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The role of intellectual property protection, knowledge spillovers and coopetitive portfolios

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DISSERTATION

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Für meine Eltern,
die mich immer ermutigt und unterstützt haben.

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Nina Karthaus
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Chapter 1
Motivation & outline

1.1 Collaboration for innovation

In today's global world, it is highly important for firms to gain and sustain a competitive advantage. In order to stay ahead of competition, firms are required to continuously innovate. Firms' own, internal resources are often not sufficient to develop novel ideas. Therefore, many firms open up their innovation process to outside parties (Laursen & Salter, 2014). Many companies among which for instance the Bayer AG and Philips[1] recognize this potential for joint value creation through knowledge sharing, such that research and development (R&D) can be accelerated, enhancing societal welfare through faster introduction of new products (Bayer AG, 2020; Koninklijke Philips N.V., 2021).

Often, firms collaborate with a variety of different partners such as universities, customers, suppliers or competitors (see e.g. Belderbos et al., 2004, 2006, 2018; Cassiman & Veugelers, 2002; Un et al., 2010) to achieve different kinds of innovations. While suppliers' complementary but also similar resources are likely to help firms improve existing products, knowledge and insights provided by universities and customers enable firms to introduce new-to-the-market innovations (Aschhoff & Schmidt, 2008; Belderbos, Carree, & Lokshin, 2004; Callahan & Lasry, 2004; Menguc et al., 2013). In addition to that, collaboration with competitors can be beneficial for innovation as competitors possess similar resources and expertise (Chiambaretto, Bengtsson, et al., 2020; Cygler et al., 2018; Gnyawali & Park, 2009; Quintana-Garcia & Benavides-Velasco, 2004). Nevertheless, the collaboration between competing firms deserves special attention, as it entails the natural paradox between collaboration and competition (Fernandez, Chiambaretto, et al., 2018). Research shows that tensions exist between value creation and value appropriation when rivals collaborate, because partners ultimately aim to outperform each other (Gnyawali

[1] Officially, Philips is called Koninklijke Philps N.V. From here onward, the shorter company name Philips is used.

& Ryan Charleton, 2017; Raza-Ullah & Kostis, 2020; Tidström, 2018). This can mitigate the potential benefits to be drawn from such collaboration.

1.2 From collaboration with competitors to coopetition

Collaboration between competitors has been documented for centuries. In fact, records show that as early as in the Roman Empire, competing vendors have engaged in collaboration to reduce costs and risks. In particular, maritime merchants grouped together in order to receive a collective loan, which allowed them to invest in a shared mode of transportation (Temin, 2001). Such joint efforts – also described in the literature as "*collegia*" (Broekaert, 2011, p. 225) – helped them to reduce the risk for each individual merchant, e.g. in case the products did not make it to their final destination or if a buyer would commit fraud. This joint initiation drastically reduced potential transaction costs (Broekaert, 2011; Kessler & Temin, 2007). A more recent example of collaboration between competitors is the collaborative car development of Volkswagen and Ford (Volkswagen AG, 2020). The two companies agreed on collaborating to "*drive significant scale and efficiencies and enable both companies to share investments in vehicle architectures that deliver distinct capabilities and technologies*" (Volkswagen AG, 2020). Similarly, Siemens and Philips joined forces to develop semiconductors together by combining resources (Doz et al., 1989). Another example is that of pharmaceutical companies BioNTech and Pfizer who jointly aimed to accelerate the vaccine development during the COVID-19 pandemic (Bildstein & Zanardi, 2021; Pfizer Inc., 2020).

It took until the beginning of the 1990s for the term 'coopetition' to be coined by business man Raymond John "Ray" Noorda (Dagnino, 2007; Fisher, 1992). According to Fisher (1992), Noorda described the business philosophy of his company Novell[2] as "co-opetition". The IT company took a rather humble approach to strategy and noticed the benefits of sharing and combining efforts with others, in contrast to market players such as Microsoft, who presented themselves as "*almost everybody's enemy*" (Fisher, 1992). Noorda assumed that if Novell's industry grows, the company would grow with it, and recognized the

[2] Officially, the company was registered as Novell Inc., here referred to as Novell for brevity. Noorda was Novell's CEO between 1982 and 1994. More information about the company at that time can be found in the annual report for 1993 on the website of the U.S. Security and Exchange Commission (Novell Inc., 1994).

value of collaboration between competitors (Fisher, 1992). In fact, Fisher (1992) quotes him saying "*there's no way you can not be partner with a whole lot of people. […] Rather than wait for that to happen, we decided we would partner with anybody and everybody that made sense"*.

