they cannot find a direct relationship between organizational capital and product innovation. The research found that organizational capital has a positive effect on social capital, while social capital has a positive effect on product innovation. Thus, these findings can only confirm an indirect relationship.

However, according to the RBV perspective, there appears to be a direct (positive) relationship between organisational capital and the degree of innovation but more needs to be known about the exact nature of the relationship (Subramaniam and Youndt, 2005). In contrast to the research of Carmona-Lavado et al. (2010) there are also studies that have found a relationship between organizational capital and innovation (Dost et al., 2016), which confirms the effect of RBV element on product innovation.

Research on intellectual capital shows that social capital has a positive interaction effect on organizational capital and innovation (Dost et al., 2016). 318 respondents who are active as chemical firms were used for this study. This study used multiple regression analysis to analyse the influence of intellectual capital elements on innovation generation & adaption. What makes this finding interesting for this study is that human capital apparently reinforces the intensity of social capital (Ottósson & Klyver, 2010). It is unclear whether human capital only positively effects the moderator social capital within the relation between organizational capital and innovation, or whether human capital also causes a positive interaction effect as a moderator variable itself. It is, of course, also possible that this indirect interaction effect is not reciprocated, but the reasoning that organisational learning is better performed when human capital is higher and therefore increases dynamic

capability (organizational capital element which is used for innovation) is leading within the development of the following hypotheses:

Hypothesis 5: Non-R&D human capital has a positive (moderation) effect on the relationship between organizational capital and product innovation.

Hypothesis 6: Non-R&D human capital has a positive (moderation) effect on the relationship between organizational capital and product-service innovation.

2.3.4 R&D and product innovation while moderated by non-R&D human capital

As mentioned in the scope of the research, R&D logically has a relationship with (product) innovation. By selecting R&D as a variable, this research could clarify whether the hiring of R&D staff is sufficient to optimise product innovation or whether the alignment/integration between R&D and non-R&D staff significantly enhances the innovation effect of the department. This section therefore describes the assumptions arising from the existing literature on R&D, (product) innovation and human capital.

Fonseca (2014) argues that organizations that make use of more R&D activities and advanced capital are more likely to conduct product and process innovation. Research has also previously shown that human capital within a company has a stimulating effect on R&D activities, but also that the use of R&D increases human capital (Cohen & Levinthal, 1990). The current investigation instead argues for the reverse relationship: the level of non-R&D Human capital affects the integration in and interaction of the R&D department with the rest of the organization and hence moderates the relationship between R&D and product innovation positively. Apart from this data, there is also the assumption that when an organization has a lot of valuable human capital, it also has better absorptive capacity (Luo, 2009). This would mean that they would be better able to provide R&D with feedback, since they are better able to interpret new information (including trends, for example), distinguishing importance within information and integrate it with existing knowledge (Cohen & Levinthal, 1990; Zahra & George, 2002; Todorova & Durisin, 2007). Therefore, the assumption that employees, who are not employed in the R&D field, could provide qualitatively better input/feedback which stimulate product innovation when possessing absorptive capacity.

Lee et al (2005) conclude in their paper that human capital (education, training and work experience) has an impact on R&D outcomes. They argue that controlling for gender and type of industry, the regression analysis shows that individual educational level has a positive effect on product improvements. The research shows that education is the most important human capital

determinant of R&D outcomes, while training also has a positive effect, albeit slightly less strongly. Finally, the positive relationship with R&D outcomes does not apply to years of experience. It appears that a negative relationship has been found here, which according to the research can be explained by the fact that individuals find it difficult to view problems from new perspectives, which limits new scientific breakthroughs. Based on the discussed literature, the following hypothesis are formulated:

Hypothesis 7: Non-R&D human capital has a positive (moderation) effect on the relationship between R&D and product innovation.

Hypothesis 8: Non-R&D human capital has a positive (moderation) effect on the relationship between R&D and product-service innovation.

2.4 Conceptual model

Below the conceptual model of this research, reflecting the expected effects on the basis of the developed hypotheses. The green lines represent an expected positive interaction effect, while the red line represent the opposite expectation: negative (autonomous) correlation. The numbers in the model represent the relationship with formulated sub-questions formulated in section 1.5.

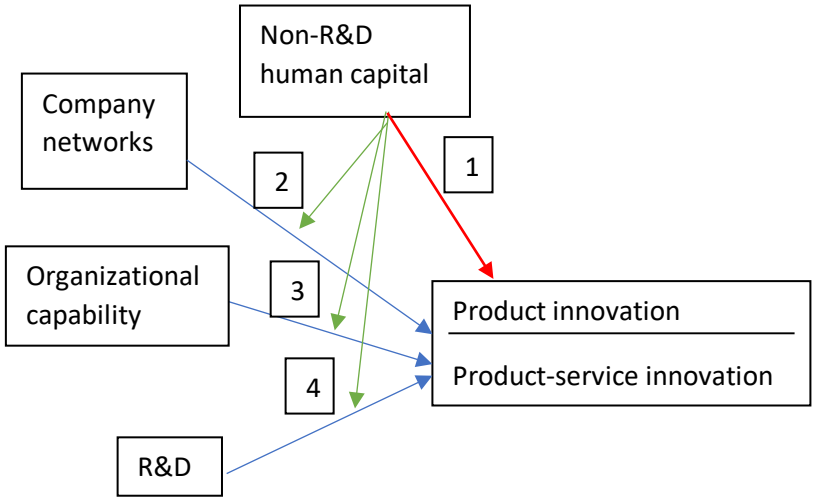

Figure 2: Overview of the expected relationship

3 Methodology

In this chapter, the research method will first be described, after this section it will become clear how the research unit is established. The operationalization is made visible below by means of a table. After that, the validity and reliability measures taken will be discussed. Finally, it will be explained how ethics are safeguarded within this research.

3.1 Research method

For this research a quantitative study is executed by using the European Manufacturing Survey (EMS). This survey was developed by a consortium of universities and other research institutes from 15 different European countries. The consortium is coordinated by the German Fraunhofer Institute in Karlsruhe, which conducts a survey every three years among industrial companies. The RU is part of this consortium and sends the questionnaire to all Dutch industrial establishments employing at least 10 employees. The questionnaire itself concerns the year 2015, but the data collection dates from October 10, 2016. The survey sample (used for this research) contains of 179 Dutch companies from seven different industries.

The data resulting from the EMS questionnaire served to gain insight into the efforts of industrial companies in the Netherlands to modernize their production and business processes. Only organizations with at least 10 employees were eligible as respondents. This data will be used during field research as the presence of RBV perspectives (intellectual capital) and R&D are identified, while data regarding the involvement in both product innovation and product-service innovation will also emerged. This makes the dataset sufficient to answer both the sub-questions and research question.

3.2 Validity and reliability

In order to guarantee internal validity, detailed research was conducted, pilot surveys were conducted and international meetings (involving representatives of 15 countries) were held to discuss the formulation of the questions. The questionnaire was initially written in English, several translation checks were also performed during the translation. Other action points have been compiled for the external validity. Firstly, the benchmark reports are provided free of charge, allowing companies to compare themselves on the basis of various indicators. In addition, several reminders were sent to the organizations. To ensure reliability, questions have been asked about practices, which do not elicit answers based on opinions. The questions concern objective data: facts, investments and performance figures.

3.3 Analysis method

SPSS data analysis software will be used for analysis. First, as made clear in the conceptual model, the autonomous relationship between the independent variables and dependent variable will be investigated by means of Pearson r correlation coefficient when the variables are at metric measurement level. In case items of ordinal scale are used, the Spearman's correlation coefficient will be conducted. A correlation coefficient of 0.70 or higher indicates a high correlation. Below that, there is moderate correlation, while a correlation coefficient below 0.50 indicates a weak relationship. A scatter plot will be shown after the analysis for an overview. This will show whether the relationship developed positively or negatively. A condition for the reliability of the relationship is the p-value, which must be $p \leq 0.05$ at all times.

After the autonomous relationships have been made visible, an attempt will be made to demonstrate the possible moderation effect of human capital. This will be done using the binary logistic regression analysis function within SPSS. In this study, a regression with interaction will be examined, so therefore the formula looks like this: $\hat{y} = b0 + b1X1 + b2X2 + b3X1X2 + u$

In this formula, bo,b1,b2,b3 all stand for regression coefficients, this means 'b' shows the mean increase in 'ŷ 'when the explanatory variable 'X' increases by 1 unit. The 'X 'values indicates the independent variables. The 'u' stands for the error which indicates which part of the dependent variables cannot be explained by the moderating variable (Field, 2018). Within SPSS regression analysis, the 'R Squared' from the model summary indicates how much of the variance in the dependent variable is explained by the explanatory variables, while the 'F' value from the Anova output test indicates the significance of the regression model. Also, in this analysis it holds that $p \leq 0.05$ to speak of a significant result (Field, 2018).

3.4 Operationalization table

This section is dedicated to the operationalisation table that has been developed. The survey questions were selected because the previously discussed literature indicated that they are related to the variables. The operationalization table consists of the columns: variable type, variable name, item, min/max, measurement level and comments. The item refers to the question number from the EMS questionnaire which can be found in Appendix 1. See appendix II for the table of operationalization.

3.5 Research ethics

In order to guarantee an ethically responsible research the scientific integrity, the five principles of the Dutch Code of Conduct for Scientific Integrity (Nederlandse Gedragscode Wetenschappelijke Integriteit - EASY, 2018) have been maintained. These principles consist of honesty, diligence, transparency, independence and responsibility. The first component is characterized by the fact that formulated results and claims are correct. Diligence can be seen in the fact that research has been carefully conducted and reported. Transparency is supported by enabling research to replicate or reproduce. The independence will be exempt from the fact that the research will not be guided by scientific considerations or wishes of arbitrary organisations/parties. Finally, the responsibility will emerge when describing the social/scientific relevance.

4. Results quantitative research

4.1 Introduction

This chapter contains of multiple analysis. Firstly, a description of the response data will follow. The previous chapter already provided information about the firms included in the EMS, but this section will show the firm sizes and how the companies are distributed across the various industries. After this section, the operationalisation table is built upon. The focus in this section is on how the variables are constructed. Once the construction of the variables is clear, the univariate analysis is discussed. Here, information is provided on the variables, including descriptive insight into the extent to which characteristics of businesses occur in the used EMS 2015 data set. This is logically followed by the bivariate analysis, in which an attempt is made to check the multicollinearity by means of a correlation table. Finally, the multivariate analysis is in the chapter. It describes the extent to which non-R&D human capital affects the relationship between innovation-promoting activities and product innovation. This will be done by means of a (binary) logistic regression analysis since product innovation consists of two dichotomous dependent variables.

4.2 Response data

The acquired data of the EMS consist of 177 respondents (N=149). The mode is the second group: 20 to 49 employees. Table 1 also indicates that more than 60% of the companies have less than 50 employees. Only 13% of the respondents have more than 100 employees. The histogram reveals a left sided skewness, which also shows that there a more small companies (based on the number of employees), than big companies.

Table 1. Overview firm size

	Frequency	Percent	Valid percent	Cumulative percent
Less than 20 employees	37	20,9%	20,9%	20,9%
20 to 49 employees	74	41,8%	41,8%	62,7%
50 to 99 employees	43	24,3%	24,3%	87,0%
100 to 249 employees	19	10,7%	10,7%	97,7%
250 or more employees	4	2,3%	2,3%	100,0%
Total:	177	100,0	100,0	100,0

An important condition for the research population is the minimum number of employees. After inspecting the frequency analysis, it can be concluded all companies meet the requirements, as no organization has less than ten people working within the business. This means no respondents had to be excluded from the data file.

Another important requirement is the type of industry the organisations operate in. The EMS targets respondents from seven industries: metals and metal products, food beverages and tobacco, textiles leather & paper and board, construction & furniture, chemicals (energy and non-energy), machinery & equipment transport, electrical and optical equipment. Within the dataset, there are 2 organisations that provide a missing value, thus they are deleted. This is in order to protect the representativeness of the data set. The exclusion of the two respondents means the total data set has a N of 175 (N=175), which will be used during the analysis in this report.

Table 2. Overview industry

Industry	Frequency	Percentage
Metals and metal products	37	21,1%
Food, beverages and Tobacco	18	10,3%
Textiles, Leather, Paper and Board	22	12,4%
Construction, Furniture	13	7,3%
Chemicals (energy and non-energy)	22	12,4,4%
Machinery, Equipment Transport	31	17,5%
Electrical and Optical equipment	32	18,1%

In the table above there is an overview of the industries the companies operate in. As visible, the most organisations belong to the metal industry, followed by the electrical and optical equipment industry. This is somewhat striking since, according to CBS (2014), the metal sector is not the largest compared to the other 6 industries involved. According to their report, the construction industry is the largest, while it has the least number of respondents. The second least represented group is the food industry, while CBS (2014) reports that this is the third largest industry in reality. These are some of the findings that need to be mapped to reflect representativeness. However, all the other industries are well represented.

