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Organising for Innovation Through Corporate Board Interlocks

Master Thesis

Master's programme in Business Administration, specialisation Strategic Management

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Preface

Before you lies the master thesis "Organising for Innovation Through Corporate Board Interlocks" which was written in order to fulfil the graduation requirements of the Master's programme in Business Administration, specialisation Strategic Management at the Nijmegen School of Management, Radboud University.

Is has taken some ups and downs to get to the point of this finished thesis, but in the end I am quite pleased with the results obtained. The thesis has been written based on a literature review of knowledge management and social network literature in relation to innovation and a multiple regression analysis performed using a dataset constructed from public information sources.

I would to thank my thesis supervisor Dr. Rick Aalbers for his patience and ongoing constructive criticisms along the way to steer me in the right direction and for providing me with useful information where needed. The same goes for my second examiner Dr. Ayse Saka-Helmhout who's comments on my research proposal really helped me to re-evaluate my theoretical framework.

Finally, I would like to thank my family and friends for their ongoing support. If I ever lost interest, they kept me motivated to continue.

Bastiaan Klaasse
Nijmegen, May 2017

Abstract

The goal of this study is twofold. First, it draws on knowledge management and social network literature in order to explain through which mechanisms corporate board interlocks are related to innovation. This is done by systematically reviewing literature coming from these research areas and formulating three hypothesis. Second, it is to empirically determine the relation between corporate board interlocks and a board's commitment to innovation by performing a lagged hierarchical multiple regression analysis using public company data. The empirical results indicate that it is in part possible to arrange innovation at the level of the board through intra-industry interlocks. No effect was found for interlocks with companies residing outside of the focal industry.

Key words: *knowledge management, innovation, networks, corporate board interlocks.*

Contents

1. Introduction

Many studies have shown that relations exist between organisational outcomes and board characteristics (Johnson, Schnatterly, & Hill, 2012). For instance, board size and diversity in terms of occupational background are found to be negatively related (Goodstein, Gautam, & Boeker, 1994) as well as positively related (Haynes & Hillman, 2010) to strategic change. Also, board size and ties to financial institutions are positively related to survival in times of industrial decline (Filatotchev & Toms, 2003) and board diversity is often associated with innovation (Crossan & Apaydin, 2010; Midavaine, Dolfsma, & Aalbers, 2016). Focussing on corporate ties specifically, Yoo & Reed (2015) find that top managers with intra-industry ties (connections with entities inside the focal industry) are more likely to adopt a resource imitation strategy. Geletkanycz & Hambrick (1997) show that that extra-industry ties (connections with entities outside the focal industry) are in turn negatively related to strategic conformity. It can be concluded that a relation exists between board characteristics such as the configuration of corporate ties and the strategic direction of the firm.

An important aspect of a firm's strategy should be innovation, since it is regarded as the most important determinant of organisational performance and a critical source of competitive advantage (Crossan & Apaydin, 2010; Miller & Triana, 2009), especially in the high-tech industry which is characterised by high levels of research & development (Ahuja, 2000; Stuart, 2000). In order for an organisation to innovate, access to the right resources is critical. It is no surprise to see that both of these themes have been emerging in knowledge management studies in the past two decades (Lee & Chen, 2012). In an ever faster changing and internationalising market, the knowledge a firm requires for innovation (Quintane, Casselman, Reiche, & Nylund, 2011) is spread across more countries, organisations and people. Therefore, innovation advantages no longer lie in the organisation's internal resources, but in its ability to recognize, assimilate and apply valuable external knowledge (Cegarra-Ciprés, Roca-Puig, & Bou-Llusar, 2014). For knowledge intensive firms (Millar, Lockett, & Mahon, 2016) such as those in the high-tech industry, it becomes increasingly important to strategically manage their knowledge resources in support of their innovative capabilities. Access to knowledge can be managed and arranged at different organisational levels. This study, however is focussed at the top level, the board, as previous studies have already shown that board characteristics are related to an organisation's strategic direction. Furthermore, Chen, Ho & Hsu (2013), argue that the effect of corporate board ties on

innovation is an incomplete research area which should be investigated into more detail. Therefore, this study proposes that board interlocks can be seen as the organisational aspect that can be used to organise for innovation by linking an organisation's board to diverse and external knowledge sources that provide it with the opportunities for innovation. More specifically, this firm level study focuses on inter- and intra-industry ties of corporate board members of companies residing in The Netherlands and Germany in relation to the board's commitment to innovation.

Innovation is a term that is sometimes hard to grasp as it is interpreted in many ways. Innovation is often seen as something fundamentally new, which has never been done or seen before. However, many scholars do not define innovation as such. For instance, Dougherty (1999) defines product innovation as: "the conceptualization, development, operationalization, manufacture, launch, and ongoing management of new products and service. (…) 'New' means new to the organization and can involve customers, new users, new manufacturing, new distribution and logistics, new product technologies, and any combination of these" (p. 175). Miller & Triana (2009) define corporate innovation strategies as "those strategies that provide new strategic opportunities for the firm to create new services or product lines" (p. 759) In both definitions new does not mean fundamentally new, but new to the organisation. The same notion about innovation is found in the Oslo Manual (OECD & Eurostat, 2005) which argues that: "an innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD & Eurostat, 2005, p. 46), meaning that not only innovations do not have to be fundamentally new, they also can occur within any type of organisation and any organisational aspect. This study, however, does not focus on the innovation process itself, or the success of innovation efforts, but on the board's propensity to innovate, or in other words, its commitment to innovation. It sets out to clarify how board interlocks affect the boards strategic decision making process in terms allocating resources to innovation.

The goal of this study is twofold. First, it draws on knowledge management and social network literature in order to explain through which mechanisms corporate board interlocks are related to innovation. This is done by systematically reviewing literature coming from these research areas and formulating three hypothesis. Second, it is to empirically determine the relation between corporate board interlocks and a board's commitment to innovation by performing a lagged hierarchical multiple regression analysis using public company data.

2. Theoretical Background

2.1 Knowledge management & innovation

This paragraph is written in part based on a systematic literature review methodology which is explained in appendix I-A.

During the last two decades both firm resources and innovation have been important themes in knowledge management literature (Lee & Chen, 2012). Knowledge management is defined by Inkinen (2016) as "the conscious organizational and managerial practices intended to achieve organizational goals through efficient and effective management of the firm's knowledge resources" (p. 232). It entails how organisations obtain knowledge for instance through organisation learning which is critical for maintaining a firm's competitive advantage (Venkitachalam & Busch, 2012). Conclusions from Inkinen's (2016) literature review support the knowledge-based theory of the firm which states that "the success of firms is up to both their current knowledge and also how they use and develop it" (p. 240). Studies reviewed by Inkinen (2016) show that knowledge-based human resource practices (i.e. strengthening affective commitment and trust building), technology oriented practices for knowledge management (i.e. the effective use of information technology) and strategic management of knowledge (i.e. monitoring and measuring a firm's knowledge resources) all are proven to be influential drivers of innovation and firm performance.

So what are the antecedent of innovation looking from this perspective, how can firms strategically manage their knowledge resources? Phelps, Heidl & Whadwa (2012) argue that social network relationships are influential in explaining the processes of knowledge creation, diffusion, absorption and application. Network ties (Ahuja, 2000) and central network positions (Van Wijk, Jansen, & Lyles, 2008; Tsai, 2001) are found to be positive stimulants of innovation. The latter study does show however, that this effect also depends on the level of absorptive capacity which relates to the ability to recognize valuable external information, assimilate and apply it (Cohen & Levinthal, 1990).

The question arises which network relations matter or to what knowledge sources firm's should be connected in order to benefit. Hambrick & Mason's (1984) upper echelon perspective states that organisational outcomes are partially predicted by managerial characteristics. Organisational outcomes are to a large extent a function of its top management team and board (Dezso & Ross, 2012). Board characteristics include for instance board size, average age and gender diversity but can also include managerial network ties, for instance

connections to other organisations through corporate board interlocks which occur when companies share one or multiple board members. An interlocked board member can be seen as a tie in a network of interlocked boards while the end of the tie, the other organisation, may provide the focal company with the resources, for instance in the form of financial aid or knowledge (Lamb & Roundy, 2016). Therefore, this study proposes that corporate board interlocks can be seen as an organisational aspect which can be used for the strategic management of knowledge and innovation by linking an organisation's board to diverse and external knowledge sources that provide it with the opportunities for innovation

2.2 Corporate board interlocks

Characteristic to coordinated market economies in general, and countries such as Germany and The Netherlands in particular, is the two tier-board system. Within this system the top decision-making body of organisations is divided between two boards that meet separately from each other. An executive board that is responsible for the day to day operation of the organisation and a supervisory board which is tasked with monitoring the actions and functioning of the executives, approving strategy and protecting the interests of the shareholders (Heemskerk, 2007). In terms of a one-tier system, were only one governing board exists, it can best be compared to inside and outside directorships. Inside directors are employed on a daily basis by the company where they reside in the board, outside directors are not (Westphal & Bednar, 2005; Pfeffer, 1972). If a member of an executive or supervisory board of one organisation also occupies a position in the board of another firm, two organisations become connected through this board member. This connection between two corporate boards is known as a corporate board interlock or an interlocking directorate (Heemskerk, 2007).

From the perspective of the firm, board interlocks may serve different purposes such as monitoring capabilities, signalling to (potential) investors, gaining access to the human capital of board members and, most relevant to this study, providing the firm with crucial resources such as access to diverse and unique information (Lamb & Roundy, 2016). Howard, Withers & Tihanyi (2016) for instance find that interlocked firms are more likely to engage in R&D alliances which gains them access to each other's knowledge resources.

Scholars often distinguish between two types of interlocks: inter- and intra-industry (Crossan & Apaydin, 2010; Haynes & Hillman, 2010), also known as vertical and horizontal interlocks respectively (Ruigrok, Peck, & Keller, 2006). This classification refers to whether

an interlock is with a company within the same industry (intra) or whether is with a company outside of the focal industry (inter).

In order to develop a theoretical basis for explaining how these two types of interlocks affect a board's propensity to innovate, another literature review is conducted which is discussed in appendix I-B. Based on this review, the proposed effect of inter-industry interlocks is explained (also see figure 1) using the network theoretical concept of ties to non-local knowledge coming from Granovetter's (1973; 1983) 'the strength of weak ties' and absorptive capacity theory (AC) (Cohen & Levinthal, 1990) which was already briefly mentioned in paragraph 2.1. The proposed effect of intra-industry ties is grounded in the network theoretical concepts of social capital theory (Coleman, 1988) and industry embeddedness which also originates in Granovetter's (1973; 1983) 'the strength of weak ties'.

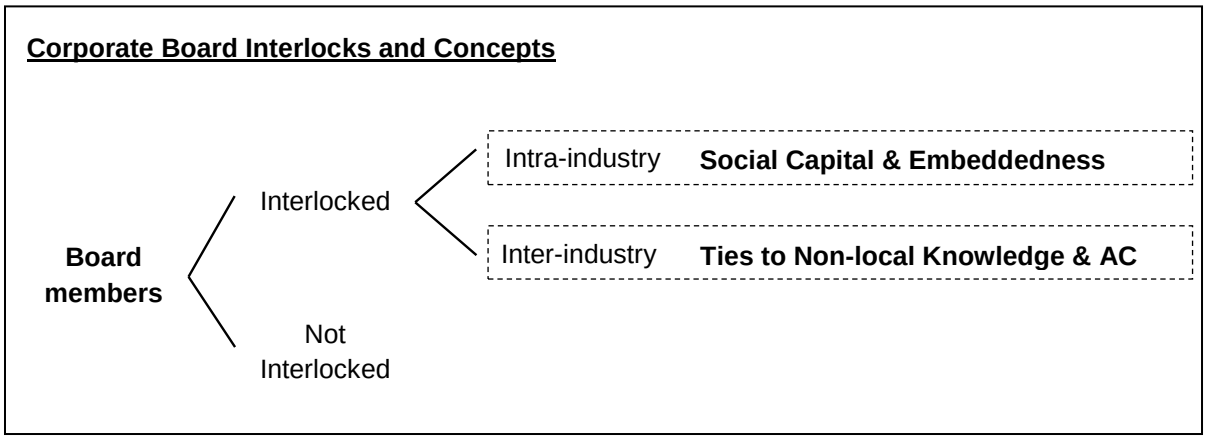


Figure 1: Corporate board interlock classifications and relating concepts.

2.3 Inter-industry interlocks

Absorptive capacity is "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" which is "a critical component of innovative capabilities" and is "largely a function of the firm's level of prior related knowledge (Cohen & Levinthal, 1990, p. 128). The concept of organisational absorptive capacity is based on the individual cognitive structures that underlie learning. Cohen & Levinthal (1990) present evidence that prior knowledge increases the ability to memorise new knowledge (acquisition) and the ability to recall and use it. Furthermore, in case that the new knowledge is a set of learning skills, a prior set of learning skills can enhance the performance on a new learning task (Howard, Withers, & Tihanyi, 2016). Problem solving and learning capabilities however, are so similar that no differentiation is made, the only difference lies in what is learned: learning capabilities involve the development of the capacity to assimilate existing knowledge, while problem-solving skills represent a capacity to create new

knowledge. The most important notion is that the ability to assimilate information is a function of pre-existing knowledge: learning performance is greatest when the subject is related to something that is already familiar. Here the concept of knowledge diversity emerges. If uncertainty exists in the knowledge domains from which potentially useful information may emerge, a diverse background increases the chance that information will relate to what is already known. As such, knowledge diversity not only increases assimilative powers, but it also acts as a stimulant to innovation processes by enabling one to make novel associations and linkages (Cohen & Levinthal, 1990).

Ye, Hao & Patel (2016) address knowledge diversity and provide evidence for its positive effect on innovation. Their study focusses specifically on the complementary joint relationship between internal (residing within the firm) and external (residing outside the firm) knowledge diversity (called heterogeneity in their study) in influencing innovation performance. Findings indicate, in line with absorptive capacity theory, that firms depending too much on external knowledge and too little on internal knowledge, lack the ability to assimilate because a diversity of internal knowledge increases the chance that the firm can relate to novel information. Building on the same arguments derived from absorptive capacity theory, similar results were found by Lin (2011) who shows that firms with high levels of knowledge diversity benefit more from strategic alliances and mergers and acquisitions in terms of firm performance. Other scholars refer to external knowledge diversity as the 'breath of external knowledge sources' (Leiponen, 2012; Garriga, Von Krogh, & Spaeth, 2013) and also find positive associations with innovation performance. Focussing specifically on internal knowledge diversity, Carnabuci & Operti (2013) show that the internal diversity of knowledge among a firm's inventors decreases innovation by recombinant reuse and increases innovation by creating new combinations. Reuse refers to the extent to which organisations innovate by reconfiguring and refining known technological combinations while creation refers to the extent to which they innovate by creating new technological combinations. It is argued that the diversity of knowledge among inventors raises cognitive barriers that obstruct the knowledge to flow from where it is held to where it is needed. Because inventors have to develop solutions themselves, and because they are better equipped to make novel associations and linkages (Cohen & Levinthal, 1990), knowledge diversity stimulates innovation by recombinant creation.

An interesting notion on absorptive capacity comes from a study by Larrañeta, Zahra, & González (2012) that investigates the moderating effect of absorptive capacity on the relation between the diversity and novelty of external knowledge sources and strategic variety (a

firm's range of competitive actions). Evidence is found for the direct positive relation between the novelty and diversity of external knowledge and strategic variety. However, the effect of absorptive capacity is less straight forward. Larrañeta et al. (2012) find that a highly developed absorptive capacity tends to homogenize the effect of diversity and novelty on strategic variety, weakening the relationship. The authors argue that there are upper limits to the potential gains from absorptive capacity and that above a certain threshold, it can oppose strategic variety because of a (too) well developed ability to select and link different types of knowledge along well-known paths. These self-reinforcing habitual pattern of actions help an organisation to deepen its existing knowledge, but not to engage in something new, and in case of this study is not necessarily beneficial to strategic variety.

However, the most important notion to take away from absorptive capacity theory in relation to innovation is that a diversity of internal knowledge enables the assimilation and application of external knowledge as it occurs. This is also the link between absorptive capacity theory and the network theoretical concept of the strength of weak ties (Granovetter, 1973; 1983). Kesidou & Snijders (2012) stress the importance of indirect ties and connections to non-local networks. Indirect ties or contacts are the connections one has through its direct contacts. They build on Granovetters's (1973; 1983) work to explain that indirect ties are the channels through which distant ideas, influences, or information may reach an actor. "The fewer indirect contacts one has the more encapsulated he will be in terms of knowledge of the world beyond his own friendship circle" a state referred to as 'embeddedness' (Granovetter, 1973, p. 1371). Indirect ties allow organisations to source a great diversity of information outside their inner circle of close relations and potentially enclose a great source on new information as the indirect tie itself could be embedded in another dense network of actors. Consistent with this theory Kesidou & Snijders (2012) show that firms with indirect local ties show higher innovation performance than other firms in the same regional cluster. They also find that organisations linked to non-local knowledge networks (networks outside the regional cluster) show better innovation performance than those who do not.

The effect of ties to non-local knowledge in the form of inter-industry interlocks is two-fold. First, ties with companies outside of the focal company's industry, increase a board's internal knowledge diversity as board members reside in multiple domains. Following absorptive capacity theory this improves the board's ability to recognize and pursue innovation opportunities. Second, inter-industry ties can be seen as the ties to non-local networks that contain a great variety of information. Inter-industry ties therefore increase both

the availability of external information as well as the ability to take advantage from it. This conclusion leads to the first hypothesis:

H1: There is positive relation between the number of inter-industry interlocks and innovation in terms of R&D expenditure.

2.4 Intra-industry interlocks

Coleman's (1988) social capital theory addresses the level of closure in a network. Maximum closure occurs when all actors in a network are interconnected. The higher the number of actual ties in a network in relation to the number of possible ties, the higher the level of closure (or network density). Social capital is quite an intangible concept as it relates to the value that is in the structure of relations between and among (corporate) actors. It relates to how actors can benefit from aspects of the social network around them. Coleman (1988) addresses three forms of social capital: social norms, obligations and expectations and information channels. He argues that the social structure that best facilitates these three forms of social capital is network closure. Strong norms and values arise when community is strongly interconnected through network ties enabling effective sanctioning mechanisms that reduce opportunistic behaviour. Social capital in the form of obligations and expectations relates to the trust between actors and the reciprocity of actions. Actors that have provided favours to others in the past, can expect to be reciprocated in the future. Social capital also occurs as the potential of information that is inherent in social relations. High levels of closure allows information to flow freely through a network improving accessibility of information for all network actors. A synthesis of empirical literature by Zheng (2010) finds that all three of these forms of social capital can be positively linked to innovation.

The latter two points are also confirmed in a study by Laursen, Masciarelli, & Prencipe (2012) which adresses the effect of regional social capital among manufacturing companies on the introduction of product innovations. They focus on the difference in social capital between different geographic regions and how this affects the effectiveness of internal and external R&D activities and the propensity to innovate. It is argued that social capital enables innovation because it helps connecting people accros organisations and to combine their knowledge. Increased trust enables the external knowledge search and provides organisations with learning opportunities on how to deal with managing outsourced R&D activities. Furthermore, social capital does not only enhance the ability the recognize knowledge and opportunities on the supply side, it also can improve the understanding of local demands. The

results support these theses as a positive relation is found between the level of social capital and the introduction of product innovations.

Parra-Requena, Ruiz-Ortega, García-Villaverde & Rodrigo-Alarcón (2015) investigate the effect of social capital on innovation within the Spanish footwear industry. Social capital here is operationalised as network density, trust between network actors and cognitive proximity. Cognitive proximity relates to the extent to which companies share goals, objectives, and have a common understanding of how an innovation should be established. They specifically focus on the role of knowledge acquisition and find that it is this variable that explaines (mediates) the relation with social capital. They find that knowledge acquisition positively mediates the relation between trust and innovativeness and cognitive proximity and innovativeness. Trust in itself does not explain differences in innovativeness adeaquately, it is argued. It is the increased ability to obtain external knowledge because actors are more willing to share as a result of trust, that explains innovativeness. The same is said for cognitive proximity since a shared vission or set of values enables actors to identify en effectively communicate valuable knowledge.

Moving away from the initial innovation generation or recognition phase, a study by Foss, Lyngsie, & Zahra (2013) focusses on the factors that underlie the successful development of a new (innovation) opportunity. They focus on the role of external knowledge and organisational design in successfully exploiting new opportunities and bringing them to market. The extent to which an organisation is able to recognize problems related to novel opportunities and is able to solve those, is a function of external knowledge sources containing such information. One must think of industry specific standards or certain production capabilities for instance. Furthermore, they address the importance of the organisation's structure in bringing external knowledge into the organisation, specifically decentralisation of decision making and the coordination of work flow. A significant three-way interaction shows that a combination of these two with using external knowledge has positive effect on the exploitation of new opportunities. Although this does not directly relate to innovation in terms of generating new ideas, it does show that external knowledge in combination with the right internal conditions of decentralisation and coordination, is crucial for developing and monetizing those ideas.

Chen, Ho & Hsu (2013) endorse the effect of social capital as they argue that it helps to link firm to critical information and resources in their environment. They find that board social capital enhances the counsel that boards can provide to their CEO and enhance their decision making towards a more R&D oriented approach.

The effects of social capital may not all benefit innovation. Carnabuci & Operti (2013) for instance also investigate the effect of collaborative integration on recombinant reuse and recombinant creation (innovation by reconfiguration and innovation by creation) and find that a dense network is not necessarily favourable to innovation. Collaborative integration is the extent to which a firm's inventors are part of one integrated intra-organizational network. The study finds that this embeddedness into the intra-organisational network, increases recombinant reuse and decreases creation. An integrated network allows information to flow from those who possess it to those who need it, enabling reuse of existing combinations. If the intra-organisational network is more scattered, knowledge stays with those who developed it and inventors facing a new challenge are more likely to develop new solutions themselves. This corresponds to Geletkanysz & Hambrick's (1997) partial support for the hypotheses that top executives intra-industry ties lead to strategic conformity. To put this in Granovetter's (1973; 1983) terms, intra-industry ties could lead to embeddeness into a group of industry peers, reducing the ability to look outside industry boundaries, lacking connections to distant and diverse bodies of knowledge thus reducing innovative capabilities. Uzzi's (1996; 1997) studies show results that support these negative effects of embeddeness in relation to firm performance. However, only from a certain treshold. Until this treshold, embedded firms have shown more chance of survival than firms that maintain 'arm's-length' market relationships.