In 1996, Brandenburger and Nalebuff introduced the term 'coopetition' to the academic world (Brandenburger & Nalebuff, 1996; Dagnino, 2007). They view coopetition as a relatively broad concept, defining competitors rather loosely: "*A player is your competitor if customers value your product less when they have the other player's product than when they have your product alone.*" (Bengtsson & Kock, 2000, p. 415). In that case, coopetition could thus occur "*horizontally between 'classic' competitors and vertically between up- and downstream partners*" (Bouncken & Fredrich, 2012, p. 3). Based on this definition, firms from different sectors could be competing and subsequently coopeting. While some more recent publications draw on this understanding of competitors (see e.g. Bouncken et al., 2015; Chou & Zolkiewski, 2018; Garri, 2020), there also exists a substantial stream of literature that adopts a less broad definition (see e.g. Bengtsson & Kock, 2000; Bouncken et al., 2018, 2020; Rai, 2016). This thesis adopts this narrower definition in line with the literature that classifies competitors as firms that operate in one industry and produce and sell similar products. Accordingly, coopetition is defined as collaboration between such competitors.[3]

1.2.1 Coopetition and innovation

The examples above suggest that firms engage in coopetition with the goal of gaining and sustaining a competitive advantage. Firms collaborate with their rivals in order to share industry-related risks and costs (see e.g. Hagedoorn, 1993; Raza-Ullah & Kostis, 2020). For instance, Amazon opened up its web services infrastructure to third-party retailers in late 2000 by launching Amazon Marketplace (Amazon.com, 2001). On the one hand, this allowed Amazon to reduce its operating costs, while gaining revenues from commissions and subscriptions at the same time. On the other hand, third-party vendors were able to make use of a well-developed IT infrastructure, gaining access to a larger group of customers than they could reach on their own (Amazon.com, 2001; Ritala et al., 2014). Moreover, rivals that operate in the same industries and

[3] This is also in line with the definition of competitors formulated in the Oslo Manual (Eurostat, 2005), which provides the baseline for the data used in the analyses in this dissertation.

produce similar products possess compatible and relevant resources and skills (Raza-Ullah & Kostis, 2020; Ritala & Hurmelinna-Laukkanen, 2009, 2013). Therefore, pooling and exchanging resources can help the collaboration partners to create value, develop new products and improve innovation processes (Estrada et al., 2016; Tether, 2002). Especially the exchange of knowledge plays a significant role in coopetition (Estrada, 2018; Fernandez & Chiambaretto, 2018). According to Grant (1996) knowledge is a firm's most important strategic resource. The commitment of such resources is essential in collaborative relationships in order for them to be successful (Bengtsson & Raza-Ullah, 2016; Nielsen & Nielsen, 2009). Knowledge possessed by competitors is particularly interesting for a focal firm, because it is relevant for similar products and industries (Fernandez & Chiambaretto, 2018; Raza-Ullah & Kostis, 2020). Knowledge spillovers can therefore be directly implemented and used to enhance innovation performance for instance (Estrada et al., 2016).

Despite the potential benefits of coopeting, research findings regarding the effect of coopetition on product innovation are mixed (see e.g. Ritala & Hurmelinna-Laukkanen, 2013). A number of prior studies have reported that collaborating with rivals can even harm a firm's innovation performance (see e.g. Lhuillery & Pfister, 2009; Nieto & Santamaría, 2007). The underlying tensions inherent to coopetition, high risks of exploitation and partner opportunism are some of the prominent features of this type of collaboration (Raza-Ullah et al., 2014; Ritala & Hurmelinna-Laukkanen, 2009; Tidström, 2014). This makes coopeting different from collaborating with other partner types. As collaborators remain rivals, they may aim to appropriate the value created through the collaboration for themselves individually rather than sharing it fairly. Ultimately, their goal remains to gain a competitive advantage and to outperform other market players, including their coopetition partner(s). Knowledge plays a particularly relevant role and unintentional knowledge spillovers can easily be exploited by rivaling partners such that a focal firm gets outperformed (Estrada et al., 2016; Fernandez & Chiambaretto, 2018). Since competitors have similar knowledge bases, interpreting and using their partner's knowledge is easier in the case of coopetition compared to other collaboration types. While this knowledge similarity and complementarity can, on the one hand, lead to the creation of synergies, it can, on the other hand, also accelerate the risks of opportunism. Consequently, the paradox between joint value creation and individual value

capture makes studying coopetition as a specific type of collaboration worthwhile and highly relevant.