4.3 Variable construction

In this paragraph the construction of the variables is described. The same sequence is used as the operationalization table (see figure 3, chapter 3) therefore the dependent variables are first described.

4.3.1 Construction dependent variables

The dependent variable within this report is product innovation which contains of technological product innovation and non-technological product innovation, i.e. products-services innovation.

Technological product innovation

This variable is tested by one question (9.1) from the EMS questionnaire. The question is as follow: 'Has your company introduced products that were new to your company or were technically significantly updated since 2012?'. The question indicates that this concerns a dichotomous variable, cause the respondent can either answer by yes or no.

Non-technological product innovation, i.e. products-services innovation

There is a specific question (10.3) within the EMS questionnaire that represents this variable. It asks whether the company has added any completely new (or significantly improved) product-related services since 2012. Again, this is a dichotomous yes or no question.

4.3.2 Construction of the explanatory variables

1. (Non-R&D) human capital

For this variable only one item is used, which focusses on the educational level of employees (15.1) is used. The presence of human capital within organizations is determined by the part of the workforce that possess over a graduate degree or PhD qualification level. Because the question in the EMS asks about the percentage of personnel graduated at certain levels, it concerns a ratio/interval variable. Excluding the R&D human capital will be done by including the R&D personnel as a control variable.

2. Social capital

This variable consists of six items as the cooperation is tested on different fields: Purchasing co-operation, Production co-operation, Sales/distribution co-operation, Service co-operation, R&D co-operation with customers or suppliers and R&D co-operation with research organizations or research entities. The cooperation in the field of these business units is reflected in question 6.1 of the EMS questionnaire. The question was answered with yes or no by the respondents. In this research, it will be counted how many collaborations organizations enter into. The maximum score is therefore six, for the number (of types) of collaborations that the organization enters into.

3. Organizational capital

The conditions for selecting the items that are representative of organisational capital emerged from the theoretical framework and are as follows: they should contribute to the alignment of departments within the organisation, they help to deploy resources more effectively, they contribute to organisational learning. Organizational capital consists of several dimensions that have their own items. The first dimension concerns the organization of work, which is related to the following items: requirements for the workplace layout of equipment and storage of intermediate products (3.1), standardized and detailed working instruction (3.2), Production worker task enrichment (3.3).

The second dimension is the organisation of production, which contains the items: measures to improve internal logistics (3.4) and Methods prescribed for reducing changeover and lead times during product changeover (3.7). The third-dimension concerns production management/control which is tested via the items: graphical representation of work processes and status (3.8) and methods of continuous improvement (3.11). The last item is of the dimension Human resource management within EMS: measures for retaining older workers on their knowledge for your business establishment (3.15). All these questions belong to the dichotomous category as they were only answered with yes or no. The sum of all item determines the level of organizational capital for respondents within this research.

4. R&D employment

This variable consists of one item: the percentage of workforce which belong to the R&D department. Question 15.1 from the EMS provides this research with a distribution of personnel among various departments. The percentage of R&D personnel will make this variable representative. Logically, this is a ratio/interval variable.

4.4.3 Construction moderating variable

1. (Non-R&D) human capital

For this variable only one item is used, which focusses on the educational level of employees (15.1) is used. The presence of human capital within organizations is determined by the part of the workforce that possess over a graduate degree or PhD qualification level. Because the question in the EMS asks about the percentage of personnel graduated at certain levels, it concerns a ratio/interval variable. Excluding the R&D human capital will be done by including the R&D personnel as a control variable.

4.4.4 Construction control variable

1. R&D employment

   This variable consists of one item: the percentage of workforce which belong to the R&D department. Question 15.1 from the EMS provides this research with a distribution of personnel among various departments. The percentage of R&D personnel will make this variable representative. Logically, this is a ratio/interval variable.

4.4 Univariate analysis

This paragraph provides an overview of the used variables within the analysis. These variables will be described via: mean, median, mode, standard deviation (sd), min/max, kurtosis and skewness. See table 3 below for an overview of the variables and their different values.

Table 3. Overview univariate analysis

Variable	Mean	Median	Mode	Sd	Min	Max	Kurtosis	Skewness
Human capital	16,21	10,00	10,00	14,66	0,00	80,00	4,59	2,03
Social capital	2,41	2,00	3,00	1,72	0,00	6,00	-1,12	0,11
Organizational capital	4,31	4,00	5,00	2,20	0,00	8,00	-0,95	-0,19
R&D	5,51	5,00	0,00	5,75	0,00	25,00	1,01	1,25
Product innovation	0,61	1,00	1,00	0,49	0,00	1,00	-1,80	-0,46
Product-service innovation	0,25	0,00	0,00	0,44	0,00	1,00	-0,67	1,16

This research includes two dependent variables, both variables were answered by yes or no, therefore the maximum score one is listed in the table. The mean of the first dependent variable is 0.61 which shows more organization have introduced new product (or significant improvements to their products) than not. See table 4 below for frequencies.

Table 4. Frequency table product innovation

	Frequency	Valid percentage
0 - no	68	38,4%
1,0 - yes	109	61,6%
Total	177	100,0%

This is the other way around for the second dependent variable product-service innovation, as this variable has a mean of 0,25 indicating that less organizations innovated in the area of product-service. The frequency table 5 below shows that not all 177 respondents answered this question. There are 34 organizations that did not answer this question, what caused missing values. These cases are excluded, to ensure the representativeness of the univariate analysis. Both dependent variables have a low standard deviation, which means that the data is closely clustered around the mean. This can be explained by the small range between minimum and maximum score.

Table 5. Frequency table radical product innovation

	Frequency	Valid percentage
0 - no	113	74,8%
1,0 - yes	38	25,2%
Total	128	100,0%

The explanatory variables in this analysis consist of human capital, social capital, organizational capital and R&D. What is immediately striking about the univariate analysis of these variables is the kurtosis and skewness of human capital. This variable serves as both a dependent variable and moderator variable in this study (see figure 2: conceptual model, for overview). Field (2018) states that all variables used should have a kurtosis and skewness between -3 and 3. This is not the case with human capital as this variable has a kurtosis of 4,59 and skewness of 2,03. The high kurtosis demonstrates the lack of symmetry, which should be solved. According to Field (2018) trial and error should be used to determine the most appropriate transformation. The following transformation were performed: log transformation, reciprocal transformation and square root transformation. The reciprocal made the kurtosis worse, while the other two options improved the kurtosis and skewness. However, the squared root transformation was chosen as this provided more desirable values. See the new values below in table 6.

Table 6. Skewness and kurtosis human capital

	Skewness	Kurtosis
Old value	2,025	4,604
New value HC_squareroot	,516	1,024

Table 3 also reveals that human capital is the only variable that needs transformation, since the kurtosis and skewness of the other variables are at acceptable levels. The variable R&D is used as dependent variable as well as controlling variable, as the goal is not to test the effect of human capital but non-R&D human capital on product innovation. Table 3 shows that the company with relatively the largest RD department, has about 25% of the entire staff working in this department. The average is just a lot lower at around 5.5%. For organization capital, eight items were measured to calculate presence. The univariate results show that on average organizations possess over more than four organizational capital elements. For social capital, the EMS measures how many types of collaborations the organizations engage in. EMS distinguishes between 6 types of collaborations, table 3 shows afterwards that the mean is 2.41. This means that on average organizations make use of less than half of the possible collaborations.

4.5 Bivariate analysis

This paragraph is used to investigate the level of multicollinearity. The goal is to demonstrate that the explanatory variables correlate with the dependent variable and not with each other. First of all, the criteria that needs to be checked is the normality. This study included 175 observation, therefore according to Field (2018) it can be stated that the sample size is relatively large. This means the central limit theorem helps overcoming the issues regarding normality.

To make possible multicollinearity visible, the Pearson correlation test has been conducted. The values that are higher than 0,85 indicate multicollinearity (Field, 2018). Appendix III displays an overview of the Pearson correlation values of all the variables within this research. As can be seen, no value surpasses the critical value of 0,85. The highest value is between social capital and organizational capital, estimated at 0.34** and thus still acceptable. This means the R-values in this research, show that collinearity has little threat to the model estimates.

Besides indicating the level of multicollinearity, the bivariate analysis shows some information about the relationships that may were expected because of the literature. According to Field (2018), an R-value of +/- 0.1 demonstrates a small effect, +/- 0,3 is a medium effect, while +/- 0.5 means a large effect. What is immediately striking is Product innovation seems to have a significant (low/medium) relationship with half of the dependent variables, while product-service innovation only has one significant (medium). It appears that social capital has a medium strong relationship with both dependent variables.

Hypotheses 1 and 2 state that (non-R&D) human capital has no direct relationship with product innovation and product service innovation, the R-values seem to confirm this somewhat. Thus, both R-values are very low and not significant, but it should be mentioned that here only the effects of human capital in general are tested. This relationship has not been controlled by R&D, this will be included in the next section. Appendix III shows that human capital and R&D have an R-value of 0.33**. This means that logically there is a significant relationship between companies with high human capital and companies that have R&D personnel available. It might be expected that the included human capital of R&D would ensure high significant R-value in product and product service innovation. Thus, this is not the case. Human capital, in addition to R&D, appears to correlate with social capital, but not with organizational capital. This is contrary to expectations, as these are both elements of intellectual capital. Finally, it is also notable that R&D does have a significant (low/medium) relationship with product innovation, but shows no relationship with product service innovation.

It can be concluded that this section confirms that some explanatory variables are related to the dependent variables and that the explanatory variables do not exhibit multicollinearity. In the next section, it will become clear whether the moderator non-RD human capital can significantly strengthen the examined relationships so that the hypothesis can be assessed.

4.6 Multivariate analysis

In this paragraph a binary regression analysis will be conducted. There is made use of multiple analysis, as the first analysis will be with the control variable and dependent variable. R&D is used as a control variable because the research attempts to measure the effect of non-R&D human capital rather than human capital as a whole. In addition, an attempt is made to see how this capital influences the relationship between social capital, organizational capital and product innovation. The second analysis will contain dependent variables while being controlled (autonomous). The third analysis will also include the interaction variables while being controlled. Thus, both dependent variables will have three different analysis. Before examining the results of the analysis, a few assumptions should be checked before.

There are six assumptions in total for performing a binary logistic regression (Field, 2018). The first assumptions concern the dependent variables, as they should be of nominal level. The assumption is met as both dependent variables in this research are dichotomous variables. The second assumption states that at least one independent variable should be of continuous, ordinal or nominal measurement level. This assumption is also met, as this research has four independent variables of nominal and continuous measurement level.

The third assumption concerns the independence of observations and demands that dependent variable contains categories that are mutually exhaustive and exclusive, which is the case within this research. The fourth assumptions refer to the multicollinearity. Results are presented in Appendix IV, which shows that the assumption is met. According to Field (2018) the VIF should not be bigger than 10 and the tolerance should be as close to 1 as possible. The Appendix IV, demonstrates that all VIF values are between 1,13 and 1,18, while the tolerance levels are all between 0,85 and 1. The fifth assumption concern the linearity, as the assumptions states that there needs to be a linear relationship between the continuous independent variables and the dependent variable, that is logit transformed. Field (2018) suggests that the assumption is met when the values of interaction are higher than 0.05. As can be seen in Appendix IV, almost all variables fulfil the requirements. Only the interaction effect human capital * social capital displays a value below 0,05 as it contains a value of 0,03 regarding the relation with dependent variable product-service innovation.

In order to overcome the violation of the assumption, the log variable of the interaction variable will be taken into the analysis, as this variable shows a value of 0,36 which is acceptable according to the requirements. Finally, the last assumption refers to the presence of outliners. Looking at the Appendix IV the partial regression plots, demonstrate that there are no outliners with high values which can influence the analysis. Therefore, it can be concluded that all assumptions are met.

Dependent variable: Product innovation

Analysis 1: Only with control variable R&D

The R&D variable will act as control variable, but also as independent variable within the analysis as stated before. Therefore, the data from the first analysis in which the variable is used as a control variable will be used for the analysis of R&D as an independent variable, as this data will also provide information about the strength of the autonomous relationship between R&D and product innovation. Firstly, it will be checked how well the model fits the data. The Pearson test, indicates that the model does not fit when a statistically significant result ($P < 0,05$) is found. Appendix V shows that the goodness-of-fit displays a significance value of 0,242 which indicates that the model fits the data. The Nagelkerke value (see table 7) makes clear that the proportion of the variance that can explained by this model is only 5%. In addition, the Likelihood ratio test shows that the variable R&D is statistically significant, as the P-value is 0,009 (see appendix V).

- R&D: regarding the relation with dependent variable product innovation the values of the analysis look as follow: B = 0.077, Wald = 6.109, p = 0.013. The odds ratio in this case indicates that when product innovation conducts one more unit of R&D the change in odds of getting product innovation is 1,08. This means R&D stimulates product innovation.