This study proposes that intra-industry interlocks can be used to build a firm's social capital and embed it within its respective industry. These ties not only serve as channels for obtaining technical knowledge, but also provide the board with much needed market information, knowledge about competitors and suppliers and the needs of customers so that they can engage in efficient and effective allocation of resources to R&D activities. The effect of embeddedness is difficult to predict as its negative effect seems to only occur at high levels. Focussing mainly on the positive effects of social capital and low levels of industry embeddedness through intra-industry interlocks, the second hypothesis is formulated as follows:

H2: There is a positive relation between the number of intra-industry interlocks and innovation in terms of R&D expenditure.

2.5 Moderation effect

Considering the predicted possible negative consequences of high levels of industry embeddedness related to high numbers of intra-industry interlocks such as the inability to look outside industry boundaries, it could be argued that this effect can be counteracted by means

of inter-industry interlocks as these link the organisation's board to companies outside of the respective industry. There might exist a symbiotic effect between inter- and intra-industry interlocks as the former can reduce the negative consequences related to the latter. An organisation's board can benefit from ties to external bodies of knowledge, high levels of absorptive capacity as well as industry specific knowledge without the negative consequences of industry embeddedness. In other words, the number of inter-industry interlocks might alter the relationship between intra-industry interlocks and innovation. Considering the former it is expected that the effect on this relationship by inter-industry interlocks is positive, and thus strengthens it. This means that a positive moderation effect is expected of inter-industry interlocks on the relation between intra-industry interlocks and innovation. This results in the third hypothesis:

H3: Inter-industry interlocks positively moderate the relation between intra-industry interlocks and innovation in terms of R&D expenditure in a way that the relation becomes more positive as the number of inter-industry interlocks increases.

2.6 Conceptual model

The hypothesised effects as well as the control variables that are included, are depicted in the conceptual model in figure 2. Chapter 3 elaborates on the appropriateness of the different variables, measures and methodology applied for testing the predicted effects.

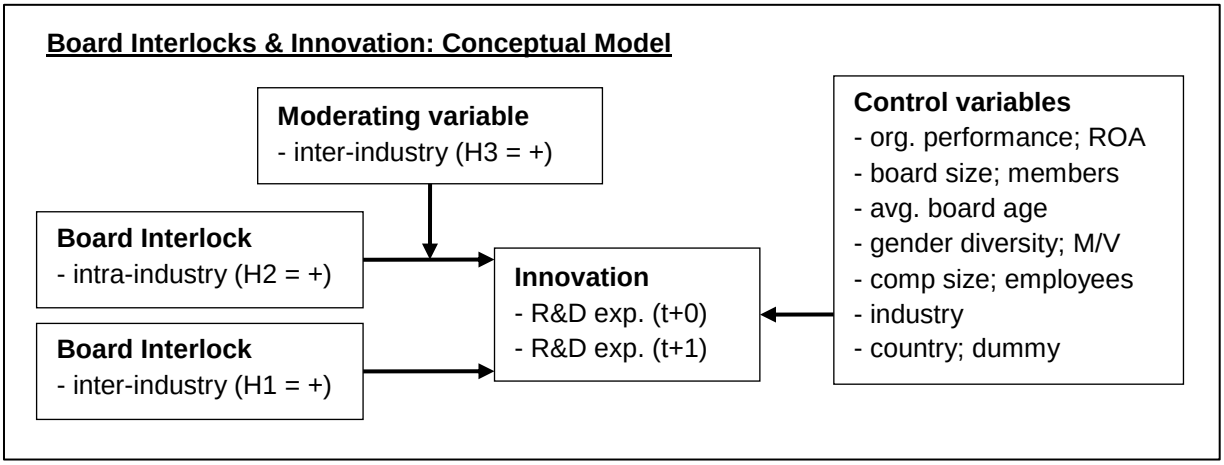


Figure 2: Conceptual model for the relation between board interlocks and innovation.

3. Methodology

3.1 Sample

Lamb & Roundy (2016) address the need for sample diversity in board interlocks research as the majority of studies is executed among firms in the USA. Therefore the sample for this study is constructed using 'high tech' companies solely from the Netherlands and Germany. Institutionally these countries are quite alike as they both are coordinated market economies which for instance require organisations to have two-tier board structures. According to NACE rev. 2 (Eurostat, 2008), the high tech aggregation includes NACE Rev. 2 codes 21 (manufacture of basic pharmaceutical products and pharmaceutical preparations) and 26 (manufacture of computer, electronic and optical products). Typically the high tech industry is characterised a high patenting frequency (Ahuja, 2000), the existence of many strategic alliances and by high levels of R&D expenditure (Stuart, 2000) which makes the industry suitable for measuring the dependent variable.

A panel dataset of 20 companies for the years 2007 through 2015 is composed using company information data base Orbis. First the top 250 companies from industry 21 and 26 are selected based on operating revenue in the year 2015. Subsequently, companies are excluded from the sample if the required data on R&D, RoA and employee numbers is not available for one of the given years, if the last available year of data is earlier than 2015 or if R&D expenditure in one of the given years is zero. From the 67 companies left, one company is extracted because its parent company is also in the list and two others because they are post box firms with headquarters not residing in The Netherlands.

Information on the organisation's board members is taken from annual reports which provide information on external directorships in each year, board member's age and gender. Orbis is again used in order to classify the industries of the companies the respective board members are interlocked with. In case the annual reports are inconclusive about age or gender Bloomberg.com's executive profile pages provide a solution.

Nine years of data between 2007 through 2015 is collected for 20 companies resulting in a sample size of n = 180, however not all companies provided the required information in their annual reports in all years. Therefore the total number of usable observations results in n=160 before and n=158 after outlier analysis for the t+0 analysis and n=141 for the lagged (t+1) analysis (this explained into detail in chapter 4). The sample size determines the statistical power of the analysis and the generalisability of the results. In case of multiple regression, the preferred method of analysis, a sample size too small (n<30) allows only

finding a strong relationship with one independent variable. If the sample size is very large (n>1000) any relationship can be statistically significant. Dependent on the strength of the relationship that is expected between the dependent and independent variables, the significance level (α) chosen, and the required statistical power (the probability of detecting a statistically significant specific level of R^2), the required sample size can be determined. In order to obtain a statistical power of 0,80 (R^2 is detected 80 percent of the times it occurs) and to identify fairly weak relationships (R^2 = 5 through 15) with a significance level of α = 0,5 using 5 through 10 independent variables, requires somewhere between 100 and 250 observations (Hair, Black, Babin, & Anderson, 2014). The sample size furthermore determines the generalisability of the results by the ratio of observations to independent variables. The minimal ratio is five to one, however the desired level lies somewhere between 10 and 20 to one. Given that the sample sizes of 158 and 141, and that the number of independent variables (including the interaction effect) in each analysis is 10, the ratios are 158/10 = 15,8 and 141/10 = 14,1 which both are well within the desired range.

3.2 Dependent variable

Innovativeness of an organisation's board, on the scale of this study, is quite difficult to measure directly. Therefore, a number of proxy variables have been considered for this purpose. For instance, Ahuja (2000) uses the yearly patenting frequency of organisations in the chemical industry as a measure for innovative capacity. It is argued that the patenting frequency is an adequate measure for that particular study since all companies belong to the same industry in which applying for patents is a common practice. The number of acquired patents reflects how successful the entire organisation has been in developing and securing new ideas. A study by Ritter et al. (2003) measures innovation success by means of product and process innovation rates. This is the percentage of sales that comes from products less than three years old and the percentage of production that is executed using facilities less than three years old. Especially the latter is a very direct way of measuring the financial success that comes from new products. The problem with both patenting frequency and innovation rates, is that they are dependent on much more than the board's strategic decision making process. They reflect the success of the innovative endeavours of the entire organisation and not the commitment to innovation at the level of the board. A solution is found in studies for instance by Midavaine et al. (2016) and Chen et al. (2013) where a firm's R&D expenditure (as a percentage of total sales) is used to measure the board's commitment to innovation. Especially when compared over multiple years and between multiple companies, R&D

expenditure gives a good representation of a board's propensity to innovate since the (strategic) allocation of resources follows directly from the board's decision making process.

However, OECD & Eurostat (2005) argue that R&D (expenditure) is merely one step in the innovation process. Other activities that should be considered belonging to the innovation process are processes such as development for preproduction, production, distribution, support activities including training an market preparation and finally the development and implementation of mew marketing and organisational methods. When studying the innovative capacity of one organisation or the innovation process itself into detail, all these activities should be included. However, this study focusses on the effect of board interlocks on innovative decision making by comparing multiple companies over a longer period of time, not the outcomes of innovation or the process itself. Furthermore, the development of R&D spending is an indicator that is easily accessible from public sources and represents how the board's actual commitment to innovation varies over time. Therefore, for the specific purpose of this study, it is a suitable variable for measuring innovation.

3.3 Independent variables

The number of interlocks is determined by checking for each board member whether it holds a position at another company. Following Heemskerk (2007), board positions at companies within the same holding company are not classified as interlocks. Also, multiple interlocks from one person to multiple companies belonging to the same parent company are counted as only one interlock. Further, only positions at executive and supervisory boards of two-tier boards and (non-)executive directorships in one-tier boards are counted as interlocks. This means that positions in shareholder committees, boards of trustees, (trade) unions, works councils, governmental organisations, foundations, museums and universities are not included in the sample.

The inter- and intra-industry interlocks are compiled by checking for each interlock whether it is with a company within or outside of the focal industry based on the two digit NACE Rev. 2 code (Eurostat, 2008). Interlocks with companies from industries other than the focal industry are categorised as inter-sector. Also, interlocks from 21 to 26 and vice versa are categorised as inter-industry interlocks. All others are intra-industry interlocks. In some cases companies have multiple secondary industry codes if they are active in more than one industry. In all cases, the two digit primary codes are used which represent the industry in which the company generates the majority of its revenues.

3.4 Moderating variables

A moderation effect of inter-industry interlocks on the relation between intra-industry interlocks and innovation is tested by creating an interaction term of inter- and intra-industry interlocks. In order to do so these variable are centred around their mean. The rationale for doing so and the method applied are both addressed in chapter 4 and appendix II.

3.5 Control variables

Given the fact that the sample consists of companies from two different countries and industries both of these variables are included in order to control for potential institutional differences. As firm performance might influence strategic decisions by the board, to either divest or invest in R&D (Chen, Ho, & Hsu, 2013) the firm's return on assets (RoA) is included as variable to control for these effects. RoA before taxation is used rather than RoA in order to account for the different fiscal environments of The Netherlands and Germany.

Board size (the total number of board members) is included as Goodstein et al. (1994) show that large boards face a number of barriers for resolute decision making such as low cohesion and decreased motivation as result of a lack of participation.

A study by Midavaine et al. (2016) finds that division between male and female board members is positively related to R&D expenditure. In order to control for this effect a gender diversity is included as a control variable using Blau's index of heterogeneity using the formula: $1 - \sum \rho_i^2$ in which ρ_i is the proportion of group member in each of the i categories. In case of two categories (male/ female) perfect heterogeneity (as many males as there are females in the board) is represented by the number 0,5. Absolute homogeneity (only males or females) is represented by the number zero.

Further, average board age is included as a control variable as tenure is found to be positively (Wu, 2014) as well as negatively (Chen, Ho, & Hsu, 2013) related to innovation. It must be mentioned however, that especially for German companies, it is quite often not possible to obtain information about the age of all board members. Often only the age of executive board members is listed in annual reports. On top of that, in Germany, members of the works councils are also members of the supervisory boards. These individuals are less known in the corporate world and as such often do not have a Bloomberg executive profile. Therefore the average board age quite often is determined based on incomplete information.

Finally, the companies size in terms of number of employees is included as a control variable as larger firms might possess larger amounts of resources to direct towards innovation (Barker III & Mueller, 2002).

3.6 Method of analysis

The preferred method of data analysis for this study is (lagged) hierarchical moderated multiple regression (OLS) as this dependence technique allows analysing one dependent variable with multiple independent (predictor) variables. This technique analyses the (known) values of the independent variables to determine the value of the single dependent variable, which is unknown. It tries to predict the dependent variable based on one or multiple independent variables. Multiple regression only works with metrically scaled variables which applies here as the dependent as well as the independent variables are ratio variables. A number of assumptions have to be met both before and after estimating the regression model in order for multiple regression to be applicable. This includes checking residual plots of the predicted dependent variable for linearity of the phenomenon measured, constant variance of the error terms (homoscedasticity), independence of the error terms, and normality of the error terms. (Hair, Black, Babin, & Anderson, 2014) The assumptions of linear regression are carefully addressed in chapter 4 and appendix II.

4. Analysis

4.1 Introduction

Two separate hierarchical moderated multiple regression analyses are performed in order to study the relation between the independent variables and R&D expenditure. First the effects are tested when R&D expenditure is measured in the same year (t+0) as the independent variables. The second analysis is a lagged regression that test the effect of the independent variables on R&D expenditure when it is measured one year after (t+1) the independent variables. R&D expenditure is a strategic choice that follows from strategic planning decisions made by the board. The effect of strategic decisions does not occur instantaneously, therefore results of strategic decisions are often measured with a time delay between the dependent and independent variables (Chen, Ho, & Hsu, 2013; Geletkanycz & Hambrick, 1997; Yoo & Reed, 2015).

The method applied follows Field's (2012) guidelines on multiple regression. The interaction effects are studied in a way similar to that of Jansen, Van Den Bosch & Volberda (2006). Each consists of five models of which the first contains the control variables. In the second, third and fourth model, the independent variables and interaction terms are included respectively. The results of the t+0 regressions are reported in appendix II-C, the results of the t+1 analysis can be found in paragraph 4.3.

4.2 Data preparation, outlier analyses & assumptions of linear regression

Appendix II-A contains a detailed description of the steps taken during data preparation. These included for instance creation of a dummy variable, centring variables, computing interaction terms and the log transformation of one of the control variables. The method applied is identical for both analyses. However, given the lagged design of the second analysis, the sample size and decisions made during preparation differ somewhat. In appendix II-B and II-D the steps taken and the decisions that were made are explained into detail. Appendix III contains the SPSS output in support of Appendix II.

4.3 Results of t+1 analysis

Table 1 contains the descriptive statistics and correlations of all the variables used in this analysis. There are weak to moderate significant correlations between the dependent variable and most of the independent variables. Only gender diversity and country do not

seem to correlate with the dependent variable. Further, there is no correlation greater than 0,9 meaning multicollinearity is not an issue here (Field, 2012).

Table 1: Descriptive statistics and correlations of t+1 analysis.

		Mean	St. Dev.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.	R&D expenses / Operating revenue % (t+1)	9,45	5,37	-									
2.	ROA using P/L before tax %	5,27	9,40	-0,35***	-								
3.	Total number of board members	14,30	5,40	-0,27**	0,06	-							
4.	Average board age in corresponding year	56,48	3,74	-0,27**	0,12	-0,03	-						
5.	Gender diversity	0,18	0,13	0,07	-0,01	0,07	0,38***	-					
6.	Number of employees (Log10)	3,91	0,63	-0,42***	0,10	0,63***	0,25**	-0,02	-				
7.	Country (NL dummy)	0,28	0,45	0,11	-0,06	-0,44***	0,30***	-0,01	0,04	-			
8.	Industry (NACE Rev. 2 Primary code)	24,65	2,23	0,15*	-0,08	-0,32***	-0,34***	-0,43***	-0,33***	0,10	-		
9.	Number of inter-industry interlocks	15,99	10,33	-0,18*	0,00	0,67***	0,09	-0,04	0,62***	0,11	-0,44***	-	
10.	Number of intra-industry interlocks	1,45	1,79	0,40***	-0,14*	-0,10	-0,12	-0,17*	0,00	0,18*	0,02	-0,02	-

Note: Pearson correlations are reported. n = 141. *p < 0,05, **p < 0,01, ***p < 0,001.

Table 2 contains the results of the hierarchical multiple regression analysis and presents the predictive power of the tested models. The first model contains all the control variables. The isolated effect of inter- and intra-industry interlocks are examined in models 2a and 2b respectively while the combined and moderated effect are entered in models 3 and 4.

Model 2a shows that the isolated effect of inter-industry is insignificant (β=0,03; p=0,85) meaning that there is no support for hypothesis 1. The effect of intra-industry interlock, isolated in model 2b (β=0,36; p<0,001), in model 3 (β=0,37; p<0,001) as well in model 4 (β=0,38; p<0,001), is positive and significant thus fully supporting hypothesis 2. Model 4 shows that there is no support for hypothesis 3 as there is no significant effect (β=0,02; p=0,82) for the moderation term of inter- and intra-industry interlocks.

The control variables in model 1 together explain 30,7% in the variance in the dependent variable with and F-ratio of 9,87. The best models in terms of predictive power are model 3 and 2b which explain 42,8% and 42,7% of the variance in de dependent variable respectively. Considering the F-ratio's and standard errors of both models, 2b outperforms model 3 given that it has a higher F-ratio of 14,02 (opposed to 12,64). Furthermore, the standard errors are somewhat lower for the control variables in model 2b. Almost a third of the total variance explained by model 2b comes from the variable intra-industry interlocks as it alone counts for 12,5% of the variance explained.

Table 2: Results of hierarchical multiple regression analysis: Effects on R&D expenditure (t+1). The standard errors and significance levels are based on 2000 bootstrap samples.

	R&D expenses / Operating revenue % (t+1)				
	Model 1	Model 2a	Model 2b	Model 3	Model 4
Intercept	43,95***	43,45**	35,93***	33,14***	32,95***
	(8,92)	(10,30)	(7,54)	(8,21)	(8,17)
Control variables					
ROA using P/L before tax %	-0,27**	-0,27**	-0,26**	-0,22*	-0,22*
	-0,15	-0,15	-0,13	-0,12	-0,12
	(0,05)	(0,05)	(0,05)	(0,05)	(0,05)
Total number of board members	0,06	0,03	0,08	-0,04	-0,04
	0,06	0,03	0,08	-0,04	-0,04
	(0,11)	(0,18)	(0,10)	(0,16)	(0,16)
Average board age in corresponding year	-0,28**	-0,27**	-0,22**	-0,21**	-0,21**
	-0,40	-0,40	-0,31	-0,29	-0,29
	(0,13)	(0,14)	(0,10)	(0,11)	(0,11)
Gender diversity	0,15	0,15	0,21**	0,24**	0,25**
	6,13	6,41	8,61	10,09	10,25
	(3,17)	(3,67)	(2,89)	(3,43)	(3,61)
Number of employees (Log10)	-0,38**	-0,37**	-0,39***	-0,39**	-0,39**
	-3,17	-3,16	-3,28	-3,27	-3,28
	(0,94)	(0,95)	(0,88)	(0,92)	(0,90)
Country (NL dummy)	0,22*	0,21	0,15	0,07	0,07
	2,67	2,48	1,81	0,85	0,85
	(1,01)	(1,64)	(0,98)	(1,53)	(1,53)
Industry (NACE Rev. 2 Primary code)	-0,03	-0,02	0,03	0,08	0,08
	-0,06	-0,04	0,06	0,20	0,20
	(0,21)	(0,29)	(0,19)	(0,25)	(0,26)
Predictor variables					
Number of inter-industry interlocks (centred)		0,03		0,15	0,15
		0,02		0,08	0,08
		(0,09)		(0,08)	(0,08)
Number of intra-industry interlocks (centred)			0,36***	0,37***	0,38***
			1,08	1,12	1,13
			(0,20)	(0,20)	(0,21)
Moderation effect					
Inter*intra (centred)					-0,02
					-0,01
					(0,03)
R^2	0,342	0,342	0,459	0,465	0,465
R^2 adjusted	0,307	0,302	0,427	0,428	0,424
	(4,47)	(4,48)	(4,06)	(4,06)	(4,07)
ΔR^2 adjusted		-0,005	0,125***	0,126***	-0,004
F-ratio	9,87***	8,85***	14,02***	12,64***	11,30***

Standardized, unstandardized regression coefficients and (std. errors) are reported. n = 141.
*p < 0,05, **p < 0,01, ***p < 0,001.

4.4 Robustness of insignificant results

Surprisingly enough no significant result was found for the effect of inter-industry interlocks on R&D expenditure and for the moderation effect of inter-industry interlocks on the relation between intra-industry interlocks and R&D expenditure.

The fact that no significant moderation effect was found means that the two variables do not interact with each other in relation the de dependent variable. From a statistical point of view this makes sense considering the very small and highly insignificant effect of inter-industry interlocks (β=0,03; p=0,85) and the fact that the variable contains no significant explanatory power (R^2=-0,005). The only way in which the moderation effect could have been significant given the insignificant moderator, would have been a cross-over interaction. In this case the outcome on the dependent variable depending on the isolated effect of inter-industry interlocks would strongly differ for low and high levels of intra-industry interlocks. A strongly insignificant and very small moderation term (β=0,02; p=0,82) indicates however, that this is not the case.

In order to check the robustness of the insignificant moderation effect, another regression is performed in which all control variables are excluded. The isolated effect of inter-industry interlocks now becomes negative (opposite to hypothesis 1) and significant (β=-0,18; p=0,01) but still only explains 3,2% (R^2=0,032) of the variance in the dependent variable. The regression coefficient (β) becoming negative makes sense given that the significant control variables all are negatively related to the dependent variable. Although the moderating variable now is significant, the moderation term still is not (β=0,03; p=0,60). Therefore it must be concluded that there is no interaction whatsoever between the number of inter- and intra-industry interlocks.

5. Conclusion

5.1 Conclusions from literature

The first goal of this study was to draw on knowledge management and social network literature in order to explain through which mechanisms corporate board interlocks are related to innovation. Based on the findings in chapter 2, it is concluded that corporate board interlocks can serve as the channels through which important information flows to an organisation's board. In other words, interlocks are a way to manage an organisation's resource dependency. Being able to dispose of the right resources is critical to innovation.

Inter-industry interlocks connect the board to non-local knowledge in the form companies residing outside its respective industry. This increases a board's internal knowledge diversity as board members reside in multiple domains. Following absorptive capacity theory this improves the board's ability to recognize and pursue innovation opportunities. These inter-industry ties further serve as the connections to non-local networks that contain a great variety of information. Inter-industry ties therefore increase both the availability of external information as well as the ability to take advantage from it.