1.2.2 Formal and informal appropriation mechanisms in coopetition

In order to be able to appropriate the jointly created value, firms make use of formal and informal mechanisms (Cohen et al., 2000; Hall et al., 2014; Levin et al., 1987). Formal mechanisms are those that rely on legal protection such as patents, design rights, copyrights and trademarks (Hall et al., 2014). Such mechanisms require the disclosure of information, which makes them useful for appropriating and protecting explicit knowledge[4] (Estrada et al., 2016). Informal mechanisms are often used to protect tacit knowledge[5] that cannot easily be put in words (Anton & Yao, 2004; Zaby, 2010). Firms employing such mechanisms rely on secrecy, complex processes and short lead-times[6] to appropriate and protect intellectual property (IP), which makes their knowledge difficult to imitate or exploit because it is either not shared at all or too complex (Anton & Yao, 2004; Hall et al., 2014). Moreover, firms relying on short lead-times are able to stay ahead of their competitors because they are able to appropriate the value created in coopetition quicker than their partners (Cohen et al., 2000).

Clearly, both types of IP mechanisms have their advantages. On the one hand, formal mechanisms provide protection by law. On the other hand, informal mechanisms are more effective in preventing other firms from appropriating the focal firm's (tacit) knowledge due to the non-disclosure nature of these mechanisms. Besides obtaining the monopolistic rights to an invention protected by formal mechanisms, firms frequently use patents as a strategic tool in order to block other players in their industry from developing similar ideas (Cohen et al., 2000). However, the requirement to disclose information, as well as the fact that formal mechanisms only provide time-limited advantages can deter firms from using such instruments (Anton & Yao, 2004; Cohen et al., 2000;

[4] Explicit knowledge is defined as information that can be codified, and therefore be communicated using words or other forms of symbols (Nonaka & Takeuchi, 1995; Popadiuk & Choo, 2006).

[5] Tacit knowledge is based on experiences and feelings in specific contexts, and is linked to an individual's beliefs and thoughts, which makes it difficult to articulate or codify (Polanyi, 1958; Popadiuk & Choo, 2006).

[6] Firms using lead-time advantages appropriate and protect IP by being first-to-market (Hall et al., 2014).

Zaby, 2010). Moreover, formal mechanisms tend to be cost- and time-intensive in their acquisition so that for instance small firms might not be able to afford them (Hall et al., 2013). In contrast, informal mechanisms do not require any information disclosure. Together, this may lead to a firm's decision not to apply for patents and to rely on informal mechanisms (see e.g. Hall et al., 2013, 2014).

As the risk of unintentional spillovers of information is heightened in coopetition, it is especially important for firms to have proper knowledge management in place when collaborating with competitors (Fernandez & Chiambaretto, 2016, 2018; Holgersson, 2018). As rivals possess similar expertise, it is easy for them to interpret and integrate each other's knowledge into their own innovation processes (Ritala & Hurmelinna-Laukkanen, 2013). Subsequently, the competitor can use the knowledge against the focal firm by introducing innovations sooner. Using formal and informal mechanisms, firms can hedge against these risks and appropriate the rents of coopetition (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2018; Holgersson, 2018). On the one hand, IP mechanisms can thus enable firms to collaborate in a safe and protected manner, as they reduce the risk of knowledge exploitation, which makes them especially relevant in the case of coopetition where partners remain competitors. On the other hand, such tools also allow firms to appropriate the jointly created value for themselves, which can aid them in achieving and sustaining a competitive advantage. Once again, this is specifically important in the case of coopetition because the more value a firm can appropriate for itself, the more it can improve its own position in the market and directly outperform its partner.

1.2.3 Coopetitive portfolios

While competitors make interesting allies for a focal firm, they are usually not a firm's only partner. Rather, firms simultaneously collaborate with a variety of different partners to foster innovation and ultimately achieve a competitive advantage (Tomlinson, 2010; Un et al., 2010). A firm that collaborates with multiple partner types forms an alliance portfolio, defined as a collection of dyadic ties with various types of partners (Wassmer, 2010). An alliance portfolio allows a firm to gain access to a broad variety of resources, enabling it to make unique resource combinations and leading to the creation of synergies (Chiambaretto & Fernandez, 2018).

Nevertheless, Wassmer and Dussauge (2012) reason that there is diminishing value that comes along with each new alliance added to the portfolio because of the trade-off between the benefits of access to additional resources and the need to manage the increased complexity. In fact, existing research warns that conflicts arise if there is too much partner diversity, as it can be detrimental for the portfolio performance (Duysters et al., 2012; Lee et al., 2017), and subsequently also harm innovation performance. Moreover, Park et al. (2014) emphasize that the tensions of individual ("dyadic") alliances pose additional challenges on the portfolio level, where multiple alliances (and their tensions) come together and require management capabilities. These conflicts can be intensified in alliance portfolios that contain at least one partnership with competitors ("coopetitive portfolios") because of the tensions inherent to coopetition itself (Cassiman et al., 2009; Chiambaretto & Fernandez, 2018; Park et al., 2014), which are likely to be accelerated at the portfolio level (Chiambaretto & Fernandez, 2016). In particular, coopetitive portfolios combine the complexities of managing multiple alliances and the fear of unintentional knowledge spillovers to competitors directly or through one of the other partners (de Leeuw et al., 2014). This stresses the importance of considering the paradoxical concept of coopetition in light of other collaborative agreements.