Analysis 2: Dependent variables and product innovation (controlled by R&D)

In this analysis the model still fits the data as the goodness-of-fit shows that Pearson has a value of p= 0,347 which is above the required p= 0.05. The Nagelkerke value is 0.13 which tells that the proportion of the variance that can be explained by the model is 13%, which is higher than the first analysis. The Likelihood ratio show that only R&D and social capital provide a statistically significant result. See appendix V or description below for exact numbers.

- Non-R&D human capital: B = -0.12, Wald = 1.15, p = 0,283. As displayed the correlation between non-R&D human capital and product innovation is not significant. In addition, the B value indicates a negative relation.
- Social capital: B= 0.30, Wald= 8.02, p = 0.005. The variable seems to have a positive relationship as B indicates. The odds of ratio confirm this by stating that by adding one more unit of social capital the change in odds of developing product innovation is 1.35. Therefore, an organization is more likely to develop product innovation than not when making use of social capital.
- Organizational capital: B = 0.04, Wald = 0.31, p = 0.58. This means the relationship between organizational capital seems to be positive but not significant as p>0.05.

Analysis 3: Interaction variables and product innovation controlled by R&D

Performing this analysis, it needs to be addressed that the that the model fits the data as the goodness-of-fit shows that Pearson has a value of p = 0.34 which is > p = 0.05. Besides that, the Nagelkerke value is 0.10, which means that the model explains 10% of the variance. Interestingly, only 1 interaction effect shows a statistically significant effect. See below the results (or appendix V):

- Human capital *social capital (log): B = 0.74, Wald= 5.74, p = 0.02. The B value indicates a positive relation between the interaction variable and product innovation, which is also reflected in the odds of ratio. This value shows that when the interaction variable gains with one unit, the odd in developing product innovation changes with 2.10. The interaction between non-R&D human capital and social capital leads to more product innovation within an organization.
- Human capital * organizational capital: B= 0.00, Wald = 0.00, p = 0.98. Despite the extraordinary B-value of 0, it is immediately noticeable that the results here are far from significant.
- Human capital * R&D: B= -0.01, Wald = 0.09, p = 0.76. The low B and Wald value do not provide much information, as the relation between the interaction variable and product innovation is not significant.

Dependent variable: product-service innovation

Analysis 1: Control variable R&D and product-service analysis

Just as in the previous analysis the same control variable is being used. The Pearson value clarifies that the model fits the data, because of Pearson value 0.35 > p 0.05. The Nagelkerke value of 0.01 confirms that the model only explains 0.1% of the variance.

- R&D: B = 0.03, Wald = 1.14, p = 0.29. It can be observed directly that the relationship between R&D and product-service innovation is not significant. This is in contrast to the relationship with the other dependent variable product innovation.

Analysis 2: Dependent variables and product-service innovation (autonomous relations and controlled by R&D)

Similarly, to the other analysis the Pearson value is sufficient as 0.47 surpasses the value p= 0.05. In addition, Nagelkerke value states that the model can explain 11% of the variance. The likelihood ratio test also indicates that only one variable is significant related to product-service innovation.

- Human capital: B = -0.12, Wald = 0.95, p = 0.45. The p-value shows that this variable has no significant correlation with the dependent variable.
- Social capital: B= 0.31, Wald = 6.27, p = 0.01. It is very noticeable that the Wald value is high, in addition, it appears to be the only variable that also shows significance in the relationship between the dependent variables. The odds of ratio statistics, clarify that with every addition of on unit of social capital, the odd in developing product-service innovation changes with 1.37.
- Organizational capital: B = 0.10, Wald = 1.07, p = 0.30. The p-value makes it immediately clear that there is no significance in the relationship between organizational capital and product-service innovation. This was somewhat predictable by the bivariate analysis conducted

Analysis 3: Interaction variables and product-service innovation (controlled by R&D)

The last analysis provides a goodness-of-fit with a Pearson value of 0.34 which is > 0.05. In this case it is safe to state the model fits the data. Besides this, the Nagelkerke displays a value of 0.03 which means the model van only explain 3% of the total variance. Below, only the data of the interaction variables will be made visible without description, since all of them are not significant. Human capital *social capital (log): B = 0.19, Wald= 0.28, p = 0.60. Human capital * organizational capital: B= 0.01, Wald = 0.27, p = 0.60. Human capital * R&D: B= -0.23, Wald = 0.178, p = 0.18.

	Technological Product innovation			**product-services innovation**		
	1	2	3	1	2	3
Control variables						
R&D	0.08**	0.07*	0.07	0.03	0.03	0.13
Explanatory variable						
(Non-R&D) Human capital	-	-0.12	0.20	-	-0.12	-0.16
Social capital	-	0.30**	0.62	-	0,31*	0.27
Organizational capital	-	0.04	0.09	-	0.10	0.05
Interaction variable						
Human capital * social capital (log)	-	-	0.74*	-	-	0.19
Human capital * organizational capital	-	-	0.00	-	-	0.01
Human capital * R&D	-	-	-0.01	-	-	-0.23
Model statistics						
Model X^2	45,88**	17,63**	10,37*	1,12	11,68	2.54
Nagelkerke R^2	0,05	0,14	0,10	0,01	0,11	0.03
N	175	175	175	175	175	175
*p<,05; ** p<,01						

Table 7: binary regression analysis product innovation and product-service innovation

After analyzing the correlations and interaction effects, the hypothesis can be tested. The first hypothesis is: **The level of a company's non-R&D human capital has no direct correlation with the engagement in technological product innovation.** The analysis shows that there is a somewhat negative relationship that is not significant. It can be stated on this basis that the first hypothesis can be accepted. The second states hypothesis**: The level of a company's non-R&D human capital has no direct correlation with the engagement in non-technological product innovation, i.e. products-services innovation.** The situation here is similar as the analysis here shows that there is a small negative relationship that is not significant. Therefore, the hypothesis can also be accepted.

The third hypothesis concerns the relationship between social capital and technological product innovation. The hypothesis is that: **The greater the non-R&D human capital of an organization, the greater the contribution of its collaboration partners to technological product innovation.** The analysis reveals that there is a significant autonomous relationship between social capital and technological product innovation. The analysis also shows that this relationship is significantly strengthened when non-R&D human capital interacts. Therefore, this hypothesis can also be accepted. The fourth hypothesis concerns social capital and product-service innovation: **The greater the non-R&D human capital of an organization, the greater the contribution of its collaboration partners to non-technological product innovation.** The analysis shows that although there is an autonomous positive relationship between social capital and product-service innovation, this relationship disappears when non-R&D human capital exhibits an interaction effect. The results are not significant in that case.

The next two hypotheses have to do with organizational capital and innovation. For example, hypothesis number five states: **Non-R&D human capital has a positive (moderation) effect on the relationship between organizational capital and product innovation.** This hypothesis should be rejected, due to the fact that both the autonomous relationship and the relationship in which non-R&D human capital interacts both show low correlations that are also not significant. The sixth hypothesis has a similar situation. The hypothesis states: **Non-R&D human capital has a positive (moderation) effect on the relationship between organizational capital and product-service innovation.** Both the autonomous relationship and the relationship including interaction are not significant, which means that the hypothesis should be rejected.

Finally, the last two hypotheses follow which argue that non-R&D human capital increases the innovation rate of R&D personnel. The first hypothesis is about product innovation: **Non-R&D human capital has a positive (moderation) effect on the relationship between R&D and product innovation.** Based on the analysis, this hypothesis cannot be accepted. The autonomous relationship between R&D and technological product innovation is stronger than the relationship involving interaction with non-R&D human capital. Besides that, the relation including interaction with non-R&D human capital seems to be not significant. The final hypothesis is as follows: **Non-R&D human capital has a positive (moderation) effect on the relationship between R&D and product-service innovation.** It can be concluded based on the analysis conducted that this hypothesis should also be rejected. R&D shows no significant relationship with product-service innovation, while this remains unchanged when non-R&D human capital acts as an interaction effect. See table 8 below, for a complete overview of the results of the hypothesis.

Hypothesis	**Status**
H1: **The level of a company's non-R&D human capital has no direct correlation with the engagement in technological product innovation**	Accepted
H2: **The level of a company's non-R&D human capital has no direct correlation with the engagement in non-technological product innovation, i.e. products-services innovation**	Accepted
H3: : **The greater the non-R&D human capital of an organization, the greater the contribution of its collaboration partners to technological product innovation**	Accepted
H4: **The greater the non-R&D human capital of an organization, the greater the contribution of its collaboration partners to non-technological product innovation.**	Rejected
H5: : **Non-R&D human capital has a positive (moderation) effect on the relationship between organizational capital and product innovation.**	Rejected
H6: **Non-R&D human capital has a positive (moderation) effect on the relationship between organizational capital and product-service innovation**	Rejected
H7: **Non-R&D human capital has a positive (moderation) effect on the relationship between R&D and product innovation.**	Rejected
H8: **Non-R&D human capital has a positive (moderation) effect on the relationship between R&D and product-service innovation**	Rejected

Table 8: overview hypothesis

5. Conclusion & discussion

The final chapter of this thesis contains of a conclusion, which will provide an answer to the research question. Following up, the results of the analysis will be interpreted and compared to the developed theoretical framework argument, which led to the hypothesis. Based on that, certain recommendations will arise for further practice and theory. Lastly, the limitations of this research will be discussed.

5.1 Conclusion

In the introduction of this research, it became clear that many researchers saw R&D as the source of innovation. Therefore, many studies have focused on the area of R&D elements and innovation. Yet, in practice, there are many companies that innovate without having an R&D department. From the available literature it appeared that RBV intellectual capital elements, in some research showed a correlation with innovation. However, literature research showed that the relationship between human capital and innovation did not show unambiguous results. The critique on linear thinking followed, revealing that there may be multiple explanatory variables (and their interaction) leading to innovation. This could be a possible cause for the lack of unambiguous results. Therefore, in addition to the autonomous relationship between RBV elements (independent variables): human capital, social capital and organizational capital, also interaction effects with human capital were investigated to examine if that may strengthen the relationship with product innovation. The choice was made to use non-R&D human capital to exclude the influence of R&D from human capital. R&D itself is also included as independent variable because an attempt was made to compare whether interaction with (non-R&D) human capital influences R&D in such a way that more innovation takes place. Within product innovation, two dimensions are included in this research as (different) dependent variables: technological product innovation and non-technological product-service innovation. Based on the introduction the following research question was formed: *'To what extent does non-R&D human capital add value to different types of organizational assets for enhancing product innovation in addition to the independent innovation impact of non-R&D human capital?'.*

The first sub-question aimed to find out whether an autonomous relationship exists between (non-R&D) human capital and product innovation. The analysis of the previous chapter shows that non-R&D human capital does not show any autonomous relationship with either product innovation or product-service innovation, which means that the RBV element does not show any direct relationship with product innovation.

The second sub-question tries to clarify to what extent non-R&D human capital influences the relationship between social capital and product innovation in the case of interaction. The analysis shows that there is a significant positive autonomous relationship between social capital and technological product innovation. The analysis also shows that when there is interaction with (non-R&D) human capital, the relationship between social capital and technological product innovation is significantly strengthened. In the case of the relationship between social capital and non-technological product-service, it appears that the autonomous relationship is significant, as opposed to the insignificant relationship when (non-R&D) human capital functions as a moderator. This means that the interaction between (non-R&D) human capital and social capital only stimulates the degree of technological product innovation.

The third sub-question tries to clarify to what extent the interaction between (non-R&D) human capital and organizational capital changes the amount of product innovation compared to the autonomous relationship between organizational capital and product innovation. The analysis shows that both the autonomous relationships and the relationship including moderator are not significant for both technological product innovation and non-technological product-service innovation.

The last sub-question tried to find out whether the interaction between (non-R&D) human capital and R&D personnel leads to a different degree of product innovation. The analysis that helps answer this question shows remarkable results. The autonomous relationship between R&D and technological product innovation seems significant but remarkably weak. This while it would be expected that the relationship would be significantly stronger. Also striking is that the interaction between R&D and non-R&D human capital results in an insignificant relationship with technological product innovation. In the case of non-technological product-service innovation, both the autonomous relationship and the relationship including interaction are insignificant.

Returning to the research question: *'To what extent does non-R&D human capital add value to different types of organizational assets for enhancing product innovation in addition to the independent innovation impact of non-R&D human capital?',* it can be concluded that (non-R&D) human capital does not have an autonomous relationship with product innovation. In addition, it can be concluded that interaction with (non-R&D) human capital is only beneficial for social capital. It should be noted, however, that this only concerns the field of technological product innovation. There is no significant relationship between organizational capital and product innovation, which is the same when (non-R&D) acts as a moderator. Finally, it appears that the moderator (non-R&D) human capital does not improve the strength in relationship between R&D and product innovation.