Intra-industry interlocks are the instrument to build a firm's social capital within its own industry. These ties not only serve as channels for obtaining technical knowledge, but also provide the board with much needed market information, knowledge about competitors and suppliers and the needs of customers. Although industry embeddedness might have negative consequences when it occurs in high levels, in low levels its effects are mainly positive. Intra-industry ties can be seen as a way to sense what is important in an organisation's direct environment and as such increase the ability to recognize and engage in opportunities for innovation.

5.2 Empirical findings

The second goal of this study was to empirically determine the relation between corporate board interlocks and a board's commitment to innovation by performing a lagged hierarchical multiple regression analysis using public company data. Not any of the models, also not in the t+0 analysis in appendix II-B and C, shows a significant relation of inter-industry interlocks to R&D expenditure. Reasons for the absence of the hypothesised relations are explored in paragraphs 4.4 and 6.1. The results do provide however, evidence for the positive effect of intra-industry interlocks. This variable explains approximately 12% of the

variation in the dependent variable. Therefore, it can be concluded that the number of intra-industry interlocks positively affects a board's commitment to innovation.

These results strengthen the existing literature on social capital in relation to innovation. The fact that the result for intra-industry ties is significant and that of inter-industry ties is not gives reason to think about which ties are important. Boards and board members should consider which resources are important for their organisations considering their strategy, the resources they require and manage their ties as such. In times of innovation intra-industry ties serve as the channels for obtaining knowledge and furthermore provide the board with market information about competitors, suppliers and the needs of customers. They strengthen an organisation's position within its environment and connect it to the multiple resources needed for innovation. Organisations looking for ways to improve their innovative capabilities can benefit from managing the configuration of their corporate board ties. From a knowledge management perspective it therefore can be concluded that intra-industry ties are in fact a means to organise for innovation.

6. Discussion

6.1 Reflection on insignificant results

From a theoretical point of view it is hard to determine what it means that there is no significant relation between inter-industry interlocks and R&D expenditure. It could mean that ties to non-local knowledge and absorptive capacity do not influence a board's R&D expenditure; the commitment to innovation. It is more likely however, that inter-industry interlocks are an ill representation of these two theoretical concepts given the fact that they have been related to innovation in many previous studies. Another explanation could be that the content and context of the domains might differ too much. As explained in absorptive capacity theory, in order for valuable information to be recognised as such, it must relate to something that is already known. Information that flows through inter-industry ties might differ to much from relevant intra-industry information in order to be of value.

Regarding the insignificant moderation effect the conclusion is that inter-industry interlocks can not be used in order to overcome the negative consequences of industry embeddedness. It must be noted however, that these negative effects might not have occurred in this study given the relatively low number of intra-industry interlocks in the sample. The average number of intra-industry interlocks is 1,45 (with a maximum of 9) against an average of 15,99 inter-industry interlocks (with a maximum of 60). If the number of intra-industry interlocks would have been higher, embeddedness might have occurred together with its possible negative consequences. In that case a high number of ties outside of the focal industry might have positively interacted with the intra-industry ties resulting in a significant interaction.

6.2 Limitations

The main limitation concerning this study is the use of a proxy variable in order to measure innovation at the level of the board. Ideally it would be measured more directly by determining the perceptions and beliefs regarding innovation of individual board members. On the scale of this quantitative study this would require an incredible amount of time and cooperation of many organisations. Such an approach therefore suits a smaller scale qualitative study better. Another concern to the dependent variable is that it is not entirely under the influence of the board as a strategic decision. Although the decision to invest a certain amount in R&D is made by the board, the ratio of R&D divided by sales, depends on

the amount of sales that is actually generated. Although budgets are made using sales forecasts, actual sales depends on market conditions and are somewhat outside of the scope of control of the board.

This study takes quite a narrow view of the concept of corporate ties by only looking at interlocks between boards. Of course this was done because of practical reasons as these types of connections are identifiable only using public sources. However, many other ties such as non-corporate and friendship ties exist as well and are also an interesting subject of study. These however, are much more difficult to map merely using public sources.

Further, the reliability of the variable 'average board age' is questionable since it was impossible to find the age of the supervisory board members for a number of German companies in the sample. In order to construct a reliable variable for future research it is advisable to obtain personnel records from companies in the sample. This ads to the completeness and reliability of the variable.

Within the two digit primary industry codes (Eurostat, 2008) there is still quite a lot of variance in company activities. The distinction between inter- and intra-industry therefore could be made more distinct if four digit codes are used. In order to obtain an adequate sample size, the focus probably has to shift from country-level to a global-level.

6.3 Possibilities for future research

Future research in this area should focus on actual innovative behaviour of board's and board members. The focus therefore might have to shift from firm-level to director-level in order identify innovative behaviour on an individual level. The question to be answered is how a director's ties influence his innovative behaviour an what influence this has on strategic decisions made by the board.

For this study it was considered to use the proportion of interlocks, relative to board size, as an independent variable. However, the number of interlocks each board member can have is (theoretically) unlimited and in that way is independent of board size. Further, considering the theoretical framework, the effect of interlocks is sought in what the ties itself represent. Therefore, only the absolute number of interlocks was used as a variable. It could be interesting however, to use the number of interlocks relative to board size as this gives an indication on how individual board members are connected outside of the focal company. This would shift the focus somewhat from firm-level to the level of the individual director.

Further, it would be interesting to investigate up to which distance from the focal industry interlocks positively affect innovation. The separation between inter- and intra-

industry here was made using the two-digit NACE Rev.2 code. What would happen to the effect of either of the two types of interlocks if this separation is shifted?

The control variable RoA is negatively related to R&D expenditure (as a percentage of sales) both in the t+0 and t+1 analysis (see table 1 and 3). This makes sense as higher returns mean that the ratio between R&D and those returns (sales) decreases. However, intuitively one might expect that adequate firm performance gives an organisation's board reason to invest, possibly also in R&D. Instead of including RoA as a control variable directly affecting R&D expenditure it would be interesting to study its moderating effect on the relation between board interlocks and R&D expenditure. And this actually applies to all control variables that do not represent board characteristics and are more external of nature. Conceptually it makes more sense to include variables of measures that the board might consider while making a strategic decision as moderators that influences the relation between the independent variable (i.e. board interlocks) and the strategic outcome (i.e. R&D expenditure) as this relation represents the decision made by the board.

6.4 Research ethics

Considering that all information used for the purpose of this study is publically available, invasion of privacy is no topic of concern. However, in order to prevent the appearance of privacy invasion, no names of board members are included in the report. Evidently, plagiarism is avoided by all means necessary.

References

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative science quarterly, 45*(3), 425-455.

Bakker, R. M. (2010). Taking Stock of Temporary Organisational Forms: A Systematic Review and Research Agenda. *International Journal of Management Reviews, 12*, 466-486.

Barker III, V. L., & Mueller, G. C. (2002). CEO characteristics and firm R&D spending. *Management Science, 48*(6), 782-801.

Bercovitz, J., & Feldman, M. (2011). The mechanisms of collaboration in inventive teams: Composition, social networks, and geography. *Research Policy, 40*, 81-93.

Carnabuci, G., & Operti, E. (2013). Where Do Firms' Recombinant Capabilities Come From? Intraorganisational Networks, Knowledge and Firms' Ability to Innovate Through Technological Recombination. *Strategic Management Journal, 34*, 1519-1613.

Cegarra-Ciprés, M., Roca-Puig, V., & Bou-Llusar, J. C. (2014, 12). External knowledge acquisition and innovation output: an analysis of the moderating effect of internal knowledge transfer. *Knowledge Management Research & Practice*(2), 203-214.

Chen, H., Ho, M. H., & Hsu, W. (2013). Does board social capital influence chief executive officers' investment decisions in research and development? *R&D Management, 43*(4), 381-393.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Coleman, J. (1988). Social Capital in the Creation of Human Capital. *American Journal of Sociology, 94*, s95-s120.

Crossan, M., & Apaydin, M. (2010). A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature. *Journal of Management Studies, 47*(6), 1154-1191.

Dalal, D. K., & Zickar, M. J. (2012). Some Common Myths About Centering Predictor Variables in Moderated Multiple Regression and Polynomial Regression. *Organizational Research Methods, 15*(3), 339-362.

Dezso, C. L., & Ross, D. G. (2012). Does Female Representation in Management Improve Firm Performance? A Panal Data Investigation. *Strategic Management Journal, 33*, 1072-1089.

Dougherty, D. (1999). Organizing for innovation. In S. R. Clegg, C. Hardy, & R. W. Nord, *Managing organizations: Current issues* (pp. 174-189). London: Sage.

Eurostat. (2008). *NACE Rev. 2: Statistical classification of economic activities in the European Community.* European Commission. Luxembourg: ffice for Official Publications of the European Communities.

Ferreras-Méndez, J. L., Newell, S., Fernández-Mesa, A., & Alegre, J. (2015). Depth and breadth of external knowledge search and performance: The mediating role of absorptive capacity. *Industrial Marketing Management, 47*, 86-97.

Field, A. (2012). *Discovering Statistics Using SPSS (3rd edition).* London: Sage.

Filatotchev, I., & Toms, S. (2003). Corporate Governance, Strategy and Survival in a Declining Industry: A Study of UK Cotton Textile Companies. *Journal of Management Studies, 40*(4), 895-920.

Foss, N. J., Lyngsie, J., & Zahra, S. A. (2013). The Role of External Knowledge Sources and Organisational Design in the Process of Opportunity Exploitation. *Strategic Management Journal, 34*, 1453-1471.

Garriga, H., Von Krogh, G., & Spaeth, S. (2013). How Constraints and Knowledge Impact Open Innovation. *Strategic Management Journal, 34*, 1134-1144.

Geletkanycz, M. A., & Hambrick, D. C. (1997). The External Ties of Top Executives: Implications for Strategic Choice and Performance. *Administrative Science Quarterly, 42*(4), 654-681.

Goodstein, J., Gautam, K., & Boeker, W. (1994). The Effects of Board Size and Diversity on Strategic Change. *Strategic Management Journal, 15*, 241-250.

Granovetter, M. (1973). The Strength of Weak Ties. *American Journal of Sociology, 78*(6), 1360-1380.

Granovetter, M. (1983). The Strength of Weak Ties: A Network Theory Revisited. *Sociological Theory, 1*, 201-203.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2014). *Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. Multivariate DataAnalysis (7th edition).* Pearson.

Hambrick, D. C., & Mason, P. A. (1984). Upper Echelons: The Organisation as a Reflection of its Top Managers. *Academy of Management Review, 9*, 193-206.

Haynes, K. T., & Hillman, A. (2010). The Effect of Board Capital and CEO Power on Strategic Change. *Strategic Management Journal, 31*, 1145-1163.

Heemskerk, E. M. (2007). Decline of the Corporate Community. Network Dynamics of the Dutch Business Elite. Amsterdam: Amsterdam University Press.

Howard, M., Withers, M., & Tihanyi, L. (2016). Knowledge Dependence and the Formation of Director Interlocks. *Academy of Management Journal*.

Inkinen, H. (2016). Review of empirical research on knowledge management practices and firm performance. *Journal of Knowledge Management, 20*(2), 230-257.

Jansen, J. J., Van Den Bosch, F. A., & Volberda, H. W. (2006). Exploratory Innovation, Exploitative Innovation, and Performance: Effects of Organizational Antecedents and Environmental Moderators. *Management Science, 52*(11), 1661-1674.

Johnson, S. G., Schnatterly, K., & Hill, A. D. (2012). Board Composition Beyond Independence: Social Capital, Human Capital, and Demographics. *Journal of Management*.

Karadimitriou, S. M., & Marshall, E. (2017). Retrieved 04 06, 2017, from The University of Sheffield: http://www.sheffield.ac.uk/polopoly_fs/1.531431!/file/MASHRegression_Further_SPSS.pdf

Kesidou, E., & Snijders, C. (2012). External Knowledge and Innovation Performance in Clusters: Empirical Evidence from the Uruguay Software Cluster. *19*(5), 437-457.

Lamb, N. H., & Roundy, P. (2016). The "ties that bind" board interlocks research: a systematic review. *Management Research Review, 39*(11), 1516-1542.

Larrañeta, B., Zahra, S. A., & González, J. L. (2012). Enriching strategic variety in new ventures through external knowledge. *Journal of Business Venturing, 27*, 401-413.

Laursen, K., Masciarelli, F., & Prencipe, A. (2012). Regions Matter: How Localized Social Capital Affects Innovation and External Knowledge Acquisition. *Organization Science, 23*(1), 177-193.

Lee, M. R., & Chen, T. T. (2012). Revealing research themes and trends in knowledge management: From 1995 to 2010. *Knowledge-Based Systems, 28*, 47-58.

Leiponen, A. (2012). The benefits of R&D and breadth in innovation strategies: a comparison of Finnish service and manufacturing firms. *Industrial and Corporate Change, 21*(5), 1255-1281.

Lin, B. W. (2011). Knowledge diversity as a moderator: inter-firm relationships, R&D investment and absorptive capacity. *Technology Analysis & Strategic Management, 23*(3), 331-343.

Midavaine, J., Dolfsma, W., & Aalbers, R. (2016). Board Diversity and R&D Investment. *Management Decision, 54*(3), 558-569.

Millar, C. C., Lockett, M., & Mahon, J. F. (2016). Knowledge intensive organisations: on the frontiers of knowledge management. *Journal of Knowledge Management, 20*(5), 845-857.

Miller, T., & Triana, M. (2009). Demographic diversity in the boardroom: Mediators of the board diversity–firm performance relationship. *Journal of Management studies, 46*(5), 755-786.

OECD & Eurostat. (2005). *The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data: Oslo Manual Thrid Edition.* Paris: OECD Publishing.

Parra-Requena, G., Ruiz-Ortega, M. J., García-Villaverde, P. M., & Rodrigo-Alarcón, J. (2015). The Mediating Role of Knowledge Acquisition on the Relationship Between External Social Capital and Innovativeness. *European Management Review, 12*, 149-169.

Pfeffer, J. (1972). Size and Composition of Corporate Boards of Directors: The Organisation and its Environment. *Administrative Science Quarterly, 17*, 218-228.

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. *Journal of Management*, 1-52.

Quintane, E., Casselman, R. M., Reiche, S. B., & Nylund, P. A. (2011). Innovation as a knowledge-based outcome. *Journal of Knowledge Management, 15*(6), 928-947.

Ritter, T., & Gemünden, H. G. (2003). Network competence: Its impact on innovation success and its antecedents. *Journal of Business Research, 56*(9), 745-755.

Ruigrok, w., Peck, S. I., & Keller, H. (2006). Board characteristics and involvement in strategic decision making: Evidence from Swiss companies. *Journal of Management Studies, 43*(5), 1201-1226.

Stuart, T. E. (2000). interorganisational Alliances and the Performance if Firms: A Study of Growth and Innvations Rates in High-Technology Industry. *Strategic Management Journal, 212*, 791-811.

Tsai, w. (2001). Knowledge Transfer in Intraorganizational Networks: Effects of Network Position andAbsorptive Capacity on Business Unit Innovation and Performance. *Academy of Management Journal, 44*(5), 996-1004.

Uzzi, B. (1996). The Sources and Consequences of Embeddedness for the Economic Performance of Organizations: The Network Effect. *American Sociological Review, 61*(4), 674-698.

Uzzi, B. (1997). Social Structure and Competition in Interfirm Networks: The Paradox of Embeddedness. *Administrative Science Quarterly, 42*(1), 35-67.

Van Wijk, R., Jansen, J. J., & Lyles, M. A. (2008). Inter- and Intra-Organizational Knowledge Transfer: A Meta-Analytic Review and Assessment of its Antecedents and Consequences. *Journal of Management Studies, 45*(4), 830-853.

Venkitachalam, K., & Busch, P. (2012). Tacit knowledge: review and possible research directions. *Journal of Knowledge Management, 16*(2), 357-372.

Westphal, J. D., & Bednar, M. K. (2005). Pluralistic Ignorance in Corporate Boards and Firms' Strategic Persistence in Response to Low Firm Performance. *Administrative Science Quarterly, 50*, 262-298.

Wu, J. (2014). The effects of external knowledge search and CEO tenure on product innovation: evidence from Chinese firms. *Industrial and Corporate Change, 23*(1), 65-89.

Ye, J., Hao, B., & Patel, P. C. (2016). Orchestrating Heterogeneous Knowledge: The Effects of Internal and External Knowledge Heterogeneity on Innovation Performance. *IEEE Transactions on Engineering Management, 63*(2), 165-176.

Yoo, J. W., & Reed, R. (2015). The Effects of Top Management Team External Ties and Board Composition on the Strategic Choice of Late Movers. *Long Range Planning, 48*, 23-34.

Zheng, W. (2010). A Social Capital Perspective of Innovation from Individuals to Nations: Where is Empirical Literature Directing Us? *International Journal of Management Reviews*, 151-183.

Appendices

Appendix I: Theoretical background: Review methodology

Appendix I-A: Knowledge management & innovation

In order to obtain an up to date overview of the key issues in the field of knowledge management in relation to innovation, a review of recent literature is conducted. This is done by searching for recent (years 2010-2017) and relevant literature reviews in the Web of Science (WoS) database using the topics 'knowledge management' and 'innovation' and narrowing down the results using a systematic methodology. Search efforts and results are logged in appendix I-C. The search log only contains an overview of the papers that were found using this methodology. Many of the papers used in this study were found through references in other articles or result from personal communication.

The review methodology applied here is similar to the method used by Bakker (2010). This is done by sequentially excluding results based on their relevance of subject category, title, abstract and full text. The Web of Science categories that are included are: business, management, operations research & management science, psychology (applied), psychology (social) and sociology. Appendix I-D contains the selection diagram and search string for this particular search and the other literature searches that are conducted for the purpose of this study. Results are excluded based on relevance of subject category by including the relevant categories into the search string which can be found beneath the selection diagrams.

The initial search yielded 26 papers. 10 where excluded based on relevance of their titles and after consideration of abstracts, 5 literature reviews coming from the field of knowledge management were left that serve as the basis for paragraph 2.1.

Appendix I-B: Board interlocks, networks & innovation

The same approach is used here as is described in the previous paragraph. This study proposes that board interlocks can be seen as the organisational aspect that can be used to organise for innovation by increasing knowledge diversity, broadening a firm's knowledge and attracting external knowledge. Innovation is operationalised as R&D expenditure and therefore the search topics included in this search are 'knowledge diversity' or 'knowledge broadness' or 'external knowledge' and 'innovation' or 'R&D' or 'research & development' or 'research and development' (also see the search log in appendix I-C and the selection

diagram and search string in appendix I-D). In this case only articles are included in the results, the selected relevant subject categories are identical to those mentioned before.

The initial search resulted in 391 possibly relevant papers. Exclusion based on studying titles yields 101 possibly relevant papers. Exclusion based on studying the paper's abstracts results in 33 studies of interest. Subsequently the full text of the remaining articles is analysed for relevance and this yields 14 distinct studies for review. These studies have been summarized in the author matrix included in appendix I-E and are more carefully discussed in paragraphs 2.3 through 2.5.

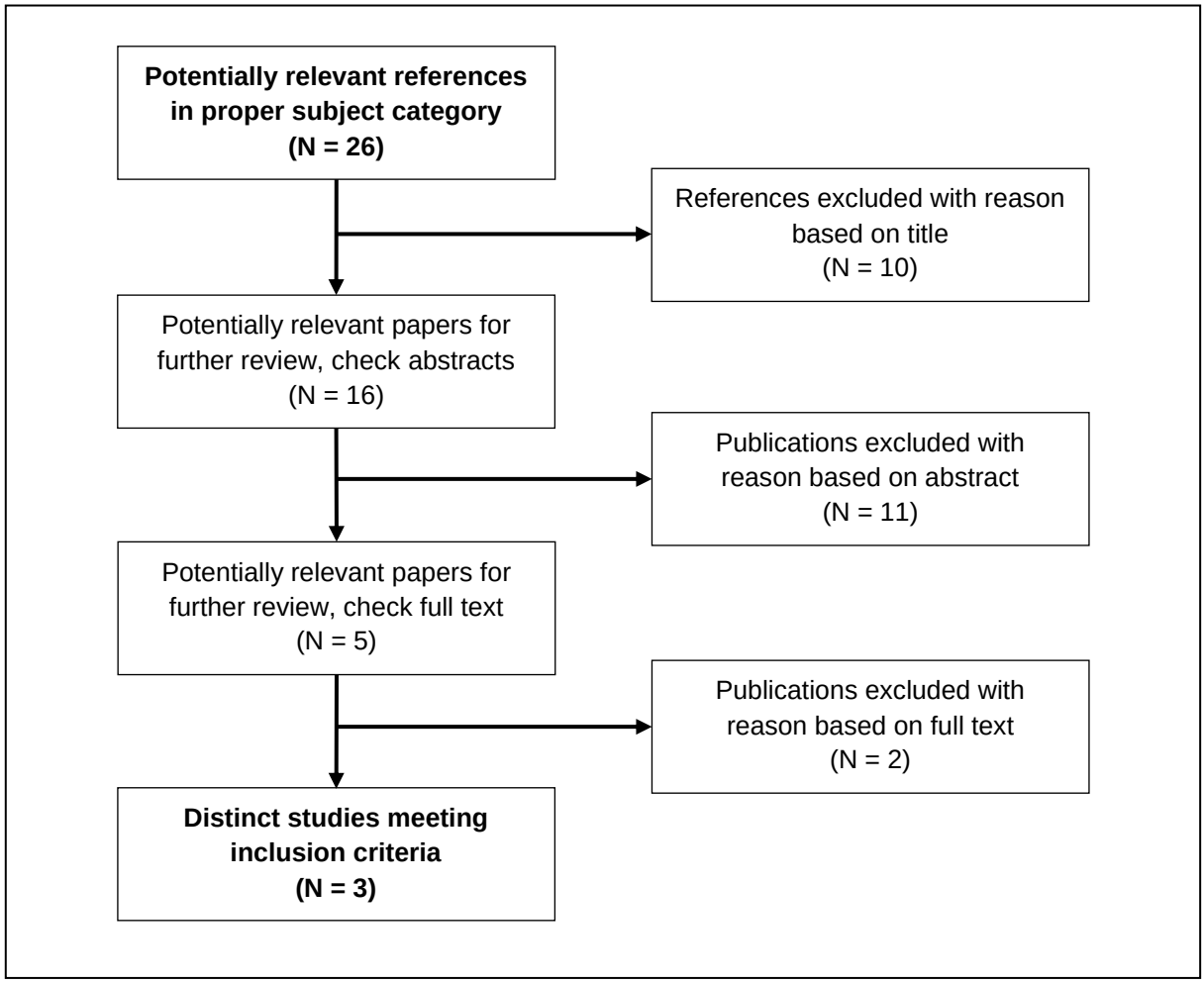
Further, a cited author search is performed using a paper by Geletkanysz & Hambrick (1997). This paper provides some useful information for strengthening the theoretical framework and a cited author search shows which recent publications build on this paper. Again the same categories are used as mentioned before and the years included are 2010 through 2017. The results are narrowed down using the selection diagram in appendix I-D. In this case the focus lies with articles specifically focussing on social capital and ties of corporate leaders and board members in relation to innovation. The initial search results in 169 papers, 15 are left after exclusion based on title, 4 after exclusion based on abstract and 2 after analysing the full text of the articles. The two remaining papers and the original by Geletkanysz & Hambrick (1997) are included in the author matrix in appendix I-E.