To date, literature especially investigating the effects of combining different types of partners with coopetition is scarce. Belderbos et al. (2006) show that certain partner types are complementary and can lead to an improved innovation performance when combined, while the combination of others can be harmful. Therefore, it follows naturally that different configurations of a firm's coopetitive portfolio also affect its innovation performance. Nevertheless, only few studies have explored the specific role of competitors in alliance portfolios and the effect on firm innovation (Park et al., 2014; Wu, 2014). In particular, little is known about how the portfolio performance might be affected in the presence of competitor collaboration. Wu (2014) and Park et al. (2014) report an inverted-U-shaped effect between the degree of coopetition in a portfolio and a firm's innovation performance, where the degree of coopetition denotes the ratio of coopetitive alliances relative to all alliances in the portfolio. Put differently, there seems to be a specific amount of ties with competitors that should be included in an alliance portfolio to maximize innovation performance.

Those findings point out that including coopetition in an alliance portfolio can thus be both beneficial but also harmful. Yet, to the best of my knowledge, little is known about the combination of coopetition with different partners and which coopetitive portfolio set-up(s) can enable firms to enhance their innovation performance.

1.3 Scope of the dissertation

The aim of this dissertation is to contribute to the coopetition literature and to extend the understanding of the role played by formal and informal mechanisms when collaborating with competitors. Despite the clear importance of knowledge management in coopetitive partnerships, few existing studies investigate the role of IP protection in the context of competitor collaboration (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2018). While some coopetition scholars consider formal IP protection, there is a lack of research focusing on informal mechanisms (Estrada et al., 2016). Therefore, this doctoral thesis seeks to answer the following question:

What is the role of formal and informal IP appropriation mechanisms in coopetition?

To address this question, Chapter 2 examines the two types of mechanisms as drivers of coopetition in industries characterized by different levels of competitive intensity and technological dynamism. Specifically, the appropriation mechanisms are considered to be signals of how valuable the knowledge is that a firm possesses, as this determines their need for coopeting in different market circumstances. Chapter 3 focuses on the role of informal IP protection in the relationship between coopetition and firm product innovation performance. In addition to that, the chapter focuses on the underlying mechanism of knowledge spillovers in coopetition. Here, informal mechanisms are seen as a signal of distrust[7], because firms feel the need to protect their knowledge from spilling over to and being exploited by their partner.

Moreover, with this dissertation, I seek to contribute to the current state of literature regarding alliance portfolios and particularly coopetitive portfolios, by identifying which partner types should be combined with coopetition for firms

[7] Please refer to Chapter 3 for the definition of trust and an in-depth line of reasoning as to how trust is relevant in collaboration and how informal mechanisms are related to that.

to achieve product innovation. Hence, Chapter 4 of this dissertation investigates the following question:

When companies ally with their competitors, which other types of firms should they partner with to enhance their innovation performance?

I investigate how the presence or absence of suppliers, customers and universities in a firm's coopetitive portfolio impacts their propensity to introduce innovations. Moreover, I analyze how this main relationship is affected by firm size and industry dynamism.

1.4 Methodology

This dissertation makes use of data gathered through the Community Innovation Survey (CIS) between 1998 and 2016. The CIS is a harmonized survey that contains questions about firms' innovation activities, such as R&D expenditures, shares of total sales due to innovation, and R&D collaboration (Eurostat, 2005). The survey is administered every two years in all EU countries and European member states of the Organization for Economic Co-operation and Development (OECD) (OECD, 2009). According to the OECD (2009), the CIS was developed in order to gather more information "*regarding types of innovations, the reasons for innovating (or not), the collaboration and linkages among agents, and the flows of knowledge*" such that innovation policies could be better established and targeted.[8]

In order to lay the ground works for the harmonized data collection, the OECD together with Eurostat developed the Oslo Manual, which provides guidelines for methodology and definitions to be employed in the CIS (Eurostat, 2005). Chapter 2 and Chapter 4 of this dissertation use the CIS data collected in the Netherlands.[9] Chapter 3 utilizes data gathered through the Mannheim Innovation Panel (MIP), which is the German contribution to the CIS. It is administered in a joint effort by the Center for European Economic Research (ZEW, Zentrum für europäische Wirtschaftsforschung), the Fraunhofer-

[8] Throughout this dissertation, I focus on product innovation. Product innovation can be defined as "*the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics*" (Eurostat, 2005, p. 48).
[9] The results in those chapters are based on own calculations using non-public microdata from Statistics Netherlands (CBS).