5.2 Discussion

In the theoretical framework several empirical studies were used to develop certain hypotheses. The first two hypotheses stated that no significant autonomous relation between (non-R&D) human capital and product innovation is expected. Even if these were correlated, a strong relationship would not be expected since the critique of the linear thinking model states that that one independent variable by itself cannot explain a dependent variable like innovation (Rothwell, 1992). To truly understand the system, research should focus on the complementarities among elements, their integration and the outcomes resulting from their interactions as Teece (1007) states. This research shows that the critique on linear thinking holds in this respect as no autonomous relationship between (non-R&D) human capital and product innovation has been experienced.

The criticism on linear thinking seems well-founded when it comes to social capital, which does have an autonomous relationship, but is not very strong, while interaction with (non-R&D) human capital considerably strengthens the relationship with technological product innovation. A possible explanation is the argument of Najafi-Tavani, et al., (2018) that collaborations with external parties (social capital) lead to more product innovation when more absorptive capacity is available. While a higher human capital (highly educated workforce) means a higher absorptive capacity according to Luo et al., (2009). However, the relationship between social capital and non-technological product-service disappears when (non-R&D) human capital interacts. It is not possible to give a justification for this based on the theoretical framework that has been drawn up. A possible explanation could be that organizations with highly educated employees focus on product innovation instead of product-service innovation collaborating with external parties.

Despite the lack of unambiguous results regarding the relationship between organizational capital and product innovation, a hypothesis has been formulated that non-R&D human capital strengthens the relationship between organizational capital and product innovation. For example, Leonard-Barton (1992) argues that organizational capital is related to product innovation because organizational capital element: dynamic capabilities, drives product innovation. Nevertheless, the analysis of this thesis shows that no relationship has been found between organizational capital and product innovation. This result is in line with the research of Dost et al., (2016) as he did not experience an autonomous relationship but did present that interaction between social capital and organizational capital resulted in a significant relationship with product innovation. However, the analysis of this research demonstrates that this positive moderation effect is not similar when (non-R&D) human capital acts as moderator. It is unknown why specifically that RBV intellectual capital does show this effect and (non-R&D) human capital does not. The reasoning that organizational learning can be better performed by highly educated employees, which according to Jashapar (1993)

increases the needed dynamic capability (organizational capital element) for product innovation therefore does not hold in this analysis.

Finally, the theoretical framework expected that higher non-R&D human capital strengthens the relationship between R&D and product innovation as a moderator. The absorptive capacity would make it possible to better understand concepts, so that R&D can be provided with better feedback/new insights. Nevertheless, it appears that the autonomous relation between R&D and product innovation is significant but remarkably low. This may be because a huge number of companies innovate without an R&D department (Arundel, 2007). Still, a stronger relationship was expected, but the analysis of this research sample shows otherwise. The interaction with non-R&D human capital has a negative effect on the strength of the relationship between R&D and product innovation, as this relationship seems to be weaker and insignificant, which is not in line with the finding of Lee et al (2005). A possible cause could be that high non-R&D human capital is not engaged in innovation, as there is a department that is already engaged in it. It is possible that the workload or the motivation of the employees ensures that they do not feel compelled to stimulate R&D development in addition to their regular work.

The starting point of this thesis: criticism on linear thinking within innovation (Rothwell, 1992) seems to be acceptable. No strong autonomic relationship was experienced. The strongest autonomous relationship (medium effect size) was between social capital and product innovation, which became much stronger when interacting with non-R&D human capital. Based on the RBV literature, it would be expected that all RBV intellectual capital elements would have a relationship with product innovation. Subramaniam and Youndt (2005) stated that RBV elements are related to product innovation, but that it is unclear exactly what these relationships exactly look like. Partly, as a result of this research, it can be argued that not all RBV elements have a direct relationship with product innovation. Nevertheless, this research shows that human capital can strengthen the relationship between social capital and product innovation. In addition, the results of Carmona-Lavado et al. (2010) show that the interaction between social capital (moderator) and organizational capital leads to more product innovation, while there is no direct relationship between organizational capital and product innovation. By taking the results of both studies into account, it can be stated that all RBV intellectual capital elements have an effect on product innovation. It only does not concern an autonomous relationship in all cases.

Some interesting theoretical implications emerged from this study. Firstly, the current literature has included many studies that have assumed that R&D is the main source of innovation, while this research shows that this is not always the case. For instance, it shows that collaborations with external parties (social capital) can make a greater contribution to product innovation than R&D. Secondly, there was ambiguity in the current literature about the role of human capital on innovation, resulting in inconclusive results. Even less was known about the role of non-(R&D). This research shows that (non-R&D) human capital is not directly related to product innovation, but (non-R&D) human capital can make other resources more effective in developing product innovation.

Moreover, this research also provides practical implications. It seems that companies do not necessarily need to set up an R&D department to achieve product innovation. For example, it appears that collaborations with external parties are more effective, which is reinforced when highly educated (non-R&D) employees are involved. An interesting finding for organizations is that this is only true for technological product innovation, whereas for non-technological product-service innovation it is more beneficial not to involve highly skilled (non-R&D) personnel within collaborations with external parties. In addition, companies can consider that the collaborations between in-house R&D personnel with highly skilled non-(R&D) personnel does not stimulate product innovation. Therefore, highly skilled non-R&D employees can better engage in other type of collaborations.

5.3 Limitations and suggestions for future research

This study ends with describing it limitations and providing some suggestions for future research. The first limitation relates to the EMS database. As the discussed literature points out, the RBV intellectual elements consist of multiple aspects, while the EMS only questions certain aspects. Human capital for example is measured by the educational level of employees, whereas also experience of the employees can influence the human capital (Hitt et al., 2001). Unfortunately, the EMS does not provide data in this area, which limits the measurement of human capital to educational attainment. In the case of the other two intellectual capital, there are also some aspects that could be included, to better capture the presence of the capitals. Another limitation within the study is that only quantitative research was conducted. By using mixed methods, it could become clear why collaborations involving highly educated (non-R&D) human capital led to technological product innovation, but not to non-technological product-service innovation for example.

For future research it will therefore be advised to include more aspects related to the RBV intellectual capitals and to use mixed methods to explain some of the interesting findings by means of, for example, interviews with those involved. In addition, another possibility for future research is to investigate other interaction effects between RBV intellectual capital elements. Now that it has become clear how (non-R&D) human capital affects the relationship between organizational capital & product innovation and social capital & product innovation. It is possible to investigate the moderation effect of organizational capital on the relationship between (non-R&D) human capital & product innovation and social capital & product innovation. This will provide even more clarity about the relationship between RBV intellectual capitals and (product) innovation in general.

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Appendix I: EMS questionnaire

Voor vragen kunt u terecht bij. dr. Peter Vaessen E-Mail: P.Vaessen @ fm.ru.nl Tel.: 024 3611266 Fax: 024 3611933

1.1 **Is uw bedrijfsvestiging** (kruis slechts één optie aan)**:**

- ☐ Het hoofdkantoor van een onderneming/groep met ook buitenlandse vestigingen
- ☐ Een dochter/divisie van een buitenlandse onderneming/groep
- ☐ Het hoofdkantoor van een onderneming/groep met alleen binnenlandse vestigingen
- ☐ Een dochter/divisie van een onderneming/groep met alleen binnenlandse vestigingen
- ☐ Een zelfstandige onderneming

1.2 Bedrijfstak (bijv. textiel, chemische industrie, machinebouw, enz.): | hoofdproductgroep | aandeel van hoofd-product (groep) in omzet ca. ___ %

1.3 **Is uw bedrijfsvestiging gelet op uw hoofdproduct(groep) leverancier van eindfabricaten of een toeleverancier van onderdelen/ materialen of bewerkingen?** (Kruis slechts één optie aan)

producent van eindfabricaten		**toeleverancier**		**aanbieder van bewerkingen**
☐ voor consumenten	☐ voor bedrijven	☐ van systemen/ installaties	☐ van halffabricaten/ onderdelen	☐ aanbieder van bewerkingen (draaien, coaten, lassen, vermalen, e.a.)

1.4 **Als u uw hoofdproduct(groep) levert aan andere bedrijven (als eindfabrikant of toeleverancier), aan welke bedrijfstak levert u dan hoofdzakelijk?** (Kruis slechts één optie aan)

Machinebouw ☐ Chemische industrie ☐ Automotive industrie ☐ Elektro-techniek ☐ andere bedrijfstak, nl.: ____

1.5 **In hoeverre voert uw bedrijfsvestiging voor het hoofdproduct de volgende activiteiten uit van het waardecreatieproces?**
Kruis voor elke activiteit aan in welke mate die in uw eigen bedrijfsvestiging dan wel elders wordt uitgevoerd.
Kruis ook aan of een activiteit in het geheel geen deel uitmaakt van het waardecreatieproces

	Waardecreatie-activiteiten					
	Onderzoek en Ontwikkeling	Ontwerp/ Vormgeving	Productie/ Verwerking/Recycling	Assemblage	Onderhoud/ Dienstverlening	Verpakken/ Distributie
grotendeels intern > 85%	☐	☐	☐	☐	☐	☐
relevant deel intern (25%-85%)	☐	☐	☐	☐	☐	☐
klein deel intern (<25%)	☐	☐	☐	☐	☐	☐
niet nodig voor vervaardiging van het hoofdproduct	☐	☐	☐	☐	☐	☐

2 **Hoe belangrijk zijn de volgende factoren voor de concurrentiepositie van uw bedrijfsvestiging?** (geef de volgorde van belangrijkheid aan met een score van 1 tot 6; 1 is het belangrijkst, gebruik elke score slechts één keer)

productprijs	productkwaliteit	innovatieve producten	aanpassing producten aan klantenwensen	tijdige levering/ korte levertijden	dienstverlening en service
○	○	○	○	○	○

3 **Welke van de volgende organisatieconcepten en werkwijzen worden momenteel in uw bedrijfsvestiging toegepast?**

Toepassing gepland voor 2018	Nee	Organisatieconcepten	Ja	Voor het eerst toegepast[1]	Omvang van het toegepaste potentieel[2]
		Organisatie van het werk			
☐	☐	Gedetailleerde voorschriften voor de werkplekinrichting van apparatuur en opslag van tussenproducten (bijv. 5-S methode)	☐	19/20	g m h
☐	☐	Gestandaardiseerde en gedetailleerde werkinstructies	☐	19/20	g m h
☐	☐	Taakverrijking productiemedewerker (integratie van planning, uitvoering of controle)	☐	19/20	g m h
		Organisatie van de productie			
☐	☐	Maatregelen ter verbetering van de interne logistiek (Value Stream Mapping/Design, ruimtelijke inrichting van productiestappen)	☐	19/20	g m h
☐	☐	Klant- of productgeoriënteerde inrichting van productie-eenheden (i.t.t. functionele indeling)	☐	19/20	g m h
☐	☐	Vraaggestuurde productie (bijv. KANBAN, afschaffen van tussenvoorraden)	☐	19/20	g m h
☐	☐	Voorgeschreven methoden voor het verkorten van omstel- en aanlooptijden bij productwisseling (bijv. Single Minute Exchange of Die; Quick Change Over)	☐	19/20	g m h
		Productiemanagement/ -beheersing			
☐	☐	Grafische weergave werkprocessen en -status (Visual Management; dashboard)	☐	19/20	g m h
☐	☐	Kwaliteitsmanagement (bijv. preventieve onderhoud, total quality management/TQM, total productie-onderhoud/TPM)	☐	19/20	g m h
☐	☐	Methoden voor operation management o.b.v. wiskundige analyse van productie (bijv. Six Sigma methode)	☐	19/20	g m h
☐	☐	Methoden van continu verbeteren (Kaizen, kwaliteitscirkels e.d.)	☐	19/20	g m h
		Energie- en milieubeheersing			
☐	☐	Gecertificeerd energie-management systeem volgens ISO 50001, voorheen: EN 16001	☐	19/20	g m h
☐	☐	Instrumenten voor productlevenscyclus-analyse (bijv. EU Ecolabel, Cradle-to-Cradle certificaat, ISO-14020)	☐	19/20	g m h
☐	☐	Het opnemen van sociale en duurzaamheidseffecten in het vaststellen van bedrijfsprestaties	☐	19/20	g m h
		Human resource management			
☐	☐	Maatregelen voor het behoud van oudere werknemers of hun kennis voor uw bedrijfsvestiging (bijv. teams met verschilllende leeftijdsgroepen, begeleidingsprogramma's, senior-junior tandems)	☐	19/20	g m h
☐	☐	Instrumenten ter bevordering van werknemersbetrokkenheid (bijv. gratis kantine, ondersteuning kinderopvang, gezinsvriendelijke werktijden)	☐	19/20	g m h
☐	☐	Gestandaardiseerde methoden van functie-ontwerp ter verbetering van gezondheids- en veiligheidsomstandigheden op het werk (bijv. Methods-time measurement (MTM))	☐	19/20	g m h
☐	☐	Financiële participatie toegankelijk voor alle werknemersgroepen (bijv. winstdelingsregelingen, aandelen(optie)plannen, enz.)	☐	19/20	g m h

Toelichting:

1 Het jaar waarin deze technologie voor het eerst werd toegepast in uw bedrijfsvestiging (maak een schatting indien u onzeker bent over het exacte jaar)

2 Daadwerkelijke toepassing ten opzichte van maximaal zinvolle toepassingsmogelijkheden: omvang van het gebruikte potentieel is “gering” bij eerste aanzetten, “midden” bij gedeeltelijke toepassing en “hoog” bij omvangrijke toepassing

4.1 **Welke van de volgende activiteiten worden uitgevoerd voor uw productiepersoneel in uw bedrijfsvestiging?**

Aanwezige competenties van productiewerknemers worden systematisch vastgelegd? ☐ nee ☐ ja

Functiebeschrijvingen zijn ontwikkeld voor specifieke functiegebieden in de productie? ☐ nee ☐ ja

Er bestaan specifieke competentieprogramma's for bepaalde functies ☐ nee ☐ ja

4.2 **Bij welke personeelsgroepen worden deze instrumenten gebruikt?**

☐ LBO of ongeschoold personeel ☐ MBO geschoold personeel ☐ Hooggeschoold personeel (HBO+WO)

4.3 **Bestaat er afzonderlijk beleid voor competentie-ontwikkeling en training van productiepersoneel?**

☐ nee ☐ ja → Is er in uw bedrijf voor dit beleid een vast jaarlijks budget beschikbaar? ☐ nee ☐ ja

5.1 **Is er een vastgesteld aantal dagen per jaar voor verdere kwalificatie, training en ontwikkeling van het productiepersoneel?**

☐ **nee** ☐ **ja** → **Hoeveel dagen per jaar is er per persoon vastgesteld?** ca. ____ dagen per jaar

5.2 **Zijn de volgende activiteiten voor verdere kwalificatie, training en ontwikkeling toegepast voor het productiepersoneel in uw bedrijfsvestiging?**

	nee	ja	In aanmerking komen de volgende groepen van productiepersoneel: LBO of ongeschoold	MBO technisch geschoold	Hooggeschoold (WO+HBO)
Training voor specifieke vaardigheden (bijv. machine-onderhoud)	☐	☐→	☐	☐	☐
Training met interdisciplinair oogmerk (bijv. taalcursussen, leiderschapstraining)	☐	☐→	☐	☐	☐
Digitale zelfscholingprogramma's (e-learning)	☐	☐→	☐	☐	☐
On-the-job training (bijv. taakrotatie, werkplekinstructie, georganiseerde ervaringsuitwisseling met collega's)	☐	☐→	☐	☐	☐
Informatie-aanbod (bijv. bedrijfstak specifieke beurzen, externe databases)	☐	☐→	☐	☐	☐
Deelname aan activiteiten voor continue kwaliteitsverbetering (bijv. kwaliteitscirkels, Kaizen)	☐	☐→	☐	☐	☐

6.1 **Werkt uw bedrijfsvestiging samen met andere bedrijven op de volgende terreinen?**
(samenwerking = vrijwillige samenwerking die verder gaat dan eenmalige transacties tussen bedrijven)

	nee	ja	Locatie van de partners: regionaal (< 50km)	nationaal (> 50km)	buiten-land
Samenwerking in inkoop	☐	☐→	☐	☐	☐
Samenwerking in de productie (voor gezamenlijke systeemleveringen of capaciteitsuitbreiding)	☐	☐→	☐	☐	☐
Samenwerking in distributie/verkoop	☐	☐→	☐	☐	☐
Samenwerking in service	☐	☐→	☐	☐	☐
Samenwerking in onderzoek en ontwikkeling met afnemers of leveranciers	☐	☐→	☐	☐	☐
Samenwerking in onderzoek & ontwikkeling (O&O) met onderzoeksinstituten (bijv. universiteiten, TNO)	☐	☐→	☐	☐	☐

6.2 **Indien uw bedrijfsvestiging voor onderzoek en ontwikkeling samenwerkt met andere bedrijven, zijn daarbij bedrijven actief op het gebied van nanotechnologie, micro-elektronica, photonen, nieuwe materialen, of biotechnologie?**

☐ **nee** ☐ **ja** → ☐ nanotechnologie ☐ micro-elektronica ☐ photonen ☐ nieuwe materialen ☐ biotechnologie

7.1 **Welke van de volgende maatregelen zijn genomen om het risico van industriële spionage te vermijden in uw bedrijfsvestiging? Sinds wanneer zijn deze ingevoerd?**

	nee	ja	sinds wanneer?
Speciale IT-veiligheidsmaatregelen (bijv. geen gebruik cloud computing, versleutelen van documenten, algemeen verbod op gebruik van draagbare data media)	☐	☐→	19/20 ____
Werknemerstrainingen en verhoging van waakzaamheid voor het gevaar van industriële spionage	☐	☐→	19/20 ____
Veiligheidsmaatregelen voor toegang tot terrein, gebouwen of kamers	☐	☐→	19/20 ____
Veiligheidsinstructies over illegale verspreiding van informatie (bijv. regelingen voor omgaan met gevoelige gegevens in relatie tot derde partijen)	☐	☐→	19/20 ____

7.2 **Heeft uw bedrijfsvestiging te maken gehad met spionage door andere bedrijven, buitenlandse overheidsorganisaties of met verdachte gevallen in de laatste vijf jaar?**

concre(e)t(e) geval(len) ☐ **nee** ☐ **ja** → ☐ ander bedrijf ☐ buitenlandse overheidsorganisatie ☐ onbekend

verdacht(e) geval(len) ☐ **nee** ☐ **ja** → ☐ ander bedrijf ☐ buitenlandse overheidsorganisatie ☐ onbekend

7.3 **Indien er sprake was van een verdacht of concreet geval, welke informatie was het doelwit van industriële spionage?**

Informatie over....

☐ Producten (bijv. ideeën, studies, ontwikkeling, ontwerp) ☐ Productie- of fabricageprocessen ☐ Klanten/toeleveranciers (bijv. contracten, prijzen) ☐ Bedrijfsstrategie (bijv. investeringsplannen)

8.1 **Welke van de volgende technologieën worden momenteel in uw bedrijfsvestiging toegepast?**

Toepassing gepland voor 2018	Nee	Technologieën	Ja	Voor het eerst gebruikt (Jaar)[1]	upgrade sinds 2012: Ja	upgrade sinds 2012: Nee	Omvang van het toegepaste potentieel[2]
		Automatisering en robotisering					
☐	☐	Industriële robots voor bewerking en fabricage (bijv. lassen, coaten, snijden)	☐	19/20	☐	☐	g m h
☐	☐	Industriële robots voor hanteren van gereedschap en werkstukken in productie (bijv. verplaatsen, assemblage, sorteren, verpakken)	☐	19/20	☐	☐	g m h
		Energie- en grondstoffenbesparing					
☐	☐	Controlesystemen die machines stilleggen bij onderbenutting (bijv. PROFI-energy)	☐	19/20	☐	☐	g m h
☐	☐	Geautomatiseerde beheerssystemen voor energie efficiënte productie	☐	19/20	☐	☐	g m h
☐	☐	Systemen t.b.v. terugwinning van kinetische en procesenergie (bijv. terugwinnen afvalwarmte)	☐	19/20	☐	☐	g m h
☐	☐	Technologieën voor energie- en/of warmteopwekking door middel van zon-, wind-, waterkracht, biomassa of geothermische energie	☐	19/20	☐	☐	g m h
		Bewerkingstechnologieën voor nieuwe materialen					
☐	☐	Productietechnologieën voor micromechanische componenten (micromachinale bewerking, lithografie, micro-injectie e.d.)	☐	19/20	☐	☐	g m h
☐	☐	Nanotechnologische productieprocessen (bijv. oppervlaktebewerking)	☐	19/20	☐	☐	g m h
☐	☐	Technieken voor verwerking van composietmateralen (bijv. carbonvezel, glasvezel)	☐	19/20	☐	☐	g m h
☐	☐	Bio- en gentechnologie in fabricageprocessen (bijv. catalysatoren, bioreactoren)	☐	19/20	☐	☐	g m h
☐	☐	Technieken voor verwerking van legeringen (aluminium-, magnesium-, titaniumlegeringen, enz.)	☐	19/20	☐	☐	g m h
		Additieve productietechnologieën					
☐	☐	Additive productietechnologie voor maken van prototypes (bijv. 3D printing, rapid prototyping; Selective Laser Sintering; Stereolithografie, Laser Beam Melting)	☐	19/20	☐	☐	g m h
☐	☐	Productie met additieve productietechnologie (incl. enkelstuksproductie; kleine productieseries; reserveonderdelen)	☐	19/20	☐	☐	g m h
☐	☐	Systemen voor Machine2Machine communicatie, Multi-agent systemen	☐	19/20	☐	☐	g m h
☐	☐	Systemen voor Cyber-Physical systems, cloud-computing	☐	19/20	☐	☐	g m h
		Digitale fabriek / IT netwerken					
☐	☐	Digitale productieplanning en roostering (bijv. ERP-systeem)	☐	19/20	☐	☐	g m h
☐	☐	Bijna real-time productiebeheersingssystemen (bijv. systemen voor gecentraliseerde aansturing en machinegegevensverwerking	☐	19/20	☐	☐	g m h
☐	☐	Digitale uitwisseling van productieplanningsgegevens met toeleveranciers en/of klanten (supply chain management)	☐	19/20	☐	☐	g m h
☐	☐	Systemen voor geautomatiseerd management van interne logistiek en orderverzameling (e.g. RFID, warehouse management system)	☐	19/20	☐	☐	g m h
☐	☐	Mobiele/draadloze apparaten voor programmering en bediening van installaties en machines (e.g. tablets)	☐	19/20	☐	☐	g m h
☐	☐	Product Lifecycle Management (PLM) systemen of Product/Productieproces datamanagement	☐	19/20	☐	☐	g m h
☐	☐	Technologieën voor veilige mens-machine interactie (bijv. coöperatieve robots, open werkstations e.d.)	☐	19/20	☐	☐	g m h
☐	☐	Digitale oplossingen voor het direct beschikbaar maken van tekeningen, werkschemas en -instructies op de werkvloer (e.g. tablets, smartphones)	☐	19/20	☐	☐	g m h

Toelichting:

1 Het jaar waarin deze technologie voor het eerst werd toegepast in uw bedrijfsvestiging (maak een schatting indien u onzeker bent over het exacte jaar)

2 Daadwerkelijke toepassing ten opzichte van maximaal zinvolle toepassingsmogelijkheden: omvang van het gebruikte potentieel is "gering" bij eerste aanzetten, "midden" bij gedeeltelijke toepassing en "hoog" bij omvangrijke toepassing

8.2 Welke van de volgende maatregelen nam uw bedrijfsvestiging om energieverbruik te verminderen?

	Toepassing gepland voor 2018	nee	ja
Afschakelsystemen voor onderdelen, machines of installaties indien niet in gebruik (bijv. afschakeling luchttoevoer, aangepaste verlichtingssensoren)	☐	☐	☐
Verbeteren van bestaande machines of installaties (bijv. hoogefficiënte motoren (IE3), aanbrengen isolatie, warmtewisseleraar)	☐	☐	☐
Voortijdige vervanging van bestaande machines of installaties door nieuwe machines of installaties	☐	☐	☐

8.3 Welke van de volgende redenen en welke van de genoemde barrières zijn van doorslaggevende betekenis voor het wel of niet invoeren van energie en warmte opwekkende technologieën op basis van hernieuwbare energie in uw vestiging?

Redenen voor invoering	Energie	Warmte
Verwachte ontwikkeling van de energieprijzen	☐	☐
Strategische redenen (bijv. "groen imago")	☐	☐
Terugdringen broeikasgassen	☐	☐
Eigen energie-opwekking ter vergroting aantal energiebronnen	☐	☐
Politieke of wettelijke bepalingen	☐	☐

Belangrijke barrières	Energie	Warmte
Te grote investeringen of voordelen ontbreken	☐	☐
Administratieve last (bijv. goedkeuringsprocedures)	☐	☐
Niet van toepassing in deze bedrijfsvestiging	☐	☐
Vooralsnog geen relevant onderwerp in deze vestiging	☐	☐
Andere barrières	☐	☐

9.1 Heeft uw bedrijf sinds 2012 producten geïntroduceerd die nieuw waren voor uw bedrijf of die technisch ingrijpend zijn vernieuwd?
(Bijv. door nieuwe grondstoffen of materialen te gebruiken, veranderingen in productiefuncties of werking e.d.)

☐ nee ☐ ja ➔ Hoe groot was het aandeel van deze producten in de omzet van het jaar 2014? ca. ___ %

➔ Hoe lang duurde gemiddeld genomen de ontwikkeling van zo'n product? (van productidee tot en met lancering) ca. ___ maanden

9.2 Hebben deze productvernieuwingen ook geleid tot betere milieu-effecten bij gebruik of verwijderen van deze nieuwe producten?