Appendix I-C: Search log

Search#	Date	Database	Search terms	Results
1	12-12-2016 - 17-12-2016	Web of Science	"knowledge diversity" OR "knowledge broadness" OR "external knowledge" AND Innovation OR R&D OR "research & development" OR "research and development"	11 papers - (Bercovitz & Feldman, 2011) - (Carnabuci & Operti, 2013) - (Foss, Lyngsie, & Zahra, 2013) - (Garriga, Von Krogh, & Spaeth, 2013) - (Kesidou & Snijders, 2012) - (Larrañeta, Zahra, & González, 2012) - (Laursen, Masciarelli, & Prencipe, 2012) - (Leiponen, 2012) - (Lin, 2011) - (Parra-Requena, Ruiz-Ortega, García-Villaverde, & Rodrigo-Alarcón, 2015) - (Ye, Hao, & Patel, 2016)
2	-	Web of Science	Cited author 2010-2017: (Geletkanycz & Hambrick, 1997)	2 papers - (Chen, Ho, & Hsu, 2013) - (Yoo & Reed, 2015)
3	12-04-2017	Web of Science	"Knowledge Management" AND Innovation	3 papers - (Inkinen, 2016) - (Venkitachalam & Busch, 2012) - (Zheng, 2010)
4	20-04-2017	Google	Themes in Knowledge Management	1 paper - (Lee & Chen, 2012)

Appendix I-D: Selection diagrams

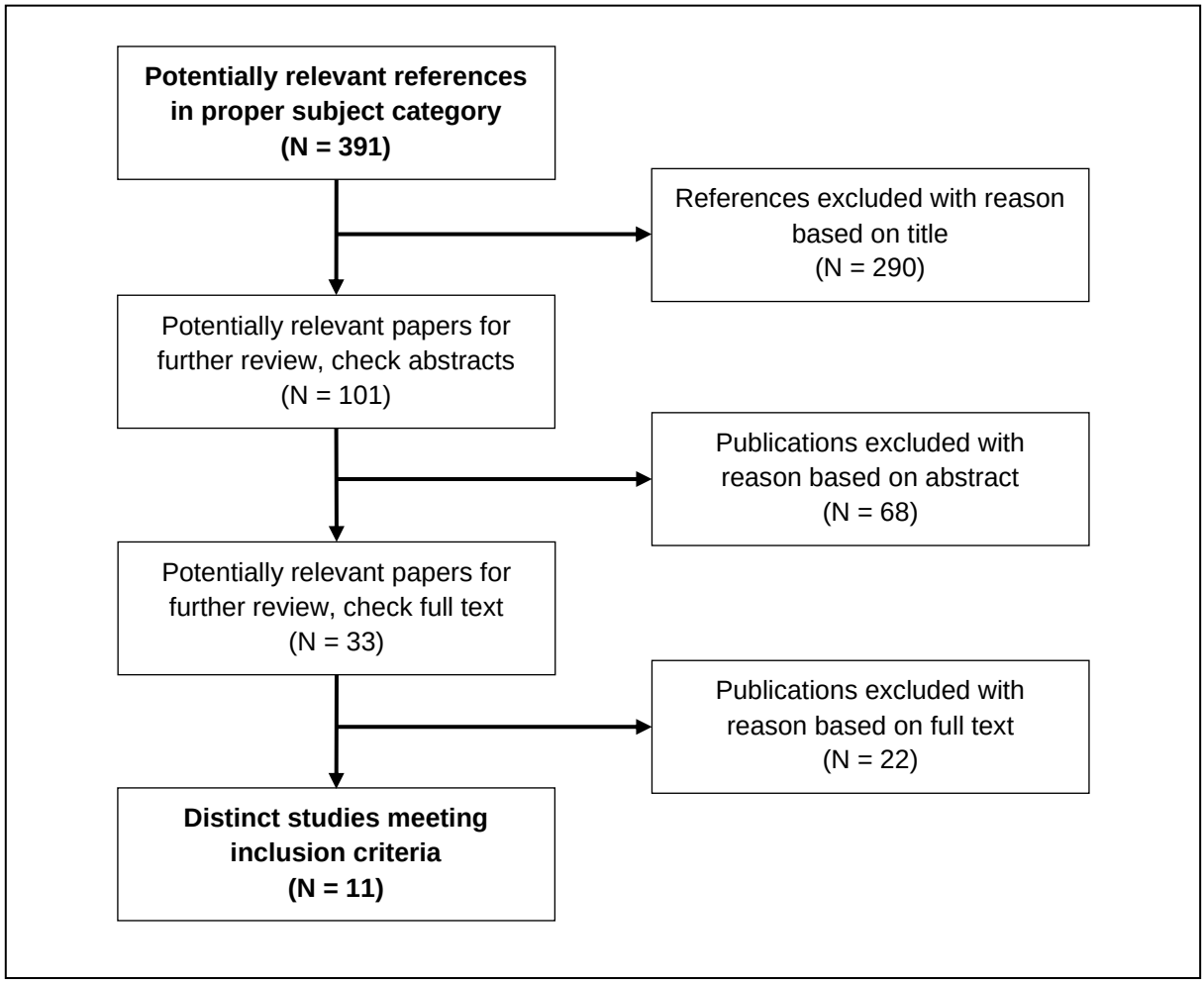
Selection diagram: Knowledge management & innovation



Web of Science search string:

TS=("knowledge management") AND TS=(innovation) AND WC=(business OR management OR operations research & management science OR psychology, applied OR psychology, social OR sociology) AND DOCUMENT TYPES: (Review)
Timespan: 2010-2017. Indexes: SCI-EXPANDED, SSCI, A&HCI, ESCI.

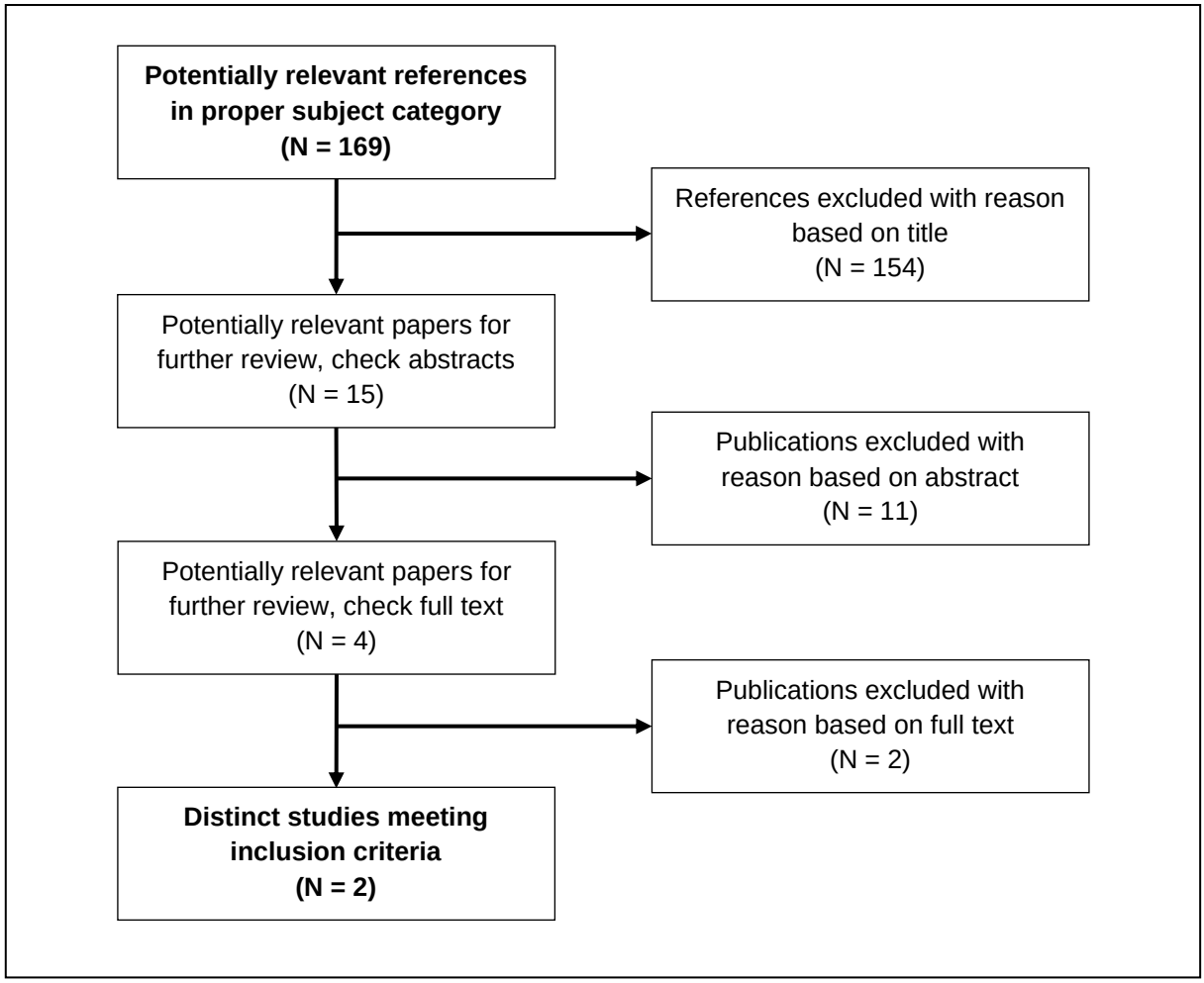
Selection diagram: Board interlocks, networks & innovation



Web of Science search string:

TS=("knowledge diversity" OR "knowledge broadness" OR "external knowledge") AND TS=(innovation OR r&d OR "research & development" OR "research and development") AND WC=(business OR management OR operations research & management science OR psychology, applied OR psychology, social OR sociology) AND DOCUMENT TYPES: (Article)
Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, ESCI.

Selection diagram: Cited author 2010-2017: (Geletkanycz & Hambrick, 1997)



Web of Science search string:

CITED AUTHOR: (Geletkanycz AND Hambrick)
Refined by: PUBLICATION YEARS: (2014 OR 2015 OR 2017 OR 2013 OR 2011 OR 2010 OR 2012 OR 2016) AND WEB OF SCIENCE CATEGORIES: (MANAGEMENT OR BUSINESS OR PSYCHOLOGY APPLIED OR SOCIOLOGY)
Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, ESCI.

Appendix I-E: Author matrix

Bibliography	Research Question	Hypotheses	Dependent Variable	Independent Variable	Mediator/ Moderator	Unit of Analysis	Sample	Main Findings
Bercovitz et al. **(2011)**	The objective of this paper is to enhance our understanding of the links between team structure and outcomes. Our subject is academic teams of university scientists and other external members who engage in inventive activity.	H1. Creative teams with more knowledge combination novelty will have a higher probability of commercialization success. H2. The higher coordination costs of a creative team that spans multiple disciplinary and/or organizational areas lowers the probability of commercialization success. H3. The greater the experience of creative team leaders working together, the greater the probability of commercialization success. H4. Creative teams with ties to external networks will have a higher probability of commercialization success. H5. Creative teams with pre-existing social ties among team members will have a higher probability of commercialization success. H6. Creative teams with local external team members will have a higher probability of commercialization success. H7a. The distance spanned by a creative team will be positively related to the core team's experience working together. H7b. The distance spanned by a creative team will be positively related to presence of pre-existing social ties between the team members. H7c. The distance spanned by a creative team will be positively related to the scientific reputations of the team members.	Commercialisation success of academic research disclosures (measured as the generation of patents, licences and royalties from the disclosure)	Coordination and communications costs Knowledge combination novelty Team experience Access to external Networks The relationship between internal and the external team member(s) Geographic proximity	- Ctrl variables: Research quality and resource base, star scientists, project type, team size, institutional differences.	Team level	Empirical (Academic research teams who disclose their invention to the university technology transfer office)	Support for H2, H3, H4, H5. No support for H6, H7abc. Some support for H1; coefficient on novelty is positive and significant for both patenting and licensing, not for royalties
Carnabuci et al. **(2013)**	Why are some firms better at building recombinant capabilities? The goal of this paper is to shed light on the antecedents of	H1: The higher a firm's degree of collaborative integration, the more the firm will innovate by reusing known technological combinations. H2: The higher a firm's degree of collaborative integration, the less the firm will innovate by creating new	Recombinant reuse (the extent to which a firm innovates by reusing technological combinations	Collaborative integration (the extent to which a firm's inventors are part of one integrated	Knowledge diversity (H5+6) (mod)	Firm level	Empirical (Panel dataset of 126 global semi-conductor	Support for H1, H2, H3, H4, H6. No support for H5. Namely, having an integrated Intra-organizational network of inventors enhances a firm's ability

Bibliography	Research Question	Hypotheses	Dependent Variable	Independent Variable	Mediator/ Moderator	Unit of Analysis	Sample	Main Findings
	recombinant creation and recombinant reuse. Complementing the predominant emphasis on the formal organizational design of the firm we examine how firms' recombinant capabilities are affected by the informal organization behind a firm's organizational chart	combinations. H3: The higher the degree of knowledge diversity among a firm's inventors, the less the firm will innovate by reusing existing technological combinations. H4: The higher the degree of knowledge diversity among a firm's inventors, the more a firm will innovate by creating new technological combinations. H5: The positive association between collaborative integration and firms' ability to innovate by recombinant reuse will decrease as the degree of knowledge diversity among the firm's inventors increases. H6: The negative association between collaborative integration and firms' ability to innovate by recombinant creation will decrease as the degree of knowledge diversity among the firm's inventors increases.	known to the firm) Recombinant creation (the extent to which a firm innovates by creating new technological combinations)	intra-organizational network) Knowledge diversity			firms.	to innovate through recombinant reuse but reduces its ability to innovate through recombinant creation. Similarly, a more diverse technological knowledge base hinders recombinant reuse but improves its ability to innovate through recombinant creation. Contrary to our expectations, however, we found suggestive evidence that combining an integrated collaboration network and a diverse knowledge base enhances both recombinant creation and recombinant reuse.
Chen et al. **(2013)**	This study attempts to fill the research gap by introducing board social capital as a potential mod-erator into the CEO characteristics–R&D investment relationship.	H1. Board social capital diminishes the negative relationship between CEO tenure and R&D investment. H2. Board social capital diminishes the negative relationship between CEO age and R&D investment. H3. Board social capital enhances the positive relationship between CEO educational level and R&D investment.	R&D Investment	CEO tenure, age and educational level.	- Ctrl variables: ROE, debt to assets, firm size, institutional ownership, CEO ownership, firm age, industry.	Firm level	Empirical (Taiwanese firms)	The results show that board social capital mitigates/enhances the negative/ positive effect of CEO tenure/CEO educational level on R&D investment, supporting the view that board social capital, as an important conduit to link firms to critical information and essential resources in the environment, may offer better counsel to CEOs and enhance their decision-making capabilities in moving toward R&D.
Ferreras-Méndez et al. **(2015)**	The study addresses, theoretically and empirically, how intensively accessing knowledge from a limited number of external channels (open search depth) and from a broad range of external channels (open	H1a. The depth of external knowledge search will be positively related to innovation performance. H1b. The breadth of external knowledge search will be positively related to innovation performance. H2a. The depth of external knowledge search will be positively related to firms' performance. H2b. The breadth of external knowledge search will be positively related to firms' performance. H3a. The depth of external	Innovation performance (the successful implementation of new ideas) Firm performance (the efficiency and effectiveness of the action adopted by the organization)	Breath of openness (different types of partners with which innovating firms associate to sustain and increase performance) Depth of openness (the extent to which	- Ctrl variables: Firm size, environmental dynamism.	Firm level	Empirical (Respondent data from CEO's and heads of R&D from Spanish bio-tech companies)	Support for H3a, H4ab. No support for H1ab, H2ab, H3b. The depth of openness facilitates access to both technological and market knowledge sources that may allow firms to renew their stock of knowledge. This stock of knowledge is a necessary condition to learn from external partners Thus, managers should use this strategy to generate the

Bibliography	Research Question	Hypotheses	Dependent Variable	Independent Variable	Mediator/ Moderator	Unit of Analysis	Sample	Main Findings
	search breadth) is related to a higher level of absorptive capacity (AC), and how this capacity may explain performance differences between firms.	knowledge search will be positively related to absorptive capacity. H3b. The breadth of external knowledge search will be positively related to absorptive capacity. H4a. Absorptive capacity will be positively related to innovation performance. H4b. Absorptive capacity will be positively related to firms' performance.	Absorptive capability	firms draw intensively from different search channels or sources of innovative ideas)				knowledge base necessary to facilitate the exploration, transformation and exploitation of the new commercial ideas identified in the environment.
Foss et al. **(2013)**	This study examines (1) the role of external knowledge sources in the process of exploiting strategic opportunities and (2) the influence of a firm's organizational design on the effect of external sources on opportunity exploitation, that is, the deployment of resources, actions, and investments to realize recognized opportunities.	H1. The extent to which a firm makes use of external knowledge sources beyond the opportunity recognition phase is positively associated with its opportunity exploitation. H2. The positive relation between external knowledge sources and opportunity exploitation is strengthened when the firm has a decentralized organizational design. H3. There is a three-way interaction between the firm's use of external knowledge sources, decentralization, and coordination, which implies that the positive association between external knowledge sources and opportunity exploitation is strongest when both decentralization and coordination are high.	Opportunity exploitation (the number of new business opportunities that firms have successfully realized in the previous three years)	External knowledge sources Decentralisation of decision-making Coordination of workflow	- Ctrl variables: Number of opportunities recognized, exploitation frequency, internal R&D, firm size, industry, state of the market.	Firm level	Empirical (Respondent data from Danish private firms)	Support for H1, H3. No support for H2. An important insight from our study centers on the role of organizational design in facilitating a firm's use of external knowledge sources in opportunity exploitation. The positive effect of the combination of high coordination, decentralization, and knowledge sourcing on opportunity exploitation is supported by the significant three-way interaction term,
Garriga et al. **(2013)**	The objectives of the study consist of the following: (1) examine the Lauren and Salter (L&S) model in different national and industrial contexts, (2) extend the L&S model by taking firm context into account, and (3) test the extended model.	H1. Constraints on the application of resources negatively affect a firm's innovative performance. H2. Abundance of innovation-relevant external knowledge positively affects a firm's innovative performance. H3a. Constraints on the application of resources positively affect the breadth of the knowledge search. H3b. Constraints on the application of resources negatively affect the depth of the knowledge search. H4. An abundance of innovation relevant external knowledge positively affects the breadth and depth of the knowledge search.	Innovative performance (radical and incremental innovation) Breadth of knowledge search Depth of knowledge search	Constraints on the application of resources toward innovation Abundance of innovation-relevant external knowledge	- Ctrl variables: Outsourced R&D, collaboration arrangements, international export, size, start-up date, industry.	Firm level	Empirical (Swiss innovation survey 2008)	Support for H2, H3ab. Partial support for H1 (only incremental), H4. If firms engage in open innovation, the optimal search strategy for external knowledge may depend on the type of innovation being pursued. It seems a firm with few constraints on applying resources may search deeper but may also consider a limited number of sources of knowledge.

Bibliography	Research Question	Hypotheses	Dependent Variable	Independent Variable	Mediator/ Moderator	Unit of Analysis	Sample	Main Findings
Geletkanycz et al. **(1997)**	We draw on complementary literatures to develop and test the idea that strategic choices are affected by the external ties of top management team members and that the informa- tional and social influences arising from external interactions will be reflected in strategic profiles, particularly the degree to which the firm's strategy conforms to or deviates from central tendencies in an industry	H1a. An executive team's intraindustry ties will be positively related to strategic conformity. H1b. An executive team's extraindustry ties will be negatively related to strategic conformity. H2. The association between strategic conformity and organizational performance will be more positive for firms operating in a more uncertain environment than for firms operating in a less uncertain environment. H3. Intraindustry ties will moderate the relationship between strategic conformity and organizational performance. The greater the combination of strategic conformity and executive team intraindustry ties, the higher the firm's performance. H4. Extraindustry ties will moderate the relationship between strategic nonconformity (deviance) and organizational performance. The greater the combination of strategic nonconformity (deviance) and executive team extraindustry ties, the higher the firm's performance.	Strategic conformity Performance	Intraindustry ties Extraindustry ties	Intraindustry ties Extraindustry ties Ctrl variables: TMT tenure, firm age, firm size, ROA, strategic conformity, environmental uncertainty.	Firm level	Empirical (30 largest publicly traded firms in branded food and computer industry)	Support for H1b, H2. Partial support for H1a, H3. No support for H4. We present evidence that organizations are affected by the social interactions that executives experience in their boundary spanning activities. Thus, the social capital that senior man- agers bring to the firm may complement the human capital they provide. Ideally, top management teams should be composed with a consideration of executives' personal ties, and there should be a market value for those ties. As our results indicate, however, the value of such ties will not be the same for all firms but, rather, will vary depending on the firm's strategic posture Ties that match the demands of the firm's strategy are helpful to performance.
Kesidou et al. **(2012)**	Do firms benefit from geographic proximity? And if yes, do they take advantage of local knowledge spill overs . Do firms rely solely on non-local knowledge linkages? Or does the presence of "knowledge gatekeepers" facilitate the absorption of knowledge from extra-cluster sources and its diffusion to the firms within the cluster?	H1. Firms involved in indirect local ties exhibit higher innovation performance than other firms in the cluster. H2. Firms involved in direct local ties exhibit higher innovation performance than other firms in the cluster. H3. Firms involved in non-local knowledge networks exhibit higher innovation performance than other firms in the cluster. H4. When we classify firms in a local cluster some of them will have the role of knowledge gatekeepers. H5. Knowledge gatekeepers will exhibit differences in their innovation performance compared to other types of firms in the cluster.	Innovation: Sales of innovation output, quality certification, number of innovations, innovation performance.	External knowledge: Indirect local ties, direct local ties, non-local knowledge networking.	- Ctrl variables: R&D, postgrad education, experience, firm size.	Firm level	Empirical (Urguay software cluster)	Support for H1, H3, H4, H5. No support for H2. "Weak" ties with other firms in the local cluster may enable a firm to capture knowledge beyond its own business circle. In line with new insights in the cluster literature, this study demonstrates that, next to local interaction, non-local knowledge networking is crucial for the innovation of the clustered firms.