Institute for System and Innovation Research (ISI), and the Institute for Applied Social Sciences (infas).

Moreover, various empirical approaches are used throughout the main chapters. Chapter 2 employs a generalized structural equation model (GSEM) to analyze the connection between use of formal (informal) appropriation mechanisms and a firm's likelihood to engage in coopetition. Chapter 3 relies on a variety of methods: first, an ordered probit assesses the effect of coopetition on incoming knowledge spillovers. Second, a fractional response probit model analyzes the effect of coopetition on a firm's product innovation performance. Thirdly, the chapter studies whether knowledge spillovers take on a mediating role in the relationship between coopetition and product innovation performance. In order to investigate this, the mediation approach as suggested by Imai, Keele, and Tingley (2010) is utilized, which can account for non-linearity. Chapter 4 makes use of a crisp-set qualitative comparative analysis (csQCA) to assess the different combinations of partners in a coopetitive portfolio that can increase innovation propensity. The csQCA approach is specifically interesting, as it is able to show that multiple coopetitive portfolio configurations can lead to the same outcome.

1.5 Structure of the dissertation

The following chapters address the questions presented above. Chapter 2 empirically assesses the relationship between a firm's use of formal and informal mechanisms and the propensity to engage in coopetition. It examines this relationship while taking into account boundary conditions of different industry contexts by focusing on both industry dynamism and level of competitiveness. Chapter 3 investigates how the use of informal IP protection influences the relationship between coopetition and a firm's innovation performance, and specifically knowledge flows between competitors. Chapter 4 particularly seeks to explore the configurations of coopetitive portfolios that enable firms to achieve innovation. Finally, Chapter 5 reviews and discusses the main findings of this dissertation. Here, I reflect on the contributions and implications for both coopetition research and for practitioners.

Chapter 2

Coopetition, formal and informal appropriation mechanisms and the role of environmental dynamism and competition intensity[10]

Firms increasingly engage in coopetition by collaborating with their direct competitors. A major challenge in such cooperative agreements is to avoid unintended knowledge flows to a competing partner. We study how reliance on knowledge protection mechanisms to safeguard intellectual property affects a firm's decision to engage in coopetition and how industry dynamism and competitive intensity affect this relationship. We put forth that formal and informal protection mechanisms signal different types of innovation and the focal firm's closeness to the technological frontier. We find that firms' reliance on formal appropriation mechanisms has a positive association with the propensity to engage in coopetition. External environments, characterized by different levels of dynamism and competitive intensity, moderate the association between the use of appropriation mechanisms and coopetition. In particular, in dynamic and competitive industries, firms are more prone to engage in coopetition when using formal appropriation mechanisms. We argue firms using these mechanisms are in need of partnerships to advance innovation performance and are better protected from the risks inherent to competitor collaboration. The reliance on informal appropriation mechanisms negatively affects the likelihood of coopetition in such environments. We conjecture this signals that firms employing informal mechanisms are more likely to prevent knowledge spillovers to a competitor by avoiding them as partnership candidates.

[10] This chapter is based on joint work with Wilko Letterie and Boris Lokshin. We thank (seminar) participants at Maastricht University, at the 2018 Competition and Innovation Summer School in Montenegro, at the 2019 ZEW/MaCCI Conference on the Economics of Innovation and Patenting in Mannheim, at the Ph.D. Colloquium of the 2019 R&D Management Conference in Paris, at the 2019 EURAM Conference in Lisbon, and at the 2019 EARIE Conference in Barcelona for their input. Moreover, we thank Prof. Dr. Jan Boone for his valuable insights and feedback regarding the profit elasticity measure.

2.1 Introduction

Due to the increasing need to stay ahead of competition, firms progressively opt to open their innovation process to external partners to gain access to a broader set of resources and skills (Laursen & Salter, 2014). Previous research has shown that the benefits and risks for firms engaging in collaboration for innovation differ between types of partners, such as customers, suppliers and research institutes. Firms may also collaborate with competitors – so-called *coopetition* – which is a very specific type of collaboration, due to the potential benefits and substantial risks it entails (Gnyawali & Ryan Charleton, 2018). Firms engage in coopetition in order to create value together, but also aim to capture this value for themselves and possibly to encroach into the core competences of their partner (Gnyawali & Ryan Charleton, 2018). Researchers who studied firms' partnerships with rivals in the context of innovation have found that these firms aim to share research and development (R&D) costs (Hagedoorn, 1993; Pellegrin-Boucher et al., 2013), as well as the risks of market uncertainty (Gnyawali & Park, 2009). Furthermore, by committing complementary resources, firms can improve their innovation processes and enhance innovative performance (Gnyawali & Park, 2009; Mitchell et al., 2002). Existing literature highlights that knowledge exchange is also one of the underlying motives to engage in coopetition (Estrada, 2018; Estrada et al., 2016). Competitors are attractive collaboration partners because they possess market- and product-related knowledge relevant for the focal firm (Raza-Ullah & Kostis, 2020; Ritala & Hurmelinna-Laukkanen, 2013).