☐ nee ☐ ja ➔ Welke verbeteringen in de milieu-effecten zijn met deze producten bereikt? (Kruis aan wat van toepassing is)

☐ Vermindering van gezondheidsrisico's bij gebruik
☐ Vermindering van energieverbruik bij gebruik
☐ Vereenvoudiging van onderhoud of herstel
☐ Verlenging productlevensduur
☐ Vermindering van milieuvervuiling bij gebruik (van grond, water, lucht, of geluid)
☐ Verbeterde recycling, terugwinning of verwijderingseigenschappen

9.3 Bevonden zich bij deze nieuwe producten (nieuw sinds 2012) ook producten, die nieuw-voor-de-markt waren en die uw bedrijfsvestiging als eerste op de markt introduceerde?

☐ nee ☐ ja ➔ Wat was hun aandeel in de omzet van 2014? ca. ___ %

➔ Zijn deze producten speciaal ontwikkeld vooral voor (kruis slechts één optie aan):

☐ bestaande klanten binnen uw huidige markt
☐ aantrekken van nieuwe klanten binnen uw huidige markt
☐ toetreding tot markten nieuw voor *uw bedrijfsvestiging*
☐ het ontwikkelen van geheel nieuwe markten

9.4 Heeft uw bedrijfsvestiging producten in het programma die u al langer dan 10 jaar aanbiedt?

☐ nee ☐ ja ➔ Welk percentage van de omzet hadden deze producten in 2014? ca. ___ %

10.1 Welke van de volgende productgerelateerde diensten biedt u uw klanten aan?
Als uw bedrijfsvestiging dergelijke diensten aanbiedt, worden zij dan ook aangeboden voor producten van andere bedrijven?

	nee	ja	Voor producten van andere bedrijven
Installatie, inbedrijfstelling	☐	☐ ➔	☐
Onderhoud en reparatie	☐	☐ ➔	☐
Training	☐	☐ ➔	☐
Ontwerp, technisch advies (incl. testen, simulaties, O&O voor klanten)	☐	☐ ➔	☐

	nee	ja	Voor producten van andere bedrijven
Software-ontwikkeling (bijv. software-aanpassing)	☐	☐ ➔	☐
Klantondersteuning op afstand (helpdesk, service hotline, website)	☐	☐ ➔	☐
Reviseren, vernieuwen (incl. functie opwaardering of software-uitbreidingen)	☐	☐ ➔	☐
End-of-life dienstverlening (bijv. recycling, opheffen, terugname)	☐	☐ ➔	☐

10.2 **Indien u productgerelateerde diensten aanbiedt, hoe hoog schat u het aandeel daarvan in de totale omzet van 2014?**
► In geval van geen omzet, vul in „0".

Aandeel in totale omzet van diensten die u in 2014 direct, d.w.z. apart, in rekening heeft gebracht ca. ___ %

Aandeel van diensten die u in 2014 indirect in rekening heeft gebracht (via de productprijs) ca. ___ %

10.3 **Heeft uw bedrijfsvestiging vanaf 2012 nieuwe productgerelateerde diensten aangeboden, die geheel nieuw zijn voor uw bedrijfsvestiging of belangrijke verbeteringen bevatten?**

☐ nee ☐ ja ➔ Hoe groot was het aandeel in de omzet van 2014 van deze sinds 2012 nieuw aangeboden productgerelateerde diensten, die uw bedrijfsvestiging direct of indirect in rekening heeft gebracht? ca.. ___ %

11 **Hoe vaak heeft uw organisatie vanaf 2012 de volgende activiteiten verricht?**

		(0=niet; 1=1 keer; 2=vaker)
Spin-offs	Opstarten van nieuwe organisaties of activiteiten buiten de onderneming	0 1 2
Uitgaand intellectueel eigendom	Verkopen, of aanbieden van licenties/patenten aan andere organisaties	0 1 2
Werknemer-betrokkenheid	Benutten van kennis en initiatieven van niet-O&O medewerkers bij het realiseren van innovaties	0 1 2
Klantbetrokkenheid	Direct betrekken van klanten in uw innovatieprocessen	0 1 2
Extern netwerken	Het samenwerken met andere organisaties (niet klanten) voor innovatie	0 1 2
Externe participatie	Deelnemen (met bijv. vermogen, kennis) in ondernemingen om toegang te krijgen tot hun kennis of om andere synergieën te creëren?	0 1 2
Uitbesteden van O&O	Uitbesteden van O&O (diensten) aan andere organisaties, zoals universiteiten, publieke onderzoeksinstellingen, commerciële ingenieurs of leveranciers?	0 1 2
Inkomend intellectueel eigendom	Kopen of in licentie nemen van intellectueel eigendom van andere organisaties	0 1 2

12. **Hoe hebben zich in uw bedrijfsvestiging de productiekosten per eenheid product (eenheidskosten) ontwikkeld in 2014?**

Gedaald met 10% of meer	Gedaald 5 - < 10%	Gedaald 0 - < 5%	Gelijk gebleven	Gestegen 0 - < 5%	Gestegen 5 - < 10%	Gestegen met 10% of meer
☐	☐	☐	☐	☐	☐	☐

13 **In de voorafgaande vragen heeft u informatie gegeven over verschillende velden van innovatie. Rangorden deze innovatievelden naar mate van belangrijkheid voor uw bedrijfsvestiging.**
Geef met een score van 1 tot 4 de volgorde van belangrijkheid aan met 1 als het belangrijkst; gebruik elke score slechts één keer.

Toevoegen van diensten aan uw producten	Organisatie-vernieuwing	Technische vernieuwing in het productieproces	Ontwikkeling van nieuwe producten
◯	◯	◯	◯

14 **Welke van de onderstaande informatiebronnen zijn het meest relevant voor belangrijke innovatie-impulsen/ideeën in uw bedrijfsvestiging op de volgende gebieden?** (Kruis maximaal drie informatiebronnen aan voor elk gebied van innovatie)

	intern				extern			
	O&O, engineering	productie-afdeling	Klanten-service	Leiding bedrijfsvestiging	Klant of gebruiker	Leverancier	Onderzoeks-instellingen, universiteiten	Conferenties, beurzen
Nieuwe producten	☐	☐	☐	☐	☐	☐	☐	☐
Nieuwe proces-technologieën	☐	☐	☐	☐	☐	☐	☐	☐
Nieuwe diensten	☐	☐	☐	☐	☐	☐	☐	☐
Nieuwe organisatie-concepten	☐	☐	☐	☐	☐	☐	☐	☐

15.1 **Wat is het opleidingsniveau van het personeel van uw bedrijfsvestiging?**

Hoger onderwijs (HBO+WO)	ca.	___ %	=100%
MBO technische opleiding	ca.	___ %	
MBO adminstratieve en commerciële opleiding	ca.	___ %	
LBO of ongeschoold	ca.	___ %	
Personeel in opleiding (leerlingen, stagiaires)	ca.	___ %	

15.2 **Hoe is het personeel in uw bedrijfsvestiging verdeeld over de volgende werkterreinen:**

Onderzoek en ontwikkeling	ca.	___ %	=100%
Ideevorming, ontwerp en vormgeving	ca.	___ %	
Fabricage en montage	ca.	___ %	
Klantenservice	ca.	___ %	
Overige (administratie, inkoop, logistiek/distributie, onderhoud, productieplanning enz.)	ca.	___ %	

16 **Heeft uw bedrijfsvestiging in de afgelopen twee jaar delen van de productie of delen van onderzoek en ontwikkeling (O&O) overgeheveld naar andere bedrijven (uitbesteding) of eigen vestigingen in het buitenland (verplaatsing) danwel vestigingen vanuit het buitenland teruggeplaatst?**

Overheveling:

	nee	**Ja:**(meerdere opties mogelijk) Naar andere bedrijven in Nederland	Naar andere bedrijven in het buitenland	naar eigen vestigingen in het buitenland	Naar welk land (landen)?	**Redenen:** (meerdere opties mogelijk) Arbeidskosten	Ontsluiting nieuwe markten	Nabijheid belangrijke klanten	Toegang tot nieuwe kennis technologieën/clusters	Belasting, heffingen, subsidies	Gebrek aan gekwalificeerd personeel in eigen land	Importbeperkingen	Nabijheid van O&O of productie die reeds is overgeheveld	Toegang tot natuurlijke hulpbronnen leveranciers	Aanwezigheid van concurrenten
Overheveling van **productie-activiteiten** sinds 2013	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Verplaatsing **onderzoeks- en ontwikkelingsactiviteiten** sinds 2013	☐	☐	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Terugplaatsing (repatriëring) vanuit het buitenland naar het thuisland

Nee	**Ja**	Vanuit andere bedrijven in het buitenland	Vanuit eigen vestigingen in het buitenland	Uit welk land/landen	Kwaliteit	Flexibiliteit, leversnelheid	Capaciteitsbenutting	Beschikbaarheid gekwalificeerd personeel	Arbeidskosten	Transportkosten/ logistieke kosten	Kosten van coördinatie en toezicht	Nabijheid van binnenlandse O&O	Verlies van kennis/ -kopiëren/piraterij	Infrastructuur
Terugplaatsing van (delen van) de **productie** sinds 2013														
☐	☐ →	☐	☐		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

17 **Geef a.u.b. de herkomst van uw toeleveringen (inputs) en de bestemming van uw producten in 2014.**
► Toeleveringen zijn gekochte onderdelen, (ruwe) materialen, productiemiddelen en diensten. Geef alleen het aandeel aan van producten gemaakt in uw bedrijfsvestiging.

Toeleveringen afkomstig uit				Producten verkocht in:			
binnenland	ca	___ %	=100% van de inkoopwaarde	binnenland	ca	___ %	=100% van de omzet
buitenland	ca	___ %		buitenland	ca	___ %	

18.1 **Heeft uw bedrijfsvestiging onderzoek en ontwikkelingsactiviteiten (O&O) uitgevoerd of laten uitvoeren door externe partners in 2014?**

☐ nee ☐ ja → O&O-uitgaven in procenten van de omzet in 2014 ca. ___ %

18.2 **Heeft uw bedrijfsvestiging sinds 2012 continu O&O uitgevoerd of laten uitvoeren door externe partners?**

☐ nee ☐ ja

19 **Welk van de volgende kenmerken zijn het meest van toepassing op uw hoofdproduct(groep)?**

Productontwikkeling (kruis slechts één optie aan)

- Op specificatie van klant ☐
- Voor een standaardprogramma waarbinnen klantspecifieke wensen gerealiseerd kunnen worden ☐
- Voor een standaardprogramma, waaruit de klant kan kiezen ☐
- Niet aanwezig in deze bedrijfsvestiging ☐

Fabricage/montage (kruis slechts één optie aan)

- Na binnenkomst klantorder (make-to-order) ☐
- Eindmontage van het product wordt uitgevoerd na binnenkomst klantorder (assemble-to-order) ☐
- Op voorraad (make-to-stock) ☐
- Niet aanwezig in deze bedrijfsvestiging ☐

Seriegrootte (kruis slechts één optie aan)

- Enkelstuksproductie ☐
- Kleine of middelgrote series (20-1.000 stuks per maand) ☐
- Grote series (meer dan 1.000 stuks per maand) ☐
- Geen discrete productie (procesindustrie) ☐

Productcomplexiteit (kruis slechts één optie aan)

- Eenvoudige producten ☐
- Producten van middelgrote complexiteit ☐
- Complexe producten ☐

20 **Beantwoordt u de volgende vragen over uw hoofdproduct(groep).**

Wat is de gemiddelde productietijd van uw hoofdproduct(groep)? (doorlooptijd vanaf moment dat opdracht binnenkomt bij productie tot product klaar is voor levering) ca. ____ werk-dagen of ____ uren

Hoeveel procent van de orders wordt op tijd afgeleverd? ca. ____ %

Hoeveel procent van uw productie moet na kwaliteitscontrole nabewerking ondergaan of geheel worden afgekeurd? ca. ____ %

Welk percentage van de geleverde bestellingen heeft klachten van klanten opgeleverd vanwege kwaliteitsproblemen? ca. ____ %

21 **Hier worden enkele gegevens over uw bedrijfsvestiging gevraagd:**

Jaaromzet 2014 ____ miljoen € 2012 ____ miljoen €

Aantal werknemers (excl. uitzendkrachten) 2014 ____ aantal

Aantal werknemers dat is afgevloeid in 2014 2014 ____ aantal

Had uw bedrijfsvestiging uitzendkrachten in dienst in 2014? ☐ nee ☐ ja ➔ Hoeveel uitzendkrachten waren in 2014 gemiddeld in dienst bij uw bedrijfsvestiging? ca. ____ aantal

Inkoop 2014 (ingekochte onderdelen, materialen en diensten) ____ miljoen €

Afschrijvingen op machines en installaties 2014 (zonder grond en gebouwen) ____ miljoen €

Investeringen in machines en installaties 2014 ____ miljoen €

Personeelskosten als percentage van de omzet in 2014 (incl. loonnevenkosten) ____ %