Bibliography	Research Question	Hypotheses	Dependent Variable	Independent Variable	Mediator/ Moderator	Unit of Analysis	Sample	Main Findings
Larrañeta et al. **(2012)**	This article examines the effect of the external sources of knowledge on new ventures' strategic variety.	H1. The diversity of a new venture's external knowledge sources is positively associated with its strategic variety. H2. The novelty of the knowledge a new venture gains from external sources is positively associated with its strategic variety. H3a. The absorptive capacity of a new venture will moderate the effect of the diversity of its external knowledge sources on its strategic variety. H3b. The absorptive capacity of a new venture will moderate the effect of the novelty of the knowledge gained from external sources on its strategic variety. H4. The degree of social development of the regional cluster in which the new venture is located has an inverted U-shape relationship with its strategic variety.	Strategic variety (managers evaluation of strategy company strategy)	The diversity of external knowledge sources The novelty of external knowledge The degree of social development of the cluster	Absorptive capacity (mod)	Firm level	Emprical (Respondent data from Spanish new ventures)	Support for H1 - H4. We found that the diversity and the novelty of external knowledge are positively and significantly elated to new ventures' strategic variety. We find that the role of absorptive capacity is not as straightforward as depicted in the literature. Specifically the infusion of diverse and novel external knowledge into new ventures' operations through their absorptive capacity can promote the conception of different business concepts and varied business models.
Laursen et al. **(2012)**	This paper draws on social capital theory, the relational view of the firm, and the geography literature to examine the importance of regional social capital for firms' innovative capabilities.	H1. Firms operating in regions with high levels of social capital in terms of social interaction are more likely to introduce product innovation. H2. Social capital and internal R&D spending are complementary in affecting the likelihood of introducing product innovation. H3. The effectiveness of externally acquired R&D on the likelihood of introducing product innovation is higher for firms operating in regions associated with high levels of social capital.	Introduction of product innovation	Social capital R&D intensity External R&D acquisition	Social capital (mod) (H3 Many ctrl variables.	Firm level	Empirical (data from Italian companies)	Support for H1, H3. Partial support for H2. We provide evidence that location matters: firms located in regions characterized by a high level of structural social capital in terms of social interaction display a higher propensity to innovate.
Leiponen **(2012)**	This article seeks to highlight the role played by R&D and "breadth" in innovation strategies in service innovation.	H1a: Breadth in terms of knowledge sourcing and innovation objectives is positively associated with innovation success of both service and manufacturing firms. H1b: Service firms benefit less than manufacturing firms from breadth in innovation strategies. H2a: Institutionalized R&D activities positively moderate the effect of breadth in innovation strategies.	Innovation success	Breadth of knowledge sourcing Breadth of innovation objectives	Institutionalization of R&D activities	Firm level	Empirical (survey data from Finish innovative-active service and manufac. Firms)	Support for H1b, H2ab. Partial support for H1a: Only breadth in terms of knowledge sourcing.

Bibliography	Research Question	Hypotheses	Dependent Variable	Independent Variable	Mediator/ Moderator	Unit of Analysis	Sample	Main Findings
		H2b. Institutionalized R&D activities by service firms positively moderate the effect of broad innovation strategies.						
Lin **(2011)**	The study examines how knowledge diversity moderates the effects of R&D investment, strategic alliances, and acquisitions on firm performance	H1. A firm's knowledge diversity will be positively associated with its performance. H2. A firm's R&D investment will be positively associated with its performance. H3. A firm's strategic alliance intensity will be positively associated with its performance. H4. A firm's acquisition intensity will be positively associated with its performance. H5. The contribution of strategic alliances on firm performance will be stronger when the firm's knowledge diversity is high. H6. The contribution of mergers and acquisitions on firm performance will be stronger when the firm's knowledge diversity is high. H7. The contribution of R&D investment on firm performance will be stronger when the firm's knowledge diversity is high.	Performance (sales growth, net earnings)	R&D expense Strategic alliance intensity Knowledge diversity	Knowledge diversity (H5-7) (mod) Ctrl variables: Economic condition, industry, firm total assets.	Firm level	Empirical (firm-year data from US technology firms)	Support for H2 (only earnings), H3, H4, H5, H6. No support for H1, H7. The main effect of knowledge diversity on firm performance is not significant and it indeed is a moderator that interacts with other variables: R&D investment, strategic alliance intensity and acquisition orientation. For firms with high knowledge diversity, strategic alliances and acquisitions seem to be more effective. On the contrary, for firms with low knowledge diversity, alliances and acquisitions seem not to improve firm performance.
Parra-Requena et al. **(2015)**	The specific aim of this paper is to study the mediating role of knowledge acquisition in order to explain the relationship between external social capital – density, trust and cognitive proximity – and a firm's innovativeness. The main contribution of this study is to demonstrate how external knowledge acquisition drives a firm's ESC to innovativeness and	H1. Knowledge acquisition will positively mediate the effect of density on innovativeness. H2. Knowledge acquisition will positively mediate the effect of trust on innovativeness. H3. Knowledge acquisition will positively mediate the effect of cognitive proximity on innovativeness.	Innovativeness	Density Trust Cognitive proximity	Knowledge acquisition (med) Ctrl variables: age, size, use of ICTs, type of shoes, local institutions, attention to consumer needs, district membership.	Firm level	Empirical (Spanish footwear companies)	Support for H2, H3. No support for H1. The results obtained show how firms with a high degree of trust in their relationships tend to develop innovativeness. We can also observe that firms with a high degree of cognitive proximity in their relationships tend to develop innovativeness.

Bibliography	Research Question	Hypotheses	Dependent Variable	Independent Variable	Mediator/ Moderator	Unit of Analysis	Sample	Main Findings
	heightens the varying effects of density, trust and cognitive proximity.							
Robertson et al. (2012)	This conceptual article, however, concentrates on process innovation by firms that are already engaged in an activity and possess existing configurations of plant and equipment.							
Ye et al. **(2016)**	Is the relationship between knowledge heterogeneity KH and innovation performance positive, negative, or an inverted U-shape? Second, how can firms combine internal KH and external KH to improve innovation performance?	H1. The relationship between internal KH and innovation performance is an inverted U-shape. H2. The relationship between external KH and innovation performance is an inverted U-shape. H3. A complementary internal and external KH is positively associated with innovation performance. H4. A balanced internal and external KH is positively associated with innovation performance.	Innovation performance	Internal KH External KH Complementary KH Balanced KH	- Ctrl variables: firm size, firm age, industry sector, R&D capability, and technological turbulence.	Firm level	Empirical (respondent data from Chines tech-intensive industries)	Support for H2, H3, H4. No support for H1. The results of multiple regression analysis also show that internal KH has a linear effect on innovation performance, rather than a curvilinear one. Internal and external KH complement one another in enabling organizational Processes. The benefits and costs associated with external KH are not homogeneous for all firms, but depend on, and are intertwined with, a firm's ability to build an internal stock of knowledge
Yoo et al. **(2015)**	We examine how the top managers' external ties and board composition directly and interactively influence the strategic choices of firms.	H1a. The greater the number of top managers hired from inside the focal industry, the more likely the adoption of resource- imitation strategies by late movers. H1b. The greater the number of top managers participating in trade associations, the more likely the adoption of resource- imitation strategies by late movers. H2a. The greater the number of top managers hired from outside the focal industry, the more likely the adoption of resource- substitution strategies by late movers.	Strategy choice at time t+1 (imitation or substitution)	Intra-industry ties Extra industry ties	Ctrl. Variables: TMT tenure, firm age, firm size, degree of diversification, strategy choice at time t,	Firm level	Empirical (firms from the computer equipment industry)	Support for H1-H3, H4a, H5a. No support for H4b, H5b. Our results indicate that top managers with intra-industry knowledge and experience tend to adopt a resource-imitation strategy whereas those with knowledge and experience from other industries tend to adopt a resource-substitution strategy. The separation of CEO and board chairperson duties also affects strategy selection. In terms of

Bibliography	Research Question	Hypotheses	Dependent Variable	Independent Variable	Mediator/ Moderator	Unit of Analysis	Sample	Main Findings
		H2b. The greater the number of top managers participating in professional associations, the more likely the adoption of resource-substitution strategies by late movers. H3a. After controlling for the effects of TMT's external ties, the ratio of outsiders on the board is positively associated with the adoption of resource-substitution strategies by late movers. H3b. After controlling for the effects of TMT's external ties, the separation of CEO and board chairperson duties is positively associated with the adoption of resource- substitution strategies by late movers. H4a. For TMTs with managers hired from inside the focal industry, the higher the proportion of outside directors the lower will be the tendency of late movers to adopt resource-imitation strategies. H4b. For TMTs with managers participating in trade associations, the higher the proportion of outside directors the lower will be the tendency of late movers to adopt resource-imitation strategies. H5a. For TMTs with managers hired from outside the focal industry, the higher the proportion of outside directors the lower will be the tendency of late movers to adopt resource-substitution strategies. H5b. For TMTs with managers participating in professional associations, the higher the proportion of outside directors the lower will be the tendency of late movers to adopt resource-substitution strategies.						interaction effects, we find that boards with a high ratio of outsiders reduce the tendencies of managers to opt for the safe strategy solutions with which they are familiar.

Appendix II: Analysis

Appendix II-A: Data preparation

In order to prepare the data file [MT Data BDL Klaasse (t+0 and t+1)] for the analysis, the variable 'country' is recoded into 'countryDE' for ISO code DE and 'countryNL' for ISO code NL because as a string variable it can not be used in regression.

Further, the variables 'int_inter' and 'int_intra' are mean centred for the purpose of moderator analysis resulting in two new variables 'inter_cent' and 'intra_cent'. These variables are used to compute an interaction (or moderation) term by multiplying inter_cent' with 'intra_cent' resulting the variable 'inter*intra'.

Centring is the process of transforming a variable into deviations around a fixed point, in this case the mean. This results in a variable that has a mean of zero meaning that if it is zero, it is actually at its average observed value. According to Field (2012) the main reason for centring variables is improved interpretability of results. If an interaction term is included in a regression analysis, the b-values of the independent variables involved in the interaction, represent the effect of the independent variable on the dependent variable in case the other independent variables (involved in the interaction) are zero. In some cases, zero is not a meaningful value for a variable, for instance a person's weight or height. A person with no weight or height would not exist at all. However, if the variable is mean centred, zero is actually the average observed value so that the value of zero is actually meaningful. In the current study this is not a problem however as it could very well be that a company's board has zero interlocks (of a certain type). Mean centring is not only useful if zero is not a meaningful value, it also improves the interpretability of the individual effects of the variables involved in the interaction. This is especially interesting when the interaction is not significant. Since the variables are centred around their mean, b-values represent the effect of their independent variable at the mean value of the sample and, they are the average effect of the independent variable across the range of scores for the other independent variables (Field, 2012). Mean centring is often applied in order to reduce multicollinearity between independent variables. A study by Dalal & Zickar (2012) however shows that this does not work. Mean centring does not affect the fit of regression models, the power to detect moderating effects and also not the reliability of interaction terms. Their study only endorsed the benefits as presented by Field (2012).

Finally, for the lagged regression (t+1), a lead variable 'r_d_t1' is computed using the variable 'r_d'. This means that the independent variables in the sample now correspond to the observed R&D expenditure one year later. It must be noted that the sample size is reduced by this transformation as no data is gathered for the last year (2015) in the sample.

Appendix II-B: Outlier Analysis & Assumptions (t+0)

Linearity of Scatterplots

Before estimating any model, it is checked whether there is at least somewhat of a linear relationship between the independent variable and the dependent variables. This is done by looking at the scatterplots that are included in Appendix III-A. After consideration of these plots a logarithmic transformation is done for the variable 'comp_size' (number of employees) into 'log_comp_size' because the data is very unevenly scattered between the smallest (603 employees) and the largest (118900 employees) observation which causes problems with linearity (Field, 2012). The scatterplots also provide reason to believe there are a small number of outliers. Their effect on the regression models will be investigated further on during the outlier analysis.

Casewise Diagnostics

Before interpreting any results it is checked whether there are any outliers or influential cases that should be deleted. The casewise diagnostics table (1) in appendix III-A shows that there are six cases that have a standardised residual greater than |2| and three greater than |2,5|. In a normal sample, 5% of the observations is expected to have standardised residuals greater than |2| and 1% greater than |2,5| (Field, 2012). In this sample it is 3,75% (-1,25%) and 1,8% (+0,8%) respectively which seems to be well within limits. There is one observation with a standardised residual well over |3| (3,969), a so called extreme outlier which needs to be investigated further (Karadimitriou & Marshall, 2017).

Different diagnostic variables (i.e. Cook's Distance and the Centred Leverage Value) can be checked in order to identify and delete influential cases. The danger in doing so however, is that variables are deleted in order to change the model outcome. Therefore one should be careful with deleting observations from the dataset. (Field, 2012). Cook's distance measures the overall influence of a case on the model. Field (2012) argues that an observation should be considered for exclusion of its Cook's Distance is greater than 1. However, according to Karadimitriou & Marshall (2017) this threshold depends on the number of observations and is given by *4/n* in which *n* is the number of observations, in this case 4/160 = 0,025. The dataset contains 14 cases with a Cook's greater than 0,025 (saved in the datafile as

a variable called COO_1). The largest one (Cook's = 0,099) listed in residuals statistics table (1) in appendix III-A corresponds with the extreme outlier mentioned in the preceding paragraph. Because caution is needed with deleting cases, only this one is excluded based on a threshold of Cook's distance of 0,095. The regression is executed again. After rerunning the regression the newly maximum Cook's Distances is 0,133 corresponding to a case with a standardized residual just over |3| (see casewise diagnostics table (2) and residual statistics table (2) in appendix III-A) Therefore this observation is excluded as well based on the same threshold and the regression is executed once again. After this third iteration, again there is one case in casewise diagnostic table (3) (appendix III-A) with a value just over |3| but its Cook's Distance is well below the earlier adopted threshold of 0,095. Following Field's (2012) advise on being careful with deleting cases, no more observations are excluded at this point, resulting in a sample size of n = 158.

Assumptions of Linear Regression

The first assumption to be tested is that of independence of the error terms which means that there is no correlation between adjacent residuals. This can be tested using the Durbin-Watson test which provides a value between 0 and 4. According to Field (2012) a value near 2 is considered good while any value under 1 or above three can be considered problematic. With this assumption violated, the estimates of the model parameters will still be valid but not optimal (Field, 2012). Initially, the Durbin-Whatson diagnostic was well below the critical value of 1. Considering that a panel dataset is used, it makes sense that the residuals are correlated. The number of interlocks in a succeeding year is not entirely independent of the number in the preceding year. The problem is fixed however by rearranging the data, sorting it to year instead of to company. This way adjacent residuals are no longer from the same company resulting in a Durbin-Watson value of 1,865, close enough to 2, thus meeting the assumption. Also see the model summary table in appendix III-A.

The second assumption is that there is no collinearity between the independent variables as this would affect the trustworthiness of the model. This is assessed by looking at the variance inflation factor (VIF). Variables with a value above 10 are cause for concern and should be deleted or aggregated with the variable it correlates with (Field, 2012). This is not the case here as the coefficients table in appendix III-A shows that the highest VIF is 4,976 which occurs in the fourth model.

The third assumption is that of homoscedasticity meaning that at each level of the independent variables, the variance of the residuals is constant. Violation of this assumption

(heteroscedasticity), invalidates confidence intervals and significance tests but does not invalidate the model parameters (Field, 2012). Heteroscedasticity can be checked by looking scatterplot of standardised residuals against predicted values which is included in appendix III-A and should look like an array of random dots. In this case however there is sideways v-shaped pattern (<) in the scatterplot indicating heteroscedasticity. The scatterplot can also be used to identify non-linearity but since the standardised residuals are quite evenly spread around a straight axis this does not seem to be a problem (Hair, Black, Babin, & Anderson, 2014).

The final assumption is that of normality of the residuals which means that it is assumed that the standardised residuals in the model are normally distributed. This is checked by viewing the histogram and the normal p-p plot included in appendix III-A (Field, 2012). Both show that the residuals are not normally distributed violating the assumption.

Bootstrapping

Since two of the four assumptions of multiple linear regression have been violated, the significance tests can not be trusted and the model parameter estimates are not optimal. In order to overcome this problem a robust method has to be applied, in this case bootstrapping, which does not build on the assumptions of homoscedasticity and normality. Therefore, bootstrapping provides an accurate estimation of the population value of the model parameters. Bootstrapping is performed using 2000 samples and a Bias Corrected and accelerated confidence interval (BCa) which is more accurate than a 95% confidence interval (Field, 2012).

Isolated effect of intra-industry interlocks

Using the hierarchical regression method, variables are entered into the model sequentially. This means that the effect of intra-industry interlocks is only tested with inter-industry interlocks already in the model. In order to find the isolated effect of intra-industry interlocks, another separate hierarchical analysis is performed using the same bootstrap parameters as before. For this analysis, the control variables are introduced in the first model and the intra-industry interlocks. The results are reported under model 2a in appendix II-C.

Appendix II-C: Results of t+0 Analysis

Table 3 contains the descriptive statistics and correlation of all the variables used in this analysis. There are weak to moderate significant correlations between the dependent variable and most of the independent variables. Only gender diversity and country do not seem to

correlate with the dependent variable. Further, there is no correlation greater than 0,9 meaning multicollinearity is not an issue here (Field, 2012).

Table 3: Descriptive statistics and correlations

		Mean	St. Dev.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1.	R&D expenses / Operating revenue % (t+0)	9,32	5,31	-									
2.	ROA using P/L before tax %	5,45	8,87	-0,44***	-								
3.	Total number of board members	14,34	5,5	-0,23**	0,05	-							
4.	Average board age in corresponding year	56,6	3,77	-0,29***	0,10	-0,03	-						
5.	Gender diversity	0,19	0,13	0,10	0,00	0,07	0,33***	-					
6.	Number of employees (Log10)	3,92	0,64	-0,42***	0,08	0,63***	0,25**	0,00	-				
7.	Country (NL dummy)	0,28	0,45	0,08	-0,06	-0,45***	0,3***	0,01	0,02	-			
8.	Industry (NACE Rev. 2 Primary code)	24,64	2,23	0,14*	-0,05	-0,32***	-0,33***	-0,43***	-0,33***	0,10	-		
9.	Number of inter-industry interlocks	15,78	9,99	-0,16*	0,00	0,65***	0,08	-0,03*	0,61***	0,11	-0,43***	-	
10.	Number of intra-industry interlocks	1,42	1,74	0,34***	-0,16*	-0,11	-0,11	-0,18*	-0,01	0,17*	0,04	-0,03	-

Note: Pearson correlations are reported. n = 158. *p < 0,05, **p < 0,01, ***p < 0,001.

Table 4 contains the results of the hierarchical multiple regression analysis and presents the predictive power of the different models that are tested. The first model contains all the control variables. The isolated effect of inter- and intra-industry interlocks are examined in models 2a and 2b respectively while the combined and moderated effect are entered in models 3 and 4.

Model 2a shows that the isolated effect of inter-industry is insignificant (β=0,02; ns) meaning that there is no support for hypothesis 1. The effect of intra-industry interlocks, isolated in model 2b (β=0,28; p<0,001) as well as in model 3 (β=0,29; p<0,001) and model 4 (β=0,29; p<0,001), is positive and significant thus fully supporting hypothesis 2. Model 4 shows that there is no support for hypothesis 3 as there is no significant effect (β=0,03; ns) for the interaction term.

The control variables in model 1 together explain 38,7% in the variance in the dependent variable with and F-ratio of 15,17. The best model in terms of predictive power is model 2b which includes only the intra-industry variables which together with the control variables explains 45,6% of the variance with an F-ratio of 17,47. The variable intra-industry interlocks in model 2b explains 6,9% of the variance.

Table 4: Results of hierarchical multiple regression analysis: Effects on R&D expenditure (t+0). The standard errors and significance levels are based on 2000 bootstrap samples.

	R&D expenses / Operating revenue % (t+0)				
	Model 1	Model 2a	Model 2b	Model 3	Model 4
Intercept	42,14***	41,74***	36,63***	34,60**	35,02**
	-8,11	(9,03)	(6,94)	(8,22)	(8,22)
Control variables					
ROA using P/L before tax %	-0,38***	-0,38***	-0,34**	-0,34***	-0,34***
	-0,23	-0,23	-0,20	-0,20	-0,20
	(0,05)	(0,05)	(0,06)	(0,05)	(0,05)
Total number of board members	0,10	0,08	0,12	0,04	0,03
	0,10	0,08	0,11	0,04	0,03
	(0,09)	(0,15)	(0,09)	(0,14)	(0,14)
Average board age in corresponding year	-0,27**	-0,27**	-0,23**	-0,22**	-0,22**
	-0,38	-0,38	-0,32	-0,30	-0,30
	(0,10)	(0,11)	(0,10)	(0,11)	(0,11)
Gender diversity	0,17**	0,18*	0,22***	0,25***	0,24**
	6,97	7,15	8,94	9,86	9,58
	(2,60)	(2,89)	(2,40)	(2,74)	(2,88)
Number of employees (Log10)	-0,39***	-0,39***	-0,40***	-0,40***	-0,40***
	-3,27	-3,27	-3,34	-3,35	-3,32
	(0,78)	(0,79)	(0,81)	(0,82)	(0,82)
Country (NL dummy)	0,19*	0,18	0,14	0,08	0,09
	2,28	2,14	1,65	0,99	1,02
	(0,87)	(1,34)	(0,93)	(1,34)	(1,34)
Industry (NACE Rev. 2 Primary code)	-0,01	0,00	0,02	0,06	0,05
	-0,03	-0,01	0,05	0,14	0,13
	(0,19)	(0,24)	(0,17)	(0,23)	(0,23)
Predictor variables					
Number of inter-industry interlocks (centred)		0,02		0,10	0,11
		0,01		0,06	0,06
		(0,08)		(0,07)	(0,07)
Number of intra-industry interlocks (centred)			0,28***	0,29***	0,29**
			0,85	0,88	0,87
			(0,20)	(0,20)	(0,20)
Moderation effect					
Inter*intra (centred)					0,03
					0,01
					(0,03)
R^2	0,415	0,415	0,484	0,487	0,488
R^2 adjusted	0,387	0,383	0,456	0,456	0,453
	(4,16)	(4,17)	(3,91)	(3,91)	(3,93)
ΔR^2 adjusted		-0,004	0,069***	0,073***	-0,003
F-ratio	15,17***	13,19***	17,47***	15,60***	14,00***

Standardized, unstandardized regression coefficients and (std. errors) are reported. n = 141.
*p < 0,05, **p < 0,01, ***p < 0,001.