Coopetition differs from other types of collaboration, as it entails substantial risks for the firms involved. Appropriation risks are high because competitors have an incentive to exploit their partners and behave opportunistically (Cygler et al., 2018). The higher the partners' resource commitments to the coopetitive partnership, the more opportunities for exploitation may arise (Gnyawali & Ryan Charleton, 2018). Especially, if knowledge is committed to the collaboration, firms fear that information 'spills over' in an uncontrollable way to the collaboration partner (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2018; Oxley, 1997). One way to minimize the abovementioned risks and to diminish the possibility of unintended leakage of knowledge is by use of formal and informal appropriation mechanisms (Hall et al., 2014; Neuhäusler, 2012; Zobel et al., 2017). Early work by Levin et al. (1987) and later

by Cohen et al. (2000) established that firms draw on both formal and informal appropriation mechanisms to protect their innovative efforts. Firms that use formal appropriation mechanisms (patents, trademarks, copyrights, and design rights) have time-limited rights to take advantage of their inventions (Somaya, 2012). Additionally, firms can rely on informal appropriation mechanisms (secrecy, lead-time, and complexity) (Zobel et al., 2017). Formal mechanisms protect a firm's intellectual knowledge assets by law, and informal mechanisms mostly rely on protection by knowledge being tacit and difficult to imitate (Anton & Yao, 2004; Hall et al., 2014; Zaby, 2010).

Recent research that investigated the interplay between coopetition and firms' use of appropriation mechanisms suggests that firms are more prone to engage in collaboration with their rivals if they are able to protect their know-how (Schmiele & Sofka, 2007). Whether formal and informal appropriation mechanisms are appropriate may vary depending on the environmental conditions in which firms operate (Cassiman & Veugelers, 2002; Hagedoorn & Zobel, 2015). Similarly, the decision to engage in coopetition is also often dependent on such environmental aspects (Ritala, 2012). Consequently, the role of contextual factors seems to be particularly relevant in the study at hand. To the best of our knowledge, prior studies have not specifically examined the environmental conditions under which the reliance on formal or informal mechanisms may increase firms' propensity to engage in coopetition. This chapter examines the boundary conditions of two industry characteristics – environmental dynamism and competition intensity – on the interplay between formal and informal appropriation and competitor collaboration. By distinguishing between formal and informal appropriation mechanisms, we extend prior research on coopetition, which so far predominantly focused on the role of patents.

We argue that the interplay between a firm's environment and intellectual property (IP) protection is driven by the applicability of formal and informal appropriation mechanisms, such that formal protection is more suitable than informal mechanisms under certain conditions (Hall et al., 2014). In particular, moderately innovative ideas often are protected by patents whereas secrecy and lead time are strongly linked with more radical innovations (Anton & Yao, 2004; Zaby, 2010). We infer from this that a firm that predominantly relies on formal appropriation is characterized as not very innovative and hence may be looking

for partners to strengthen its performance. In contrast, firms use informal mechanisms to protect tacit knowledge that is core to their competitive edge. A competitor may get access to such tacit knowledge if informal mechanisms do not function properly or are insufficient (Anton & Yao, 2004; Zaby, 2010). An innovative process potentially becomes clear to the partner and could possibly be imitated. Consequently, firms that are using informal mechanisms may not be the ones that are in search of coopetition partners. Such concerns may become stronger in dynamic environments and competitive settings where firms need to monitor technological and competitive developments closely.

We distinguish between two types of environmental contexts in which firms operate. First, firms often coopete in order to share risks (Gnyawali & Park, 2009). Therefore, we focus on investigating the role of industry dynamism, as uncertainty is usually high in dynamic markets (Chiambaretto & Fernandez, 2016). Overall, Gnyawali and Ryan Charleton (2018) point out that exploring the dynamics of a firm's environment is important, due to the particularly great strategic relevance of knowledge. Sharing such knowledge with rivals can be harmful, but at the same time can be crucial for firm survival. Second, we also address competition intensity, since in highly competitive markets firms need to work harder to gain and sustain a competitive advantage. They can achieve this by engaging in coopetition (Gnyawali & Park, 2009; Gnyawali & Ryan Charleton, 2018). However, it is clear that collaboration with rivals in highly competitive industries has the potential to further increase the risk of exploitation and unintended knowledge spillovers (Wu, 2012).