Graad van capaciteitsbenutting (gemiddeld in 2014) ____ %

Totale energiekosten als percentage omzet 2014 ____ %

Rendement op de omzet (vóór belasting in 2014) ☐ negatief ☐ 0 tot 2% ☐ > 2 tot 5% ☐ > 5 tot 10% ☐ > 10%

Jaar van oprichting, c.q. inschrijving bij de Kamer van Koophandel jaar: ____

Heeft uw bedrijfsvestiging een ondernemingsraad? ☐ nee ☐ ja

22.1 **Geef uw energieverbruik aan als volgt:**

Wat was het aandeel groene stroom in het totale stroomverbruik van uw bedrijfsvestiging in 2014? ca. ____ %

Hoe groot is de te verwarmen oppervlakte van uw bedrijfsvestiging? ca. ____ m^2

22.2 **Hoe heeft het stroomverbruik van uw bedrijfsvestiging zich ontwikkeld in 2014?**

Gedaald met 10% of meer	Gedaald 5 - < 10%	Gedaald 0 - < 5%	Gelijk gebleven	Gestegen 0 - < 5%	Gestegen 5 - < 10%	Gestegen met 10% of meer
☐	☐	☐	☐	☐	☐	☐

22.3 **Hoe heeft het olie- en gasverbruik van uw bedrijfsvestiging zich ontwikkeld in 2014?**

Gedaald met 10% of meer	Gedaald 5 - < 10%	Gedaald 0 - < 5%	Gelijk gebleven	Gestegen 0 - < 5%	Gestegen 5 - < 10%	Gestegen met 10% of meer
☐	☐	☐	☐	☐	☐	☐

23 **Wie is in meerderheid of exclusief eigenaar van het bedrijf waartoe uw bedrijfsvestiging behoort?**

☐ Private eigenaar/ familie ☐ Financiële investeerder (bijv durfkapitaal) ☐ Ander bedrijf (bijv. niet-financiële investeerder) ☐ stichting ☐ overige eigenaren ☐ Geen meerderheidseigenaar

→ Is de familie actief in het management? ☐ Nee ☐ Ja

Hartelijk dank voor uw bijdrage aan dit onderzoek.

Wij verzoeken u de ingevulde vragenlijst terug te sturen per e-mail naar: P.Vaessen@fm.ru.nl

of per post naar:

Radboud Universiteit Nijmegen, t.a.v Dr P.Vaessen, Antwoordnummer 1908, 6500 VC Nijmegen

Appendix II: table of operationalization

Type variable	Variable name	Item (& question reference)	Min	Max	Measurement level	Comments
Dependent variable	Product innovation	Introducing new products (9.1)	0	1	Nominal	Yes/no
	Product-service innovation	Innovation product-related services (10.3)	0	1	Nominal	Yes/no
Independent variable	Non-R&D human capital	Educational level employees (15.1)	0	100	Ratio	(%)
	Social capital	Collaborations with external partners (6.1)	0	1	Nominal	Yes/no
	Organizational capital	Requirements for the workplace layout of equipment and storage of intermediate products (3.1)	0	1	Nominal	Yes/no
		Standardised and detailed work instructions (3.2)	0	1	Nominal	Yes/no
		Production worker task enrichment (3.3)	0	1	Nominal	Yes/no
		Measures to improve internal logistics (3.4)	0	1	Nominal	Yes/no
		Methods prescribed for reducing changeover and lead times during product changeover (3.7)	0	1	Nominal	Yes/no
		Graphical representation of work processes and status (3.8)	0	1	Nominal	Yes/no
		Methods of continuous improvement (Kaizen, quality circles, etc.)(3.11)	0	1	Nominal	Yes/no
		Measures for retaining older workers or their knowledge for your business establishment (3.15)	0	1	Nominal	Yes/no
	R&D	Distribution of personnel based on departments: for comparing R&D/Non-R&D (15.2)	0	1	Ratio	(%)
Moderating variable	Non-R&D human capital	Educational level employees (15.1)	0	100	Ratio	(%)
Control variable	R&D	Distribution of personnel based on departments: for comparing R&D/Non-R&D (15.2)	0	100	Ratio	(%)

Figure 3: table of operationalization

Appendix III: Bivariate analysis table

Pearson correlation

	1	2	3	4	5	6
1. Product innovation	1	0,11	0,04	0,26**	0,12	0,19*
2. product-service innovation		1	-0,01	0,25**	0,16	0,09
3. (non-R&D) Human capital			1	0,22**	0,15	0,33**
4. Social capital				1	0,34**	0,18*
5. Organizational capital					1	0,10
6. R&D						1

Appendix IV: Assumptions binary logistic regression

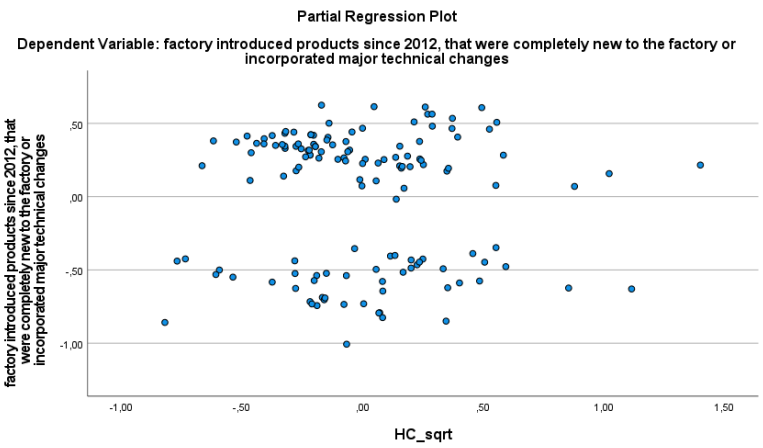
1. Multicollinearity test

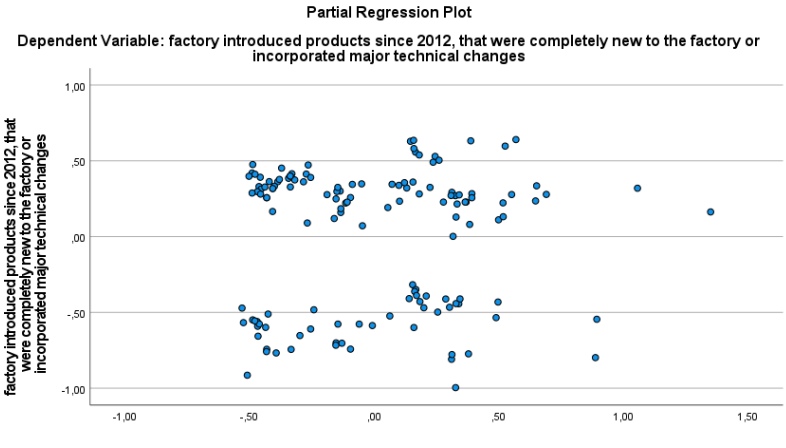
	Tolerance product innovation	VIF	Tolerance product-service innovation	VIF
Human capital	0,86	1,16	0,85	1,18
Social capital	0,85	1,18	0,85	1,18
Organizational capital	0,88	1,14	0,88	1,13
R&D	0,88	1,14	0,87	1,16

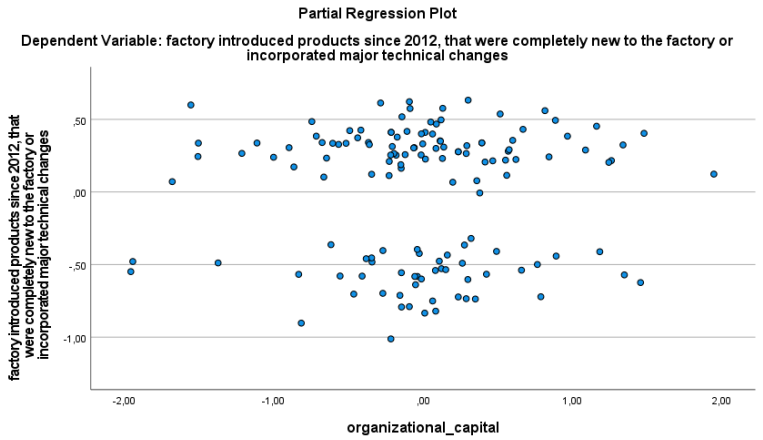
2. Linearity test

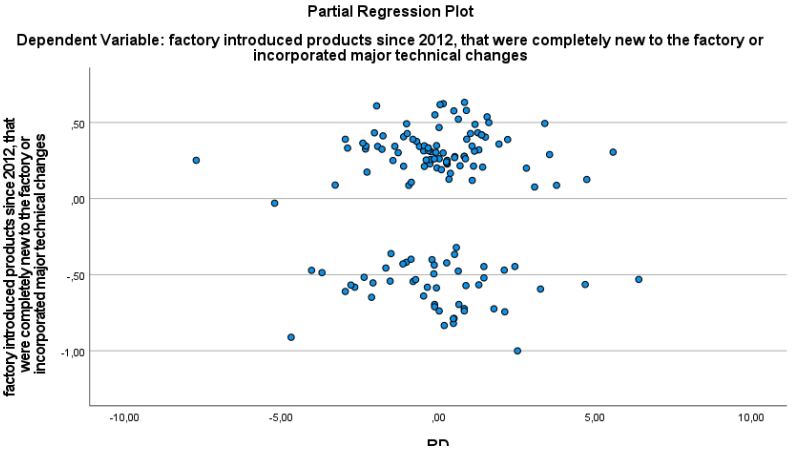
Variable	**Sign product innovation**	**Sign product-service innovation**
Human capital	0,88	0,36
Social capital	0,77	0,41
Organizational capital	0,95	0,77
R&D	0,23	0,34
HC *social capital	0,31	0,03
HC * organizational capital	0,87	0,39
HC * R&D	0,62	0,25
Human capital by human capital (log)	0,84	0,49
Social capital by social capital (log)	0,66	0,61
Organizational capital by organizational capital (log)	0,84	0,56
R&D by R&D (log)	0,91	0,50
HC *social capital by HC *social capital (log)	0,26	0,36
HC * organizational capital by HC * organizational capital (log)	0,84	0,56
HC * R&D by HC * R&D (log)	0,86	0,55

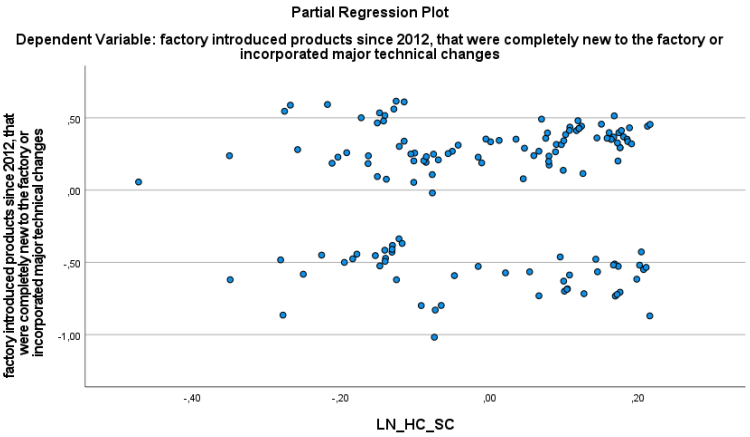
3. Influencing outliers first dependent variable: product innovation