Appendix II-D: Outlier Analysis & Assumptions (t+1)

Linearity of Scatterplots

Before estimating the models, it is checked whether there is at least somewhat of a linear relationship between the independent variable and the dependent variables. The scatterplots are included in appendix III-B. They show approximately the same results as in appendix III-A; the log10 transformation of the number of employees will be used the scatterplots provide reason to believe that there are a small number of outliers.

Casewise Diagnostics

The same method as in appendix II-B is applied here in order to identify and exclude outliers. The casewise diagnostics table (1) in appendix III-B indicates that there are five cases (3,57%, n=143) that have a standardised residual greater than |2| and three (2,14%) that are greater than |2,5|. Given that in a normal sample, these values are expected to be 5% and 1% respectively (Field, 2012), the deviations from normal are -1,43% and +1,14%. There are two observations with a standardised residual well over |3| (4,296 and 3,922), so called extreme outlier which need to be investigated further (Karadimitriou & Marshall, 2017).

Looking at the Cook's Distances of all observations (listed in the data file as a variable called COO_4), there are 7 greater than 0,025. The largest one (Cook's = 0,123) listed in residuals statistics table (1) in appendix III-B corresponds to the extreme outlier which has standardised residual of 3,922. This is almost five times the threshold proposed by (Karadimitriou & Marshall, 2017) but also well below Field's (2012) advised value of 1. Given the fact that it is an extreme outlier and considering its relatively high Cook's Distance, this case is excluded from the sample. After rerunning the regression analysis, casewise diagnostics table (2) in appendix III-B shows that there is still an extreme outlier with a standardized residual of 4,631. However, this case does not correspond to the largest Cook's distance of 0,099 in residuals statistics table (2) but to the second largest Cook's Distance of 0,095 (see variable COO_5 in the data file). Given its large standardized residual, this case is excluded from the sample and the regression is executed again. In appendix III-B casewise diagnostics table (3) shows that the largest standardized residual after the third regression is 3,402 which again corresponds to the second largest Cook's Distance of 0,094 (COO_6 in the data file). The other outlier with a standardised residual of 3,149 corresponds to the largest Cook's Distance of 0,126 depicted residual statistics table (3). Although both cases have standardised residuals somewhat greater than |3| no more cases are excluded at this point as an attempt to delete the first of these two, only increased the standardized residual of second one.

Following Field's (2012) advise on conservative outlier analysis, no more cases are deleted at this point resulting in a sample size of n = 141.

Assumptions of Linear Regression

In order to test the assumption of the independence of the error terms the Durbin-Watson diagnostic is checked which preferably is close to the value of 2 (Field, 2012). The model summary table in appendix III-B shows that in this case its value is 1,901 and with that the assumption is met.

Further the assumption that there is no collinearity between the independent variables is assessed by checking the variance inflation factors (VIF) in the coefficients table in appendix III-B which should never exceed the value of 10 (Field, 2012). The highest VIF is 5,469 which means that also this assumption is met.

The scatterplot of standardised residuals against predicted values in appendix III-B shows a same type of sideways v-shaped pattern (<) as before, indicating that there is heteroscedasticity. Given this pattern, non-linearity does not seem to be a problem here (Hair, Black, Babin, & Anderson, 2014).

Finally, the histogram and the normal p-p plot in appendix III-B show that there are problems with the normal distribution of the standardised residuals meaning that the assumption of normality is again violated.

Bootstrapping

Since the assumptions of normality and homoscedasticity have been violated, the robust method of bootstrapping is used with 2000 samples and a Bias Corrected and accelerated confidence interval (BCa) which is more accurate than a 95% confidence interval (Field, 2012).

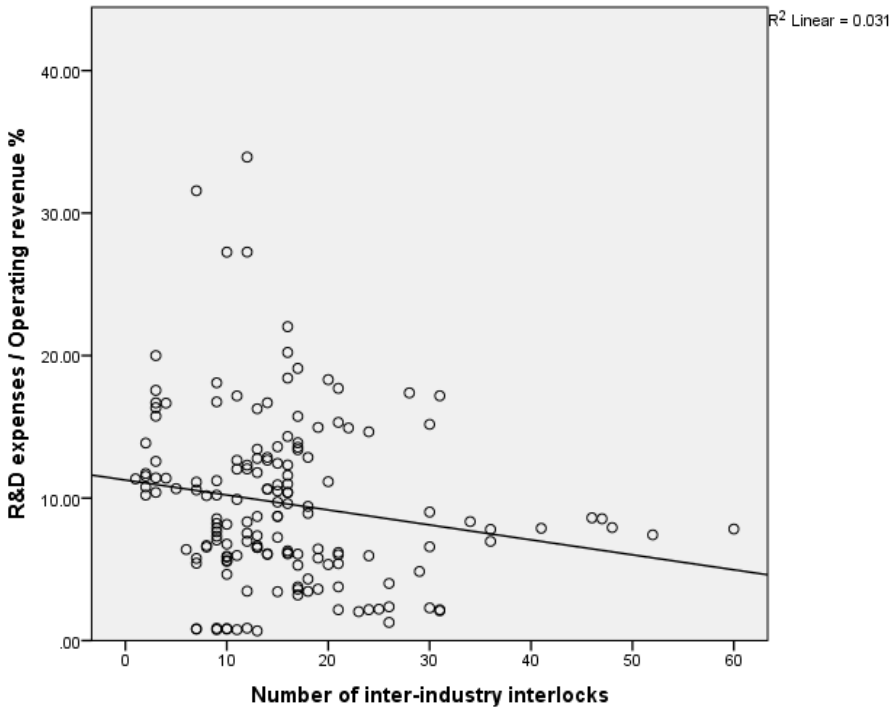
Isolated effect of intra-industry interlocks

Using the hierarchical regression method, variables are entered into the model sequentially. This means that the effect of intra-industry interlocks is only tested with inter-industry interlocks already in the model. In order to find the isolated effect of intra-industry interlocks, another separate hierarchical analysis is performed using the same bootstrap parameters as before. For this analysis, the control variables are introduced in the first model and the intra-industry interlocks. The results are reported under model 2a in paragraph 4.3.

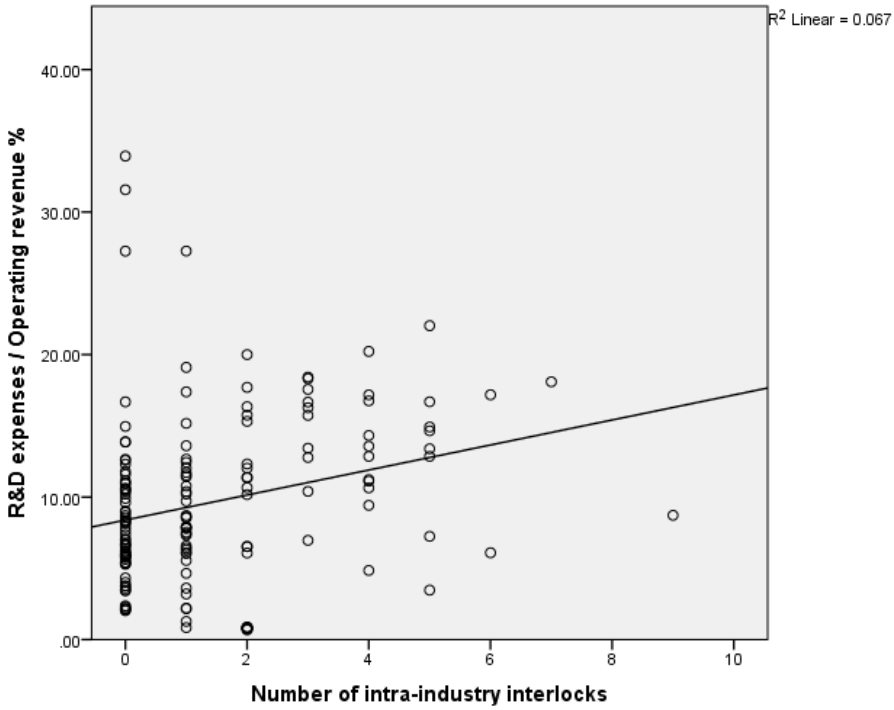
Appendix III: SPSS output

Appendix III-A: Outlier analysis & assumptions (t+0)

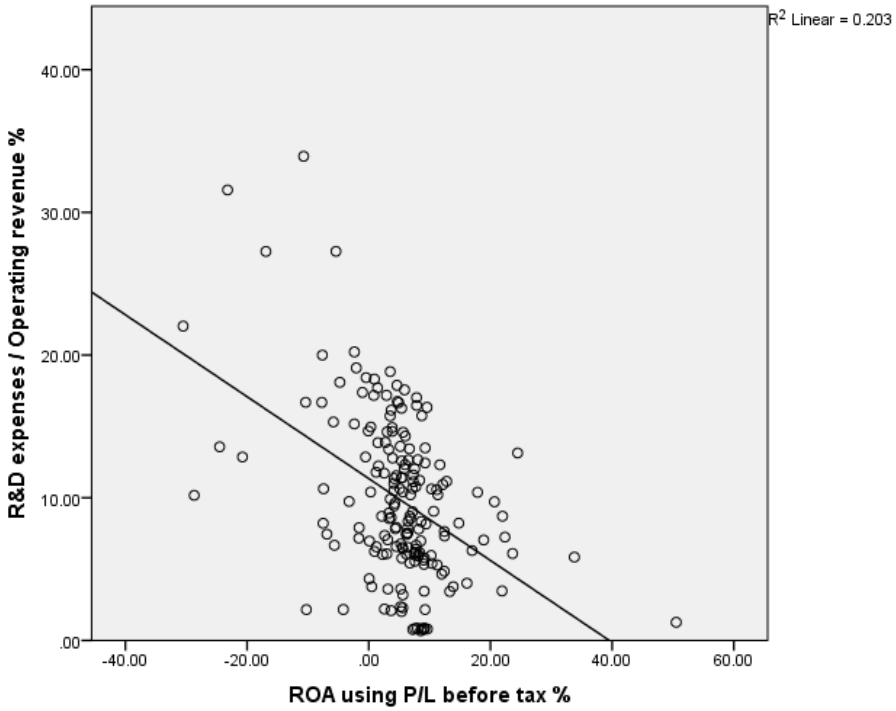
Scatterplot: Inter-industry interlocks



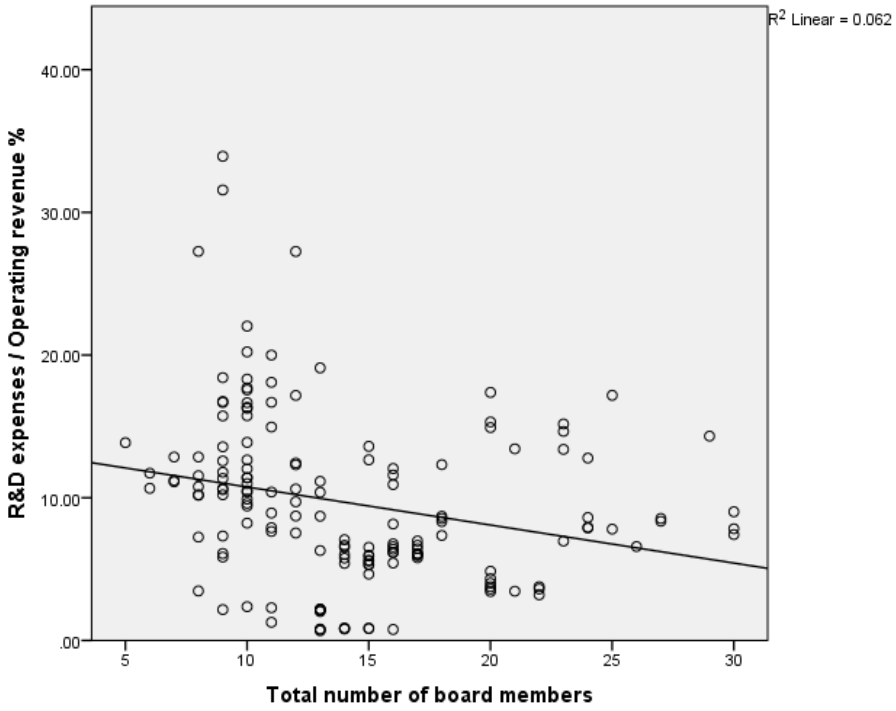
Scatterplot: Intra-industry interlocks



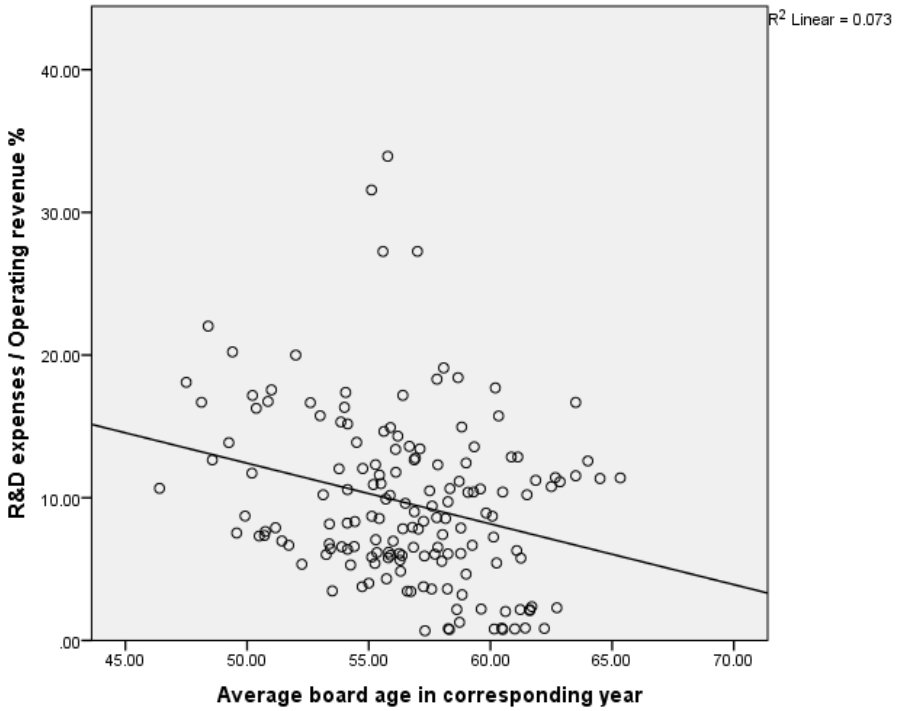
Scatterplot: ROA



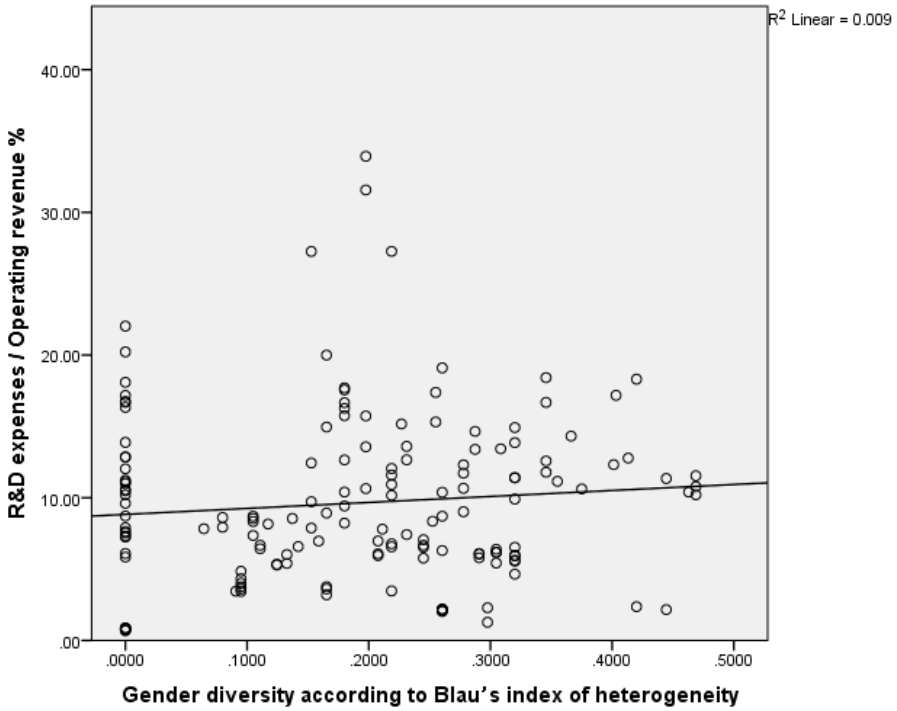
Scatterplot: Number of board members



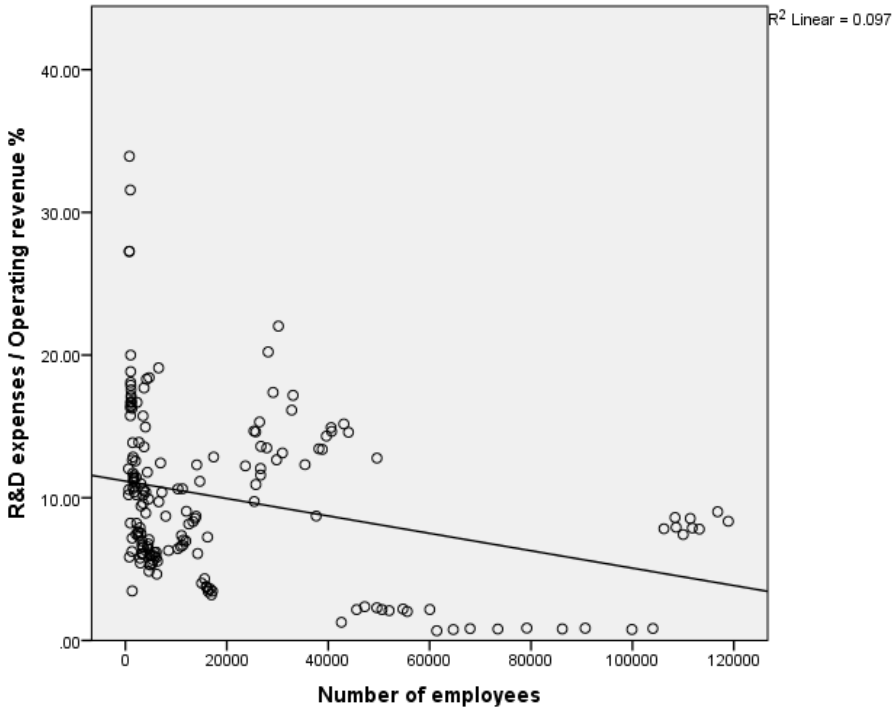
Scatterplot: Average board age



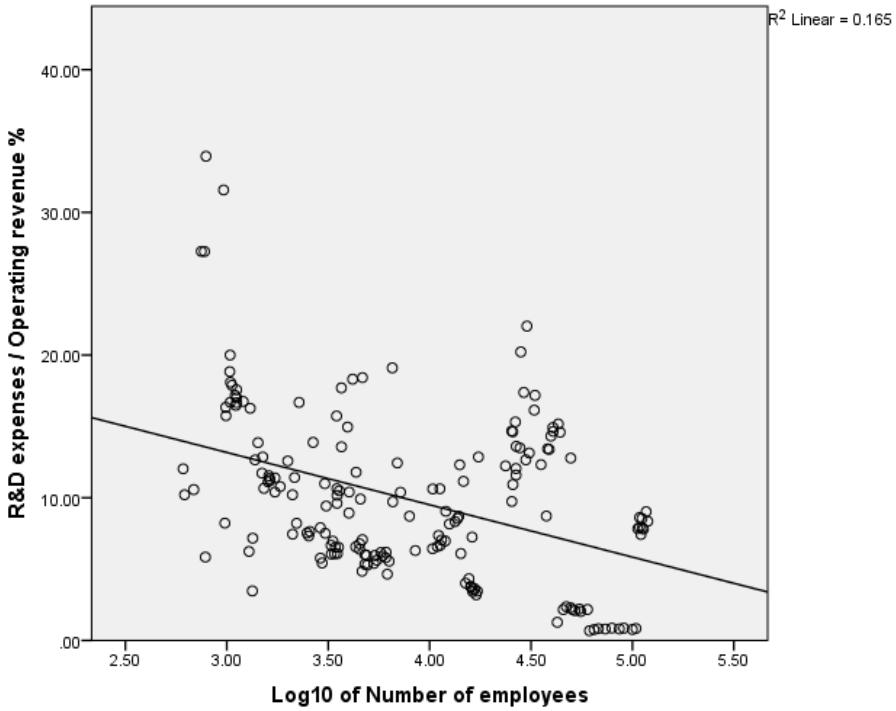
Scatterplot: Gender diversity



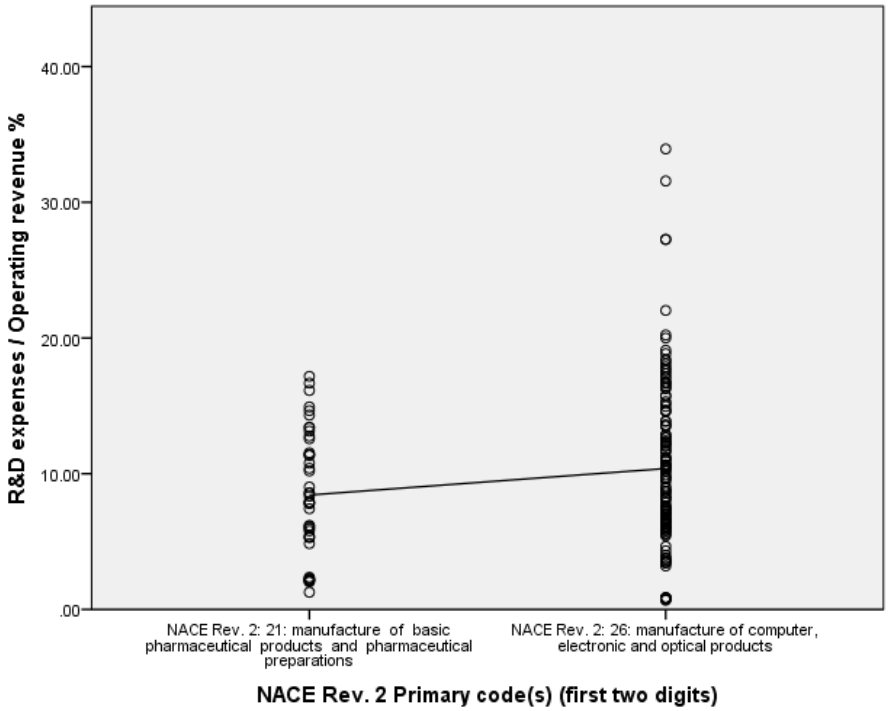
Scatterplot: Number of employees



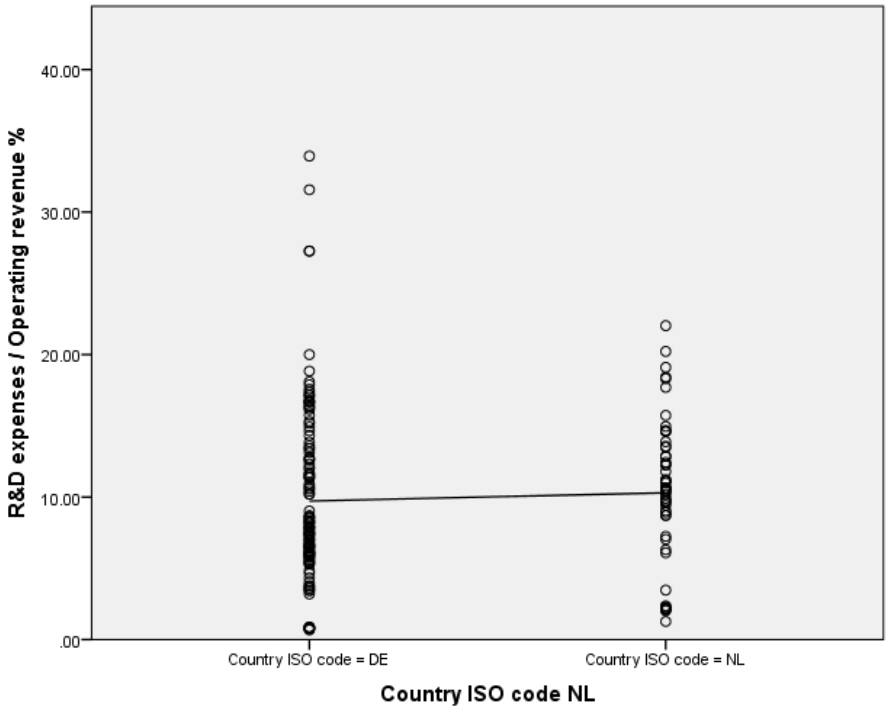
Scatterplot: Log10 of number of employees