In summary, this study addresses the following question: *What is the relation between firms' reliance on formal and informal appropriation mechanisms and the propensity to engage in coopetition, and how is this relationship affected by industry dynamism and competition intensity?* By answering this research question, we respond to a call by scholars to investigate boundary conditions that affect the IP – collaboration relationship (see e.g. Huizingh, 2011). We put forth that it is especially relevant to study the interplay of appropriation mechanisms and coopetition, because formal and informal mechanisms can be used to deal with the substantial risks inherent to competitor collaboration. This is also reflected in prior coopetition research which calls for a more thorough investigation of both types of protection mechanisms (see e.g. Estrada et al., 2016). We follow this call by specifically studying the role of formal and informal appropriation mechanisms

as an antecedent to coopetition. In doing so, we examine the link between two previously rather disconnected streams of literature (IP protection and coopetition), and specifically distinguish between two types of mechanisms. We particularly highlight that different contextual factors influence the role that IP protection plays for coopetition engagement. This is relevant for firms when they assess whether to collaborate with competitors, and under which circumstances this might be a good strategic choice. Ultimately, this study enables us to extend understanding of the coopetition phenomenon and to explain when firms engage in collaboration with rivals.

The remainder of this chapter is structured as follows. Section 2.2 provides a review of the current state of research, based on which we formulate a set of hypotheses. In Section 2.3, we describe the data, methods and measures, while Section 2.4 presents the results. In Section 2.5, we discuss the findings and reflect on the study's theoretical contributions and practical implications, as well as the limitations and suggestions for future research. Section 2.6 provides some concluding remarks.

2.2 Theoretical background and hypotheses

2.2.1 Coopetition and the role of appropriation mechanisms

Coopetition is understood as collaboration with rivals (see e.g. Bengtsson & Kock, 2000; Bouncken & Fredrich, 2012; Brandenburger & Nalebuff, 1996; Estrada et al., 2016; Gnyawali et al., 2006). Firms engaging in coopetition need to find a balance between benefiting from collaboration and coping with risks associated with opening up to competitors (Raza-Ullah et al., 2014). On the one hand, firms aim to create value together, but on the other hand, they want to capture most of this value for themselves (Gnyawali & Ryan Charleton, 2018).

In order to create value together in coopetition, rivals pool and share their resources. In line with the resource-based view (RBV), competitors can carve a competitive advantage when these resources are scarce, imperfectly imitable, valuable, and not substitutable (Barney, 1991; Mowery et al., 1998). This resonates with the open innovation perspective according to which firms often can improve their performance by adopting a collaborative approach to innovation (Chesbrough, 2003; Enkel et al., 2009; Laursen & Salter, 2006; Vanhaverbeke & Cloodt, 2014). By collaborating, the involved competitors can share and pool unique but at the same time complementary and compatible

resources and capabilities, which enables them to enhance their innovation processes and its outcomes, ultimately creating value together (Gnyawali & Park, 2009; Miotti & Sachwald, 2003; Mitchell et al., 2002). Moreover, scholars also highlight the increased efficiency within the R&D process when rivals collaborate, which leads to potential cost savings for both partners (Bengtsson & Kock, 2000; Cygler et al., 2018; Gnyawali & Park, 2009).

While joint value creation is a major incentive for firms to engage in coopetition, competitor collaboration also entails many risks related to opportunistic and free-riding behavior. In particular, collaborating partners may be tempted to behave opportunistically as they strive to appropriate as much of the jointly created value as possible (Blind et al., 2013; Cygler et al., 2018; Estrada et al., 2016; Gnyawali & Ryan Charleton, 2018; Nieto & Santamaría, 2007; Quintana-Garcia & Benavides-Velasco, 2004). This is consistent with the transaction cost economics (TCE) perspective (Williamson, 1981). Besides the threat of opportunism, the commitment of strategically important resources such as knowledge, also poses the appropriation risk: information unintentionally spilling over to the competing partner (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2018; Oxley, 1997). Unintended leakages of the focal firm's knowledge can benefit an alliance partner, and this can be detrimental to the focal firm's competitive position, particularly when the said partner is a direct rival (Lavie, 2006; Ritala & Hurmelinna-Laukkanen, 2009). In sum, despite the potential benefits for coopeting firms due to resource sharing, the appropriation and opportunism risks can substantially harm the success of coopetition (Ilvonen & Vuori, 2013; Ritala & Hurmelinna-Laukkanen, 2013).