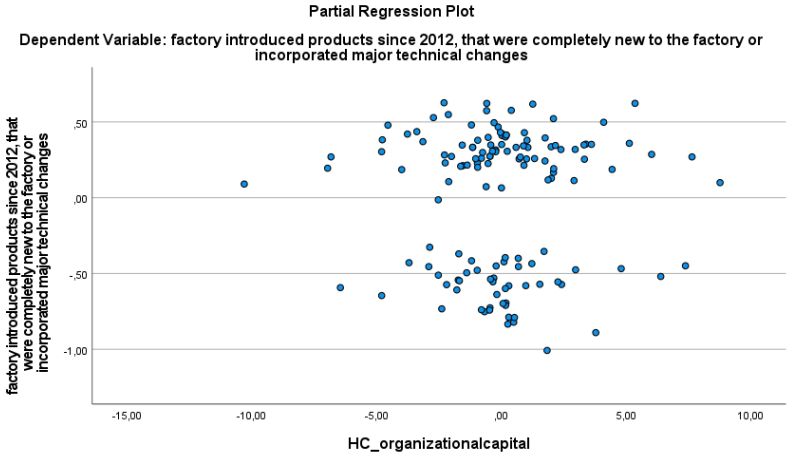


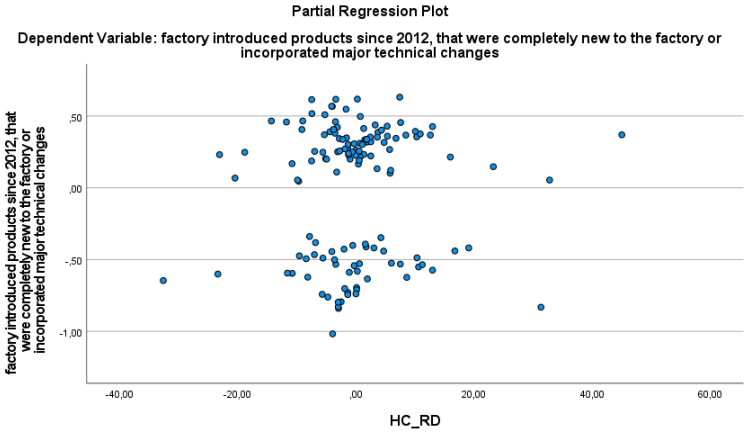




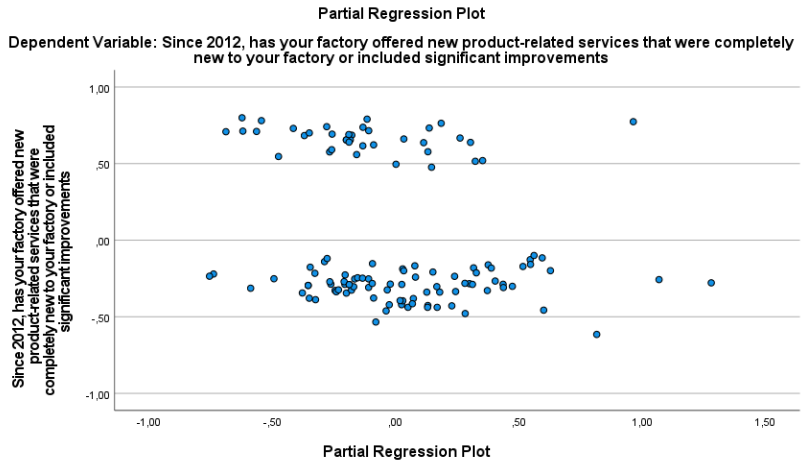


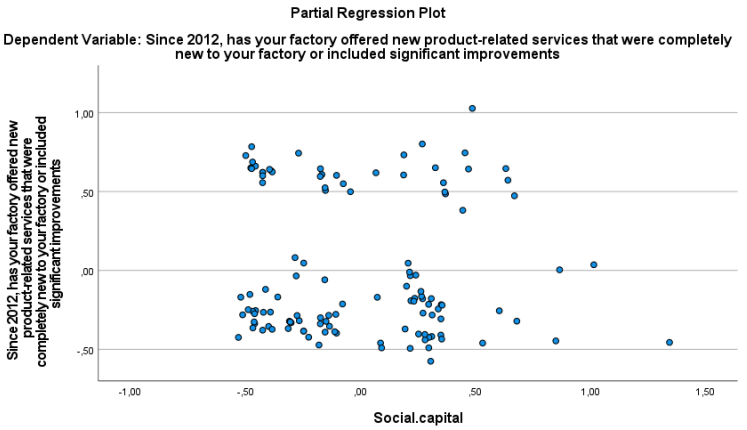


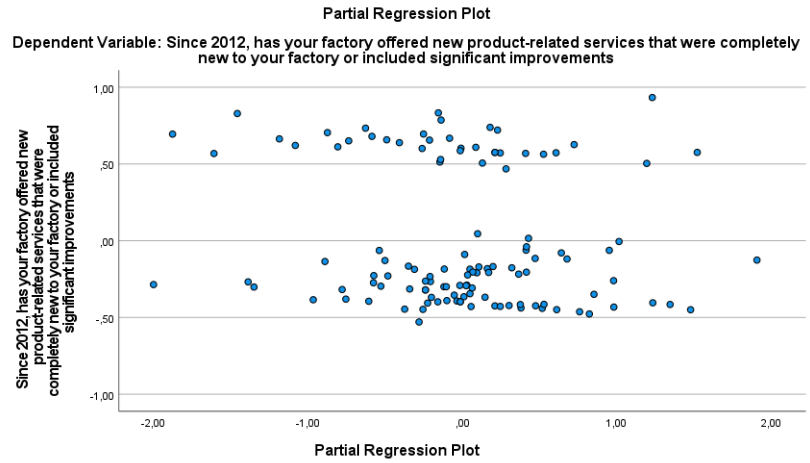


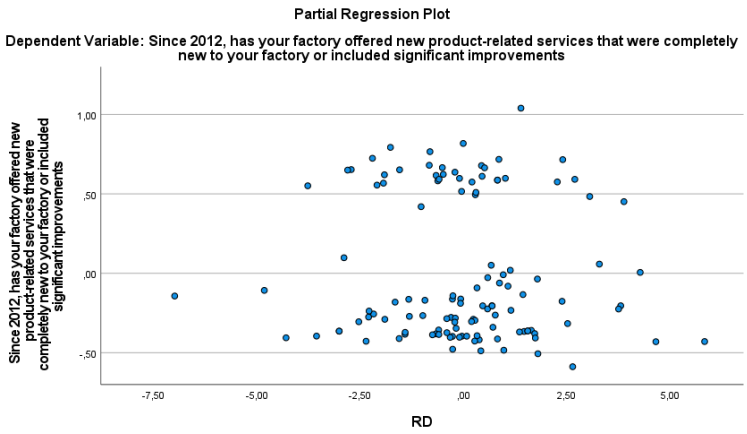


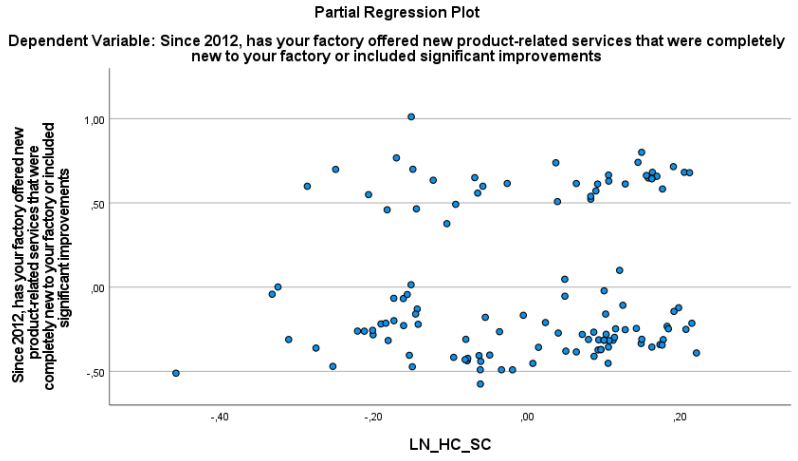
4. Influencing outliers second dependent variable: product-service innovation

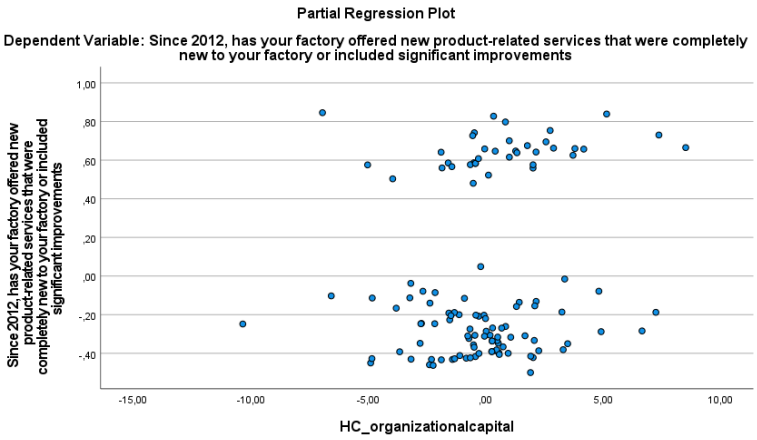


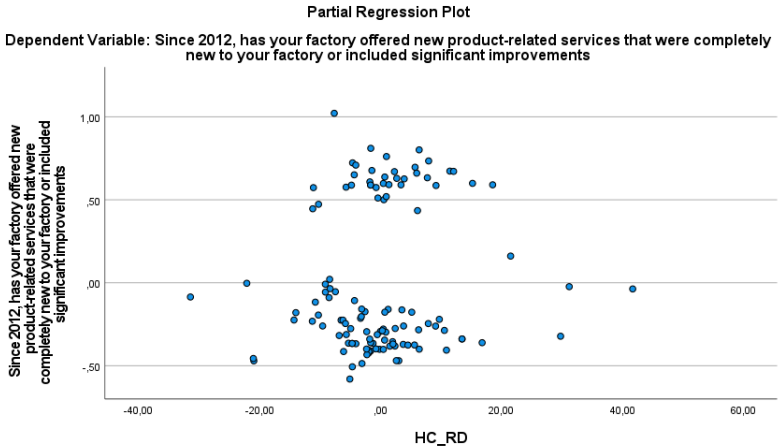












Appendix V: Binary regression analysis product innovation

Analysis 1

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	16,131	13	,242
Deviance	18,198	13	,150

Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	54,749	57,914	52,749			
Final	49,879	56,209	45,879	6,870	1	,009

Likelihood Ratio Tests

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	47,948	51,113	45,948	,069	1	,793
RD	54,749	57,914	52,749	6,870	1	,009

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	RD	,077	,031	6,109	1	,013	1,080
	Constant	,057	,217	,069	1	,793	1,059

a. Variable(s) entered on step 1: RD.

Analysis 2

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	168,499	162	,347
Deviance	204,067	162	,014

Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	229,481	232,645	227,481			
Final	219,848	235,671	209,848	17,633	4	,001

Likelihood Ratio Tests

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	218,500	231,160	210,500	,653	1	,419
RD	223,031	235,690	215,031	5,184	1	,023
HC_sqrt	219,005	231,665	211,005	1,158	1	,282
Social.capital	226,324	238,983	218,324	8,476	1	,004
organizational_capital	218,157	230,816	210,157	,309	1	,578

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
RD	,073	,034	4,757	1	,029	1,076
HC_sqrt	-,116	,108	1,153	1	,283	,890
Social.capital	,300	,106	8,022	1	,005	1,350
organizational_capital	,044	,079	,309	1	,578	1,045

Analysis 3

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	130,909	125	,341
Deviance	158,936	125	,022

Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	175,695	178,615	173,695			
Final	173,331	187,930	163,331	10,365	4	,035

Likelihood Ratio Tests

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	175,169	186,849	167,169	3,839	1	,050
RD	172,037	183,716	164,037	,706	1	,401
LN_HC_SC	177,275	188,955	169,275	5,944	1	,015
HC_organizationalcapital	171,331	183,011	163,331	,001	1	,981
HC_RD	171,422	183,102	163,422	,091	1	,762

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

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Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
RD	,069	,081	,720	1	,396	1,071
LN_HC_SC	,744	,311	5,735	1	,017	2,104
HC_organizationalcapital	,000	,021	,001	1	,981	1,000
HC_RD	-,005	,015	,094	1	,759	,995

Appendix VI : Binary regression analysis product-service innovation

Analysis 1

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	14,305	13	,353
Deviance	15,165	13	,297

Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	43,854	46,871	41,854			
Final	44,736	50,770	40,736	1,118	1	,290

Likelihood Ratio Tests

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	68,685	71,702	66,685	25,949	1	<,001
RD	43,854	46,871	41,854	1,118	1	,290

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	RD	,033	,031	1,143	1	,285	1,034
	Constant	-1,290	,271	22,624	1	<,001	,275

a. Variable(s) entered on step 1: RD.

Analysis 2

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	139,622	139	,469
Deviance	152,099	139	,211

Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	168,789	171,806	166,789			
Final	165,107	180,194	155,107	11,681	4	,020

Likelihood Ratio Tests

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	175,525	187,594	167,525	12,417	1	<,001
RD	163,680	175,749	155,680	,572	1	,449
HC_sqrt	164,085	176,154	156,085	,977	1	,323
Social.capital	169,742	181,811	161,742	6,634	1	,010
organizational_capital	164,187	176,257	156,187	1,080	1	,299

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
RD	,027	,035	,573	1	,449	1,027
HC_sqrt	-,123	,127	,946	1	,331	,884
Social.capital	,314	,125	6,271	1	,012	1,369
organizational_capital	,098	,095	1,067	1	,302	1,103

Analysis 3

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	114,564	109	,339
Deviance	139,132	109	,027

Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	146,679	149,467	144,679			
Final	152,140	166,077	142,140	2,539	4	,638

Likelihood Ratio Tests

	Model Fitting Criteria			Likelihood Ratio Tests		
Effect	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	154,291	165,441	146,291	4,151	1	,042
RD	152,340	163,490	144,340	2,200	1	,138
LN_HC_SC	150,423	161,573	142,423	,283	1	,595
HC_organizationalcapital	150,418	161,568	142,418	,278	1	,598
HC_RD	152,270	163,420	144,270	2,130	1	,144

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
RD	,128	,089	2,046	1	,153	1,136
LN_HC_SC	,191	,361	,280	1	,596	1,211
HC_organizationalcapital	,011	,022	,277	1	,599	1,011
HC_RD	-,023	,017	1,782	1	,182	,977