Scatterplot: Industry



Scatterplot: Country



Casewise diagnostics table (1)

Casewise Diagnostics[a]

Case Number	Std. Residual	R&D expenses / Operating revenue %	Predicted Value	Residual
14	-2.073	6.96	15.9102	-8.95024
33	-2.345	10.17	20.2948	-10.12477
120	2.795	31.57	19.5031	12.06695
140	2.218	27.26	17.6844	9.57559
161	3.969	33.93	16.7951	17.13491
180	2.576	27.27	16.1460	11.12403

a. Dependent Variable: R&D expenses / Operating revenue %

Casewise diagnostics table (2)

Casewise Diagnostics[a]

Case Number	Std. Residual	R&D expenses / Operating revenue %	Predicted Value	Residual
13	-2.219	3.47	12.5268	-9.05682
14	-2.023	6.96	15.2159	-8.25591
33	-2.341	10.17	19.7230	-9.55300
120	3.248	31.57	18.3144	13.25557
140	2.587	27.26	16.7037	10.55633
180	2.985	27.27	15.0864	12.18361

a. Dependent Variable: R&D expenses / Operating revenue %

Casewise diagnostics table (3)

Casewise Diagnostics[a]

Case Number	Std. Residual	R&D expenses / Operating revenue %	Predicted Value	Residual
13	-2.505	3.47	13.3136	-9.84362
33	-2.161	10.17	18.6642	-8.49419
140	2.973	27.26	15.5768	11.68320
180	3.304	27.27	14.2855	12.98453

a. Dependent Variable: R&D expenses / Operating revenue %

Residual statistics table (1)

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-3.7629	20.5815	9.6176	4.15198	160
Std. Predicted Value	-3.223	2.641	.000	1.000	160
Standard Error of Predicted Value	.560	2.539	1.091	.303	160
Adjusted Predicted Value	-5.1647	21.6508	9.6065	4.21592	160
Residual	-10.12477	17.13491	.00000	4.17957	160
Std. Residual	-2.345	3.969	.000	.968	160
Stud. Residual	-2.497	4.096	.001	1.007	160
Deleted Residual	-11.48083	18.25196	.01114	4.52299	160
Stud. Deleted Residual	-2.543	4.333	.003	1.018	160
Mahal. Distance	1.684	54.011	9.938	6.812	160
Cook's Distance	.000	.099	.008	.016	160
Centered Leverage Value	.011	.340	.063	.043	160

a. Dependent Variable: R&D expenses / Operating revenue %

Residual statistics table (2)

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-2.8173	20.2038	9.4647	3.94498	159
Std. Predicted Value	-3.113	2.722	.000	1.000	159
Standard Error of Predicted Value	.532	2.400	1.034	.288	159
Adjusted Predicted Value	-3.9748	21.0153	9.4549	3.99960	159
Residual	-9.55300	13.25557	.00000	3.94968	159
Std. Residual	-2.341	3.248	.000	.968	159
Stud. Residual	-2.494	3.417	.001	1.007	159
Deleted Residual	-10.84534	14.67105	.00979	4.28170	159
Stud. Deleted Residual	-2.540	3.548	.002	1.016	159
Mahal. Distance	1.687	53.666	9.937	6.827	159
Cook's Distance	.000	.113	.008	.016	159
Centered Leverage Value	.011	.340	.063	.043	159

a. Dependent Variable: R&D expenses / Operating revenue %

Model summary

(After bootstrapping.)

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.644[a]	.415	.387	4.15921	.415	15.171	7	150	.000	
2	.644[b]	.415	.383	4.17264	.000	.036	1	149	.850	
3	.698[c]	.487	.456	3.91992	.072	20.831	1	148	.000	
4	.698[d]	.488	.453	3.92994	.001	.247	1	147	.620	1.865

a. Predictors: (Constant), NACE Rev. 2 Primary code(s) (first two digits), ROA using P/L before tax % , Country ISO code NL, Log10 of Number of employees, Gender diversity according to Blau's index of heterogeneity, Average board age in corresponding year, Total number of board members

b. Predictors: (Constant), NACE Rev. 2 Primary code(s) (first two digits), ROA using P/L before tax % , Country ISO code NL, Log10 of Number of employees, Gender diversity according to Blau's index of heterogeneity, Average board age in corresponding year, Total number of board members, Centred number of inter-industry interlocks

c. Predictors: (Constant), NACE Rev. 2 Primary code(s) (first two digits), ROA using P/L before tax % , Country ISO code NL, Log10 of Number of employees, Gender diversity according to Blau's index of heterogeneity, Average board age in corresponding year, Total number of board members, Centred number of inter-industry interlocks, Centred number of intra-industry interlocks

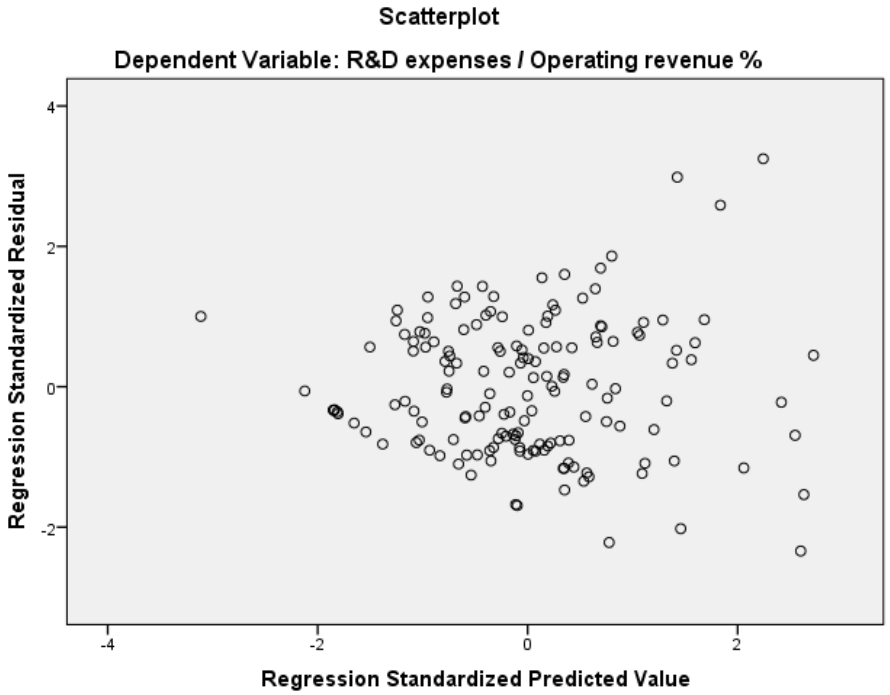
d. Predictors: (Constant), NACE Rev. 2 Primary code(s) (first two digits), ROA using P/L before tax % , Country ISO code NL, Log10 of Number of employees, Gender diversity according to Blau's index of heterogeneity, Average board age in corresponding year, Total number of board members, Centred number of inter-industry interlocks, Centred number of intra-industry interlocks, Interaction inter-industry and intra-industry interlocks

Coefficients table

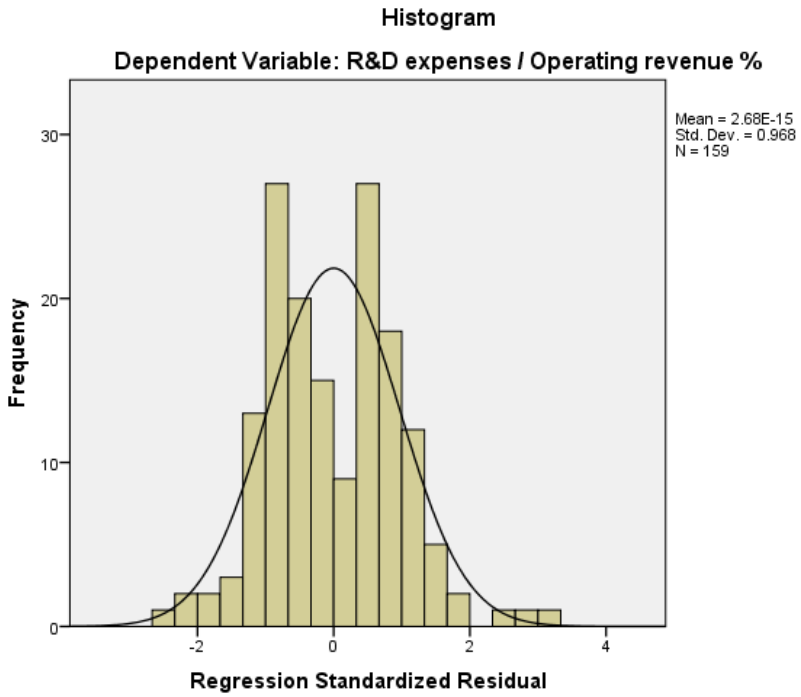
(After bootstrapping and collinearity statistics only)

Model		Collinearity Statistics	
		Tolerance	VIF
4	(Constant)		
	ROA using P/L before tax %	.953	1.049
	Total number of board members	.201	4.976
	Average board age in corresponding year	.661	1.513
	Gender diversity according to Blau's index of heterogeneity	.611	1.636
	Log10 of Number of employees	.425	2.355
	Country ISO code NL	.358	2.795
	NACE Rev. 2 Primary code(s) (first two digits)	.489	2.046
	Centred number of inter-industry interlocks	.266	3.753
	Centred number of intra-industry interlocks	.870	1.149
	Interaction inter-industry and intra-industry interlocks	.889	1.125

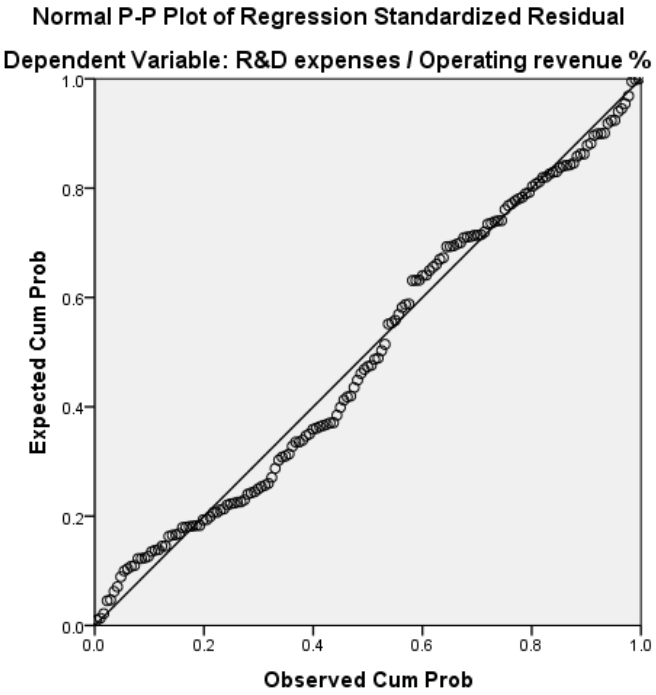
Scatterplot: ZPRED against ZRESID



Histogram: ZRESID

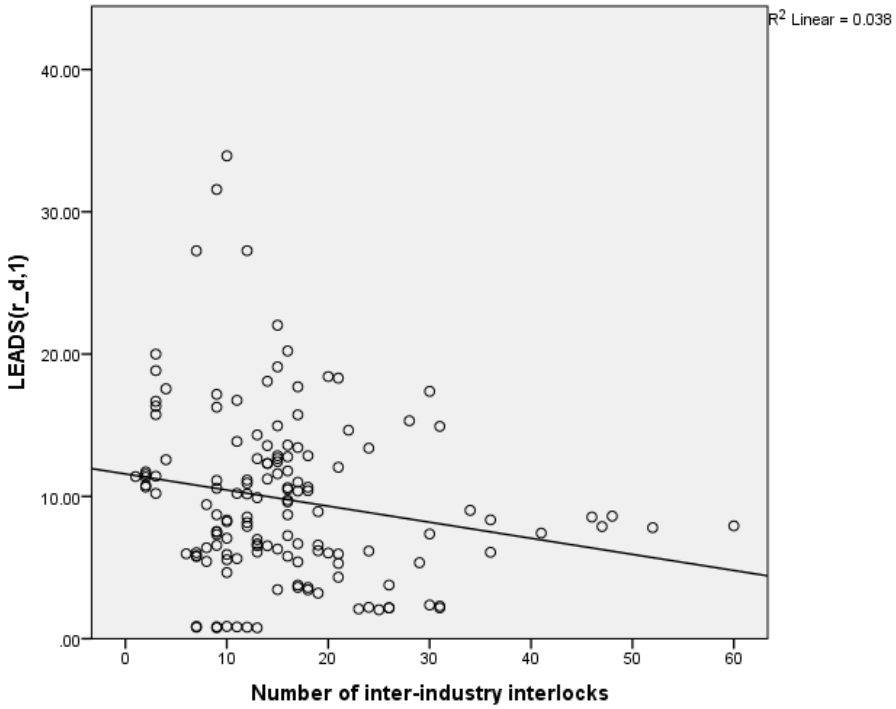


Normal p-p plot of ZRESID

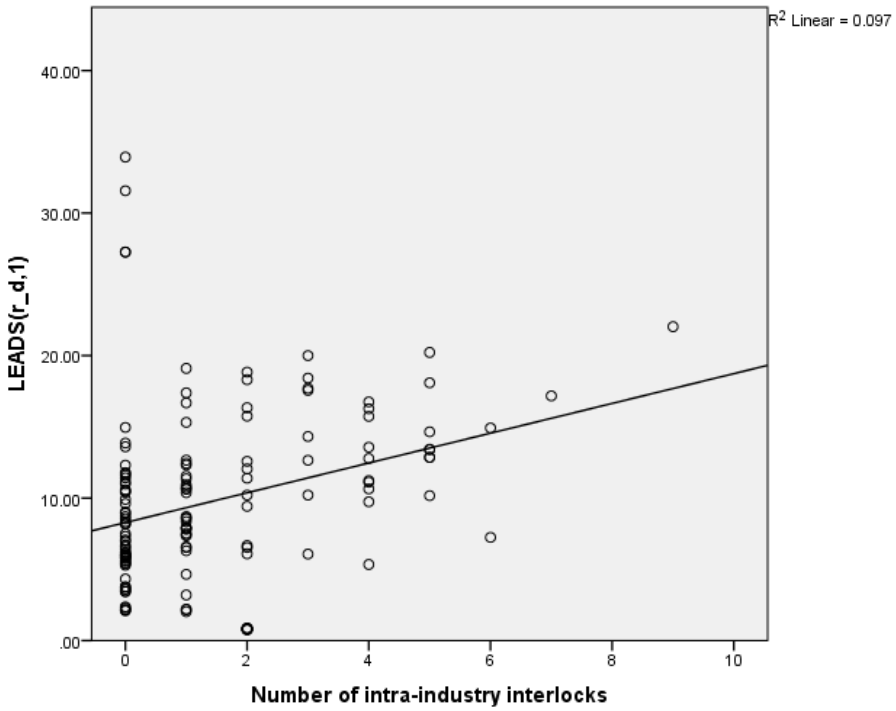


Appendix III-B: Outlier analysis & assumptions (t+1)

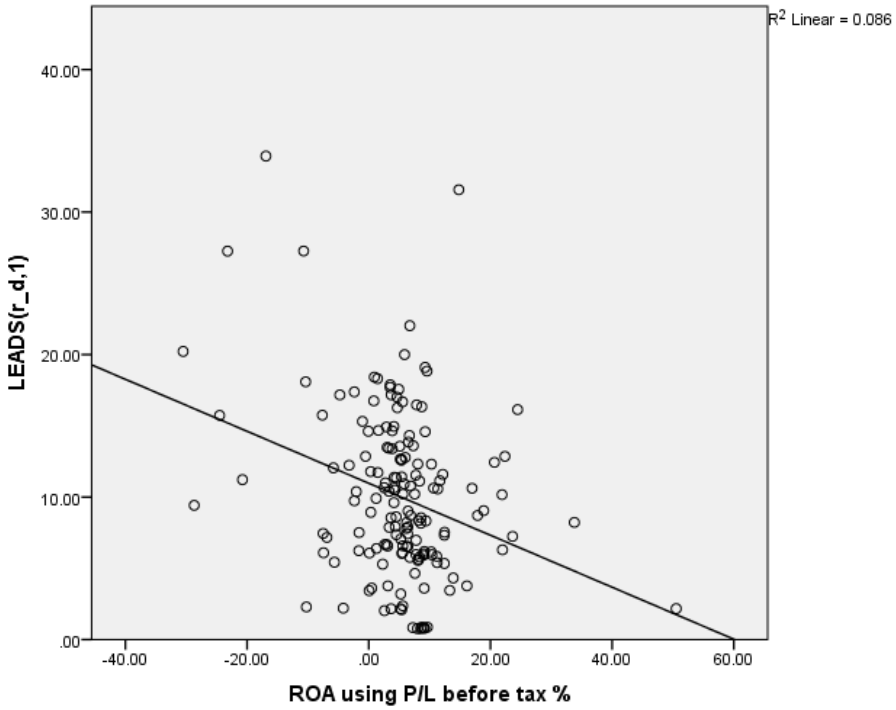
Scatterplot: Inter-industry interlocks



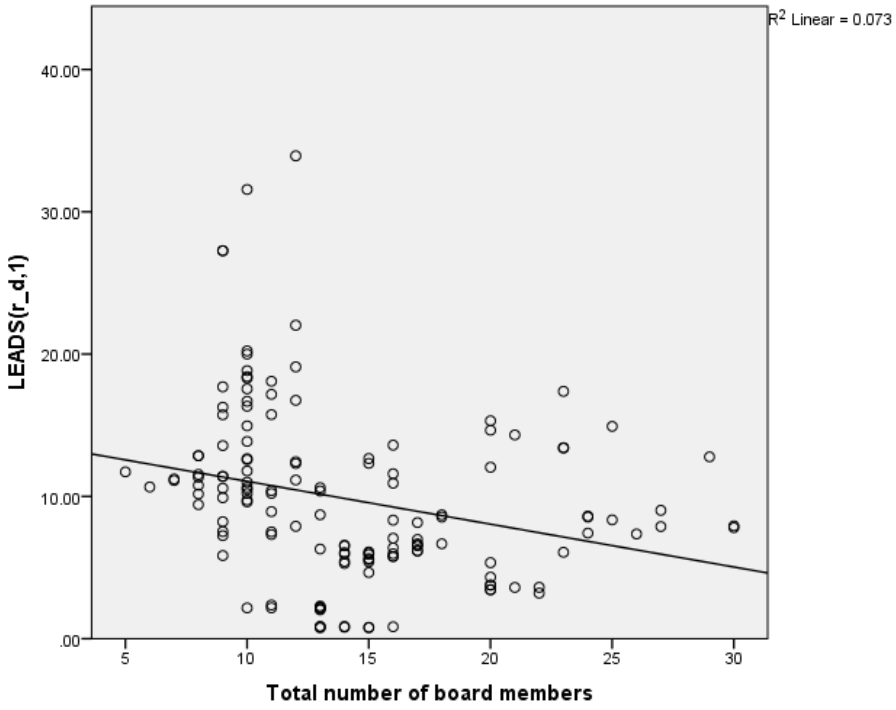
Scatterplot: Intra-industry interlocks



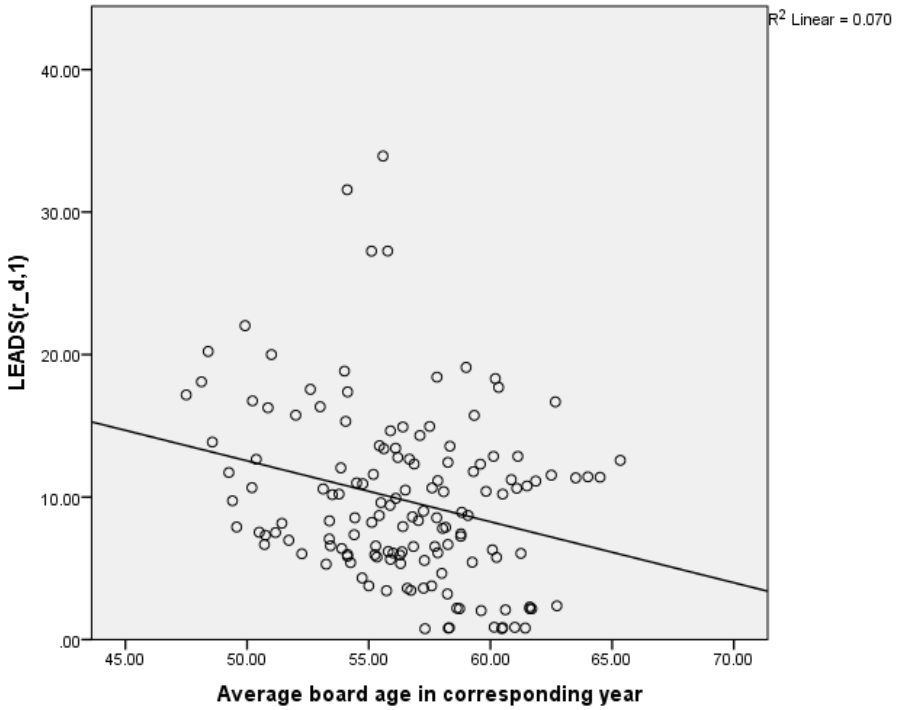
Scatterplot: ROA



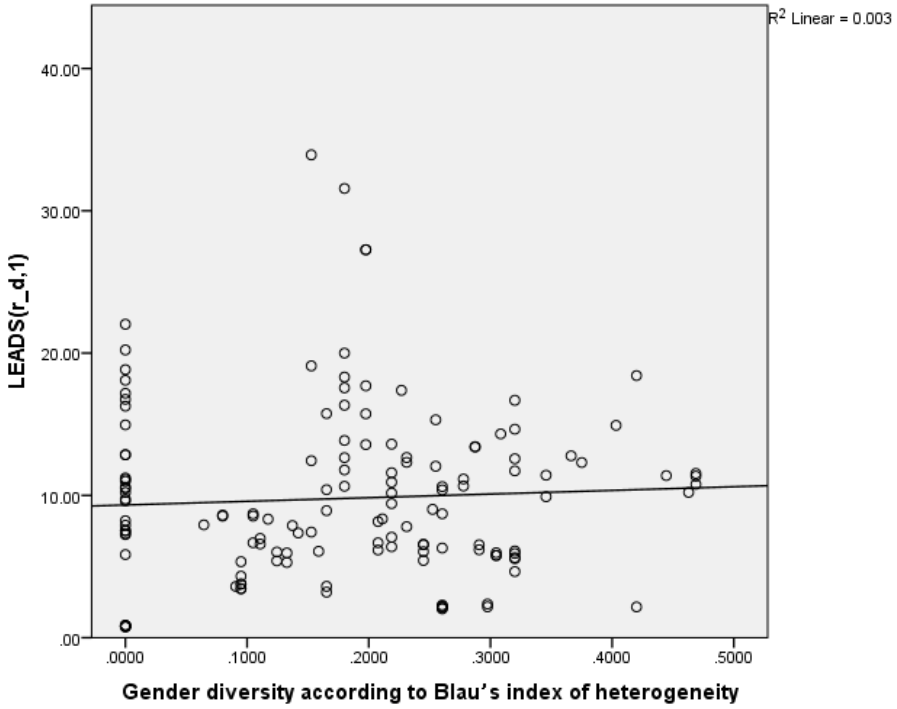
Scatterplot: Number of board members



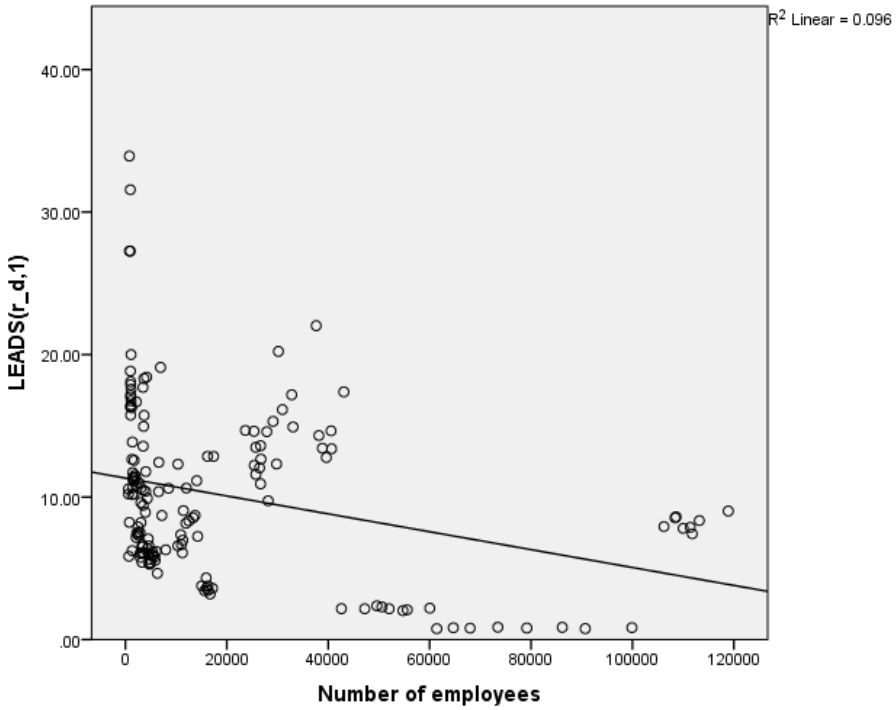
Scatterplot: Average board age



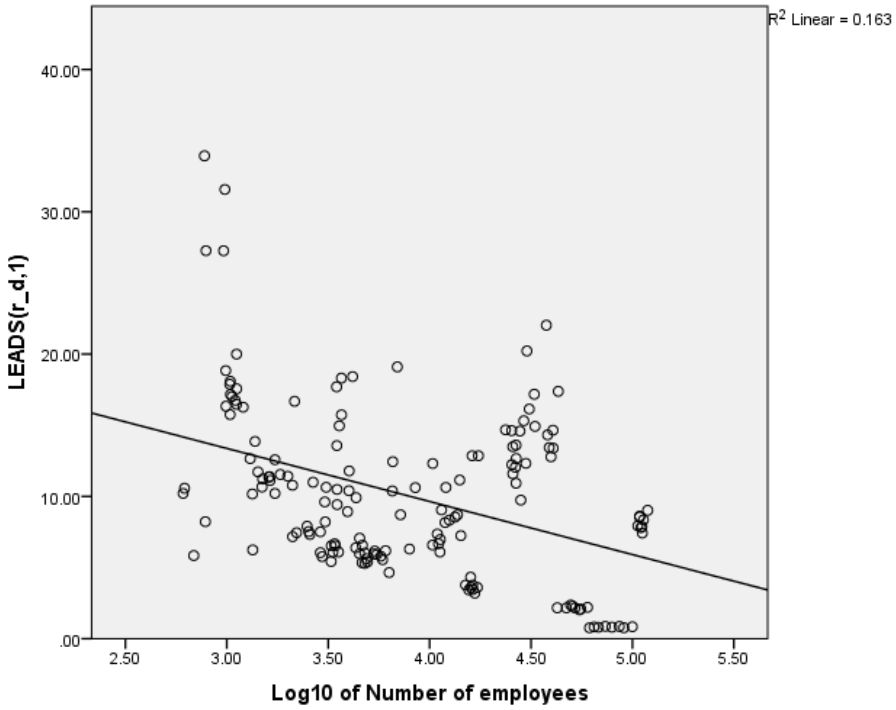
Scatterplot: Gender diversity



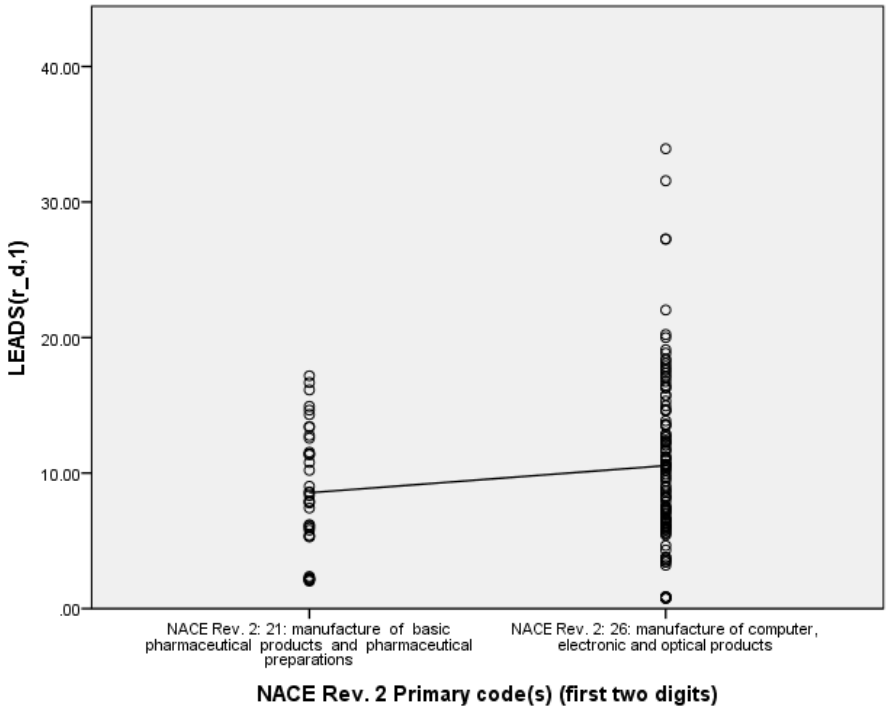
Scatterplot: Number of employees



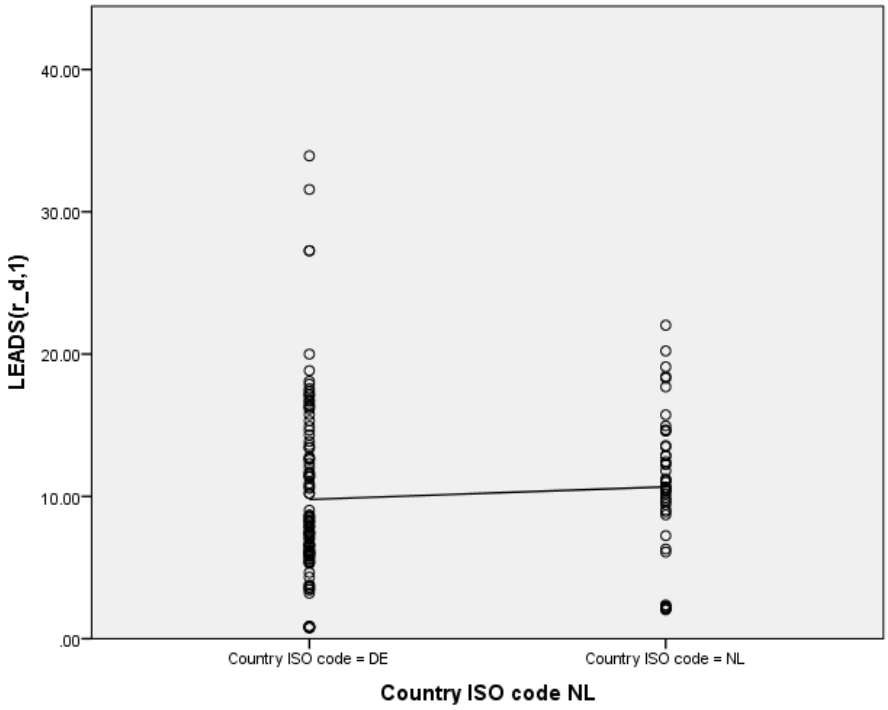
Scatterplot: Log10 of number of employees



Scatterplot: Industry



Scatterplot: Country



Casewise diagnostics table (1)

Casewise Diagnostics[a]

Case Number	Std. Residual	LEADS(r_d,1)	Predicted Value	Residual
25	2.200	19.10	8.6498	10.45022
100	4.296	31.57	11.1620	20.40803
120	2.302	27.26	16.3270	10.93303
140	3.922	33.93	15.2987	18.63127
160	2.539	27.27	15.2110	12.05899

a. Dependent Variable: LEADS(r_d,1)

Casewise diagnostics table (2)

Casewise Diagnostics[a]

Case Number	Std. Residual	LEADS(r_d,1)	Predicted Value	Residual
25	2.351	19.10	8.6212	10.47880
100	4.631	31.57	10.9274	20.64256
120	2.813	27.26	14.7192	12.54080
160	2.973	27.27	14.0173	13.25273

a. Dependent Variable: LEADS(r_d,1)

Casewise diagnostics table (3)

Casewise Diagnostics[a]

Case Number	Std. Residual	LEADS(r_d,1)	Predicted Value	Residual
25	2.586	19.10	8.5661	10.53391
120	3.149	27.26	14.4331	12.82695
160	3.402	27.27	13.4127	13.85733

a. Dependent Variable: LEADS(r_d,1)

Residual statistics table (1)

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.1905	20.3706	9.7794	3.86996	143
Std. Predicted Value	-2.219	2.737	.000	1.000	143
Standard Error of Predicted Value	.647	2.847	1.271	.347	143
Adjusted Predicted Value	.8855	21.2011	9.7781	3.92008	143
Residual	-9.47708	20.40803	.00000	4.57963	143
Std. Residual	-1.995	4.296	.000	.964	143
Stud. Residual	-2.197	4.395	.000	1.003	143
Deleted Residual	-11.49580	21.35602	.00133	4.95893	143
Stud. Deleted Residual	-2.230	4.739	.006	1.025	143
Mahal. Distance	1.641	50.027	9.930	6.694	143
Cook's Distance	.000	.123	.008	.017	143
Centered Leverage Value	.012	.352	.070	.047	143

a. Dependent Variable: LEADS(r_d,1)

Residual statistics table (2)

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.3519	20.3636	9.6094	3.68496	142
Std. Predicted Value	-1.969	2.918	.000	1.000	142
Standard Error of Predicted Value	.608	2.672	1.197	.328	142
Adjusted Predicted Value	2.5086	21.1922	9.6121	3.72133	142
Residual	-8.64546	20.64256	.00000	4.29651	142
Std. Residual	-1.940	4.631	.000	.964	142
Stud. Residual	-2.139	4.738	.000	1.003	142
Deleted Residual	-10.51054	21.60477	-.00274	4.65476	142
Stud. Deleted Residual	-2.169	5.185	.005	1.025	142
Mahal. Distance	1.631	49.673	9.930	6.730	142
Cook's Distance	.000	.099	.008	.016	142
Centered Leverage Value	.012	.352	.070	.048	142

a. Dependent Variable: LEADS(r_d,1)

Residual statistics table (3)

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.3385	20.5842	9.4536	3.65954	141
Std. Predicted Value	-1.944	3.042	.000	1.000	141
Standard Error of Predicted Value	.558	2.442	1.097	.301	141
Adjusted Predicted Value	2.3943	21.4706	9.4549	3.69423	141
Residual	-8.01012	13.85733	.00000	3.92508	141
Std. Residual	-1.967	3.402	.000	.964	141
Stud. Residual	-2.169	3.539	.000	1.005	141
Deleted Residual	-9.74886	14.99770	-.00124	4.27590	141
Stud. Deleted Residual	-2.201	3.709	.003	1.017	141
Mahal. Distance	1.635	49.340	9.929	6.716	141
Cook's Distance	.000	.124	.008	.017	141
Centered Leverage Value	.012	.352	.071	.048	141

a. Dependent Variable: LEADS(r_d,1)

Model summary

(After bootstrapping.)

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.585[a]	.342	.307	4.46641	.342	9.872	7	133	.000	
2	.585[b]	.342	.302	4.48250	.000	.047	1	132	.829	
3	.682[c]	.465	.428	4.05849	.123	30.022	1	131	.000	
4	.682[d]	.465	.424	4.07325	.000	.052	1	130	.820	1.901

a. Predictors: (Constant), NACE Rev. 2 Primary code(s) (first two digits), ROA using P/L before tax % , Country ISO code NL, Log10 of Number of employees, Gender diversity according to Blau's index of heterogeneity, Average board age in corresponding year, Total number of board members

b. Predictors: (Constant), NACE Rev. 2 Primary code(s) (first two digits), ROA using P/L before tax % , Country ISO code NL, Log10 of Number of employees, Gender diversity according to Blau's index of heterogeneity, Average board age in corresponding year, Total number of board members, Centred number of inter-industry interlocks

c. Predictors: (Constant), NACE Rev. 2 Primary code(s) (first two digits), ROA using P/L before tax % , Country ISO code NL, Log10 of Number of employees, Gender diversity according to Blau's index of heterogeneity, Average board age in corresponding year, Total number of board members, Centred number of inter-industry interlocks, Centred number of intra-industry interlocks

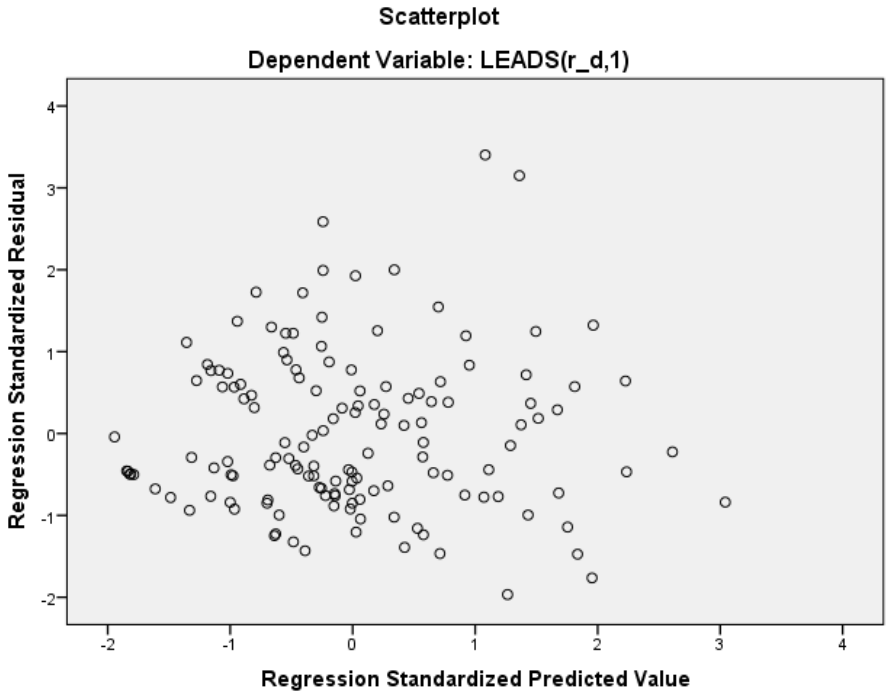
d. Predictors: (Constant), NACE Rev. 2 Primary code(s) (first two digits), ROA using P/L before tax % , Country ISO code NL, Log10 of Number of employees, Gender diversity according to Blau's index of heterogeneity, Average board age in corresponding year, Total number of board members, Centred number of inter-industry interlocks, Centred number of intra-industry interlocks, Interaction inter-industry and intra-industry interlocks

Coefficients table

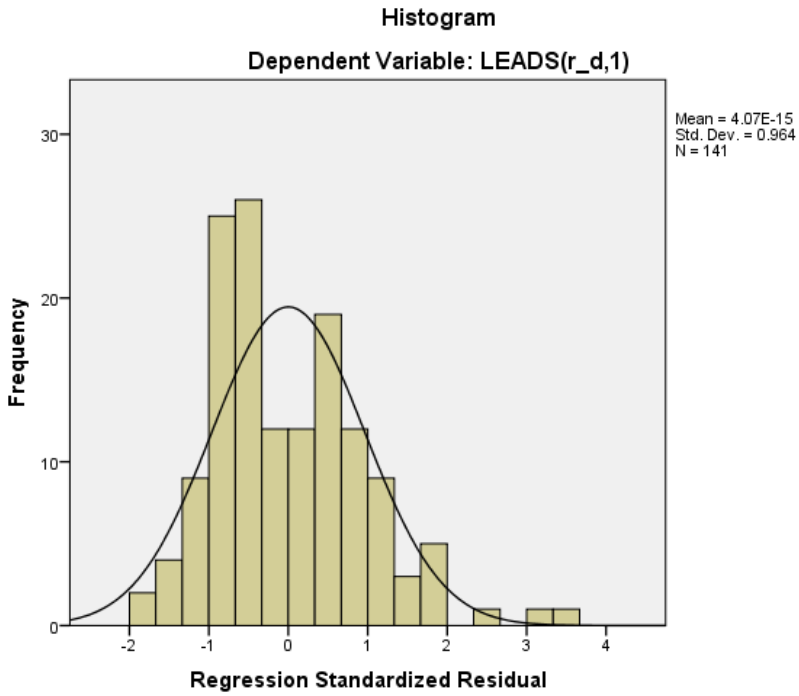
(After bootstrapping and collinearity statistics only)

Model		Collinearity Statistics	
		Tolerance	VIF
4	(Constant)		
	ROA using P/L before tax %	.940	1.064
	Total number of board members	.183	5.469
	Average board age in corresponding year	.627	1.594
	Gender diversity according to Blau's index of heterogeneity	.561	1.783
	Log10 of Number of employees	.413	2.424
	Country ISO code NL	.347	2.886
	NACE Rev. 2 Primary code(s) (first two digits)	.465	2.149
	Centred number of inter-industry interlocks	.238	4.204
	Centred number of intra-industry interlocks	.865	1.156
	Interaction inter-industry and intra-industry interlocks	.876	1.141

Scatterplot: ZPRED against ZRESID



Histogram: ZRESID



Normal p-p plot of ZRESID