In order to counter the above mentioned risks, firms ensure that appropriation mechanisms such as patents or secrecy are in place (Hall et al., 2014; Holgersson, 2018; Ritala & Hurmelinna-Laukkanen, 2009; Schmiele & Sofka, 2007). The use of the appropriation mechanisms safeguards knowledge assets from the opportunistic behavior of their partners. In addition, firms that have appropriation mechanisms installed, are able to control the knowledge outflows and diminish unintended knowledge spillovers (Czakon, 2009; Estrada et al., 2016; Ilvonen & Vuori, 2013; Ritala & Hurmelinna-Laukkanen, 2009, 2013). Firms are thus able to minimize the risks inherent to coopetition, ultimately leading to the benefits outweighing those risks. Hence, we expect that

the use of the appropriation mechanisms in turn increases firms' likelihood to engage in coopetition. Therefore, we formulate the following hypothesis:

H1: If a firm relies on (a) formal and (b) informal appropriation mechanisms, it is more likely to collaborate with competitors.

2.2.1.1 Industry dynamism

Prior research has shown that the benefits and risks associated with coopetition are often dependent on the environment a firm operates in (Chiambaretto & Fernandez, 2016; Ritala, 2012). Empirical work by Miller and Friesen (1983) already established a link between the environmental dynamism, which they define as the uncertainty with respect to competitors' actions, and strategic decision making. Partnering with competitors allows to share the risk posed by uncertainties that are especially high in dynamic environments (Chiambaretto & Fernandez, 2016). In addition, fast-changing markets incentivize firms to increase the efficiency of their innovation processes, thereby enabling them to keep up with competitors (Bengtsson & Kock, 2000; Gnyawali & Park, 2009). Knowledge-based resources play an important role in dynamic industries for firms to gain and sustain a competitive advantage (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2018; Knecht, 2014). This makes competitors especially attractive partners as they possess product- and industry-specific knowledge (Estrada et al., 2016; Fernandez & Chiambaretto, 2018; Raza-Ullah & Kostis, 2020).

To counter the risks inherent in coopetition, firms use formal and informal mechanisms. They differ, however, in their underlying nature and characteristics. In particular, formal appropriation mechanisms, such as patents, allow for controlled knowledge sharing. For example, when firms apply for patents, they choose to disclose some innovation-related information and hence engage in the process of conversion of their tacit knowledge into codified knowledge. Contrary to that, informal mechanisms diminish information sharing and are often used to protect tacit knowledge (Hall et al., 2014). Tacit knowledge has been linked to more novel, radical innovations (Castiaux, 2007; Mascitelli, 2000; Zobel et al., 2017), and informal appropriation mechanisms may be more effective to guard such knowledge. Firms using such mechanisms are able to keep up with the fast-changing rate of innovation in dynamic markets and can be considered as more innovative and thus to be close to the technological

frontier of the market. However, this is also an indication for the fact that such firms may be less in need of coopetition to achieve product innovation. In fact, collaborating with a competitor might even harm such firms as they open up their R&D and other innovation processes to partners by committing core information to the relationship (Estrada et al., 2016; Ritala & Hurmelinna-Laukkanen, 2013; Tidström, 2014). This in turn might harm the effectiveness of informal protection mechanisms such as short lead-times, as competitors gain access to the secret behind such quick time-to-market for instance. This is especially detrimental in dynamic markets where firms have a competitive advantage if they are able to keep up with the fast-changing environment.

Firms relying on formal mechanisms, however, have the need to protect explicit knowledge (Hall et al., 2014). Since such knowledge is usually connected with incremental innovations (Popadiuk & Choo, 2006), the use of formal mechanisms can consequently also be linked to incremental rather than radical innovations (Anton & Yao, 2004; Hall et al., 2014)[11]. However, dynamic industries are characterized by a high speed of new-to-the-market innovations (Belderbos, Carree, Diederen, et al., 2004). Firms that mostly draw on formal appropriation can enhance their innovation performance and catch up with firms closer to the technological frontier by partnering with competitors, as this gives them access to a broader set of relevant resources (Estrada et al., 2016). This is especially beneficial in dynamic industries, where products change quickly and require constant innovation from the market players (Weerawardena et al., 2006).

In sum, we therefore consider firms using formal mechanisms as less innovative and hence in need for a coopetition partner.[12] This is especially the case in dynamic industries that require firms to constantly keep up with the fast pace of innovation. Therefore, we expect a positive interaction effect between the use of formal appropriation mechanisms and industry dynamism. Firms relying on informal mechanisms, however, are considered to be more innovative, and therefore not looking to engage in coopetition in dynamic markets.

[11] Anton and Yao (2004), as well as Hall et al. (2014) refer to radical innovations also as large innovations.

[12] In industries such as the pharmaceutical market, patents are often seen as a means to protect radical innovations (see e.g. Hall et al., 2014). In an additional analysis, we exclude the pharmaceutical firms from the sample and find similar results as those outlined in Section 2.4.

Opening-up to a competitor can even render the (informal) protection mechanisms ineffective, as secret or complex innovation processes might become apparent, diminishing short lead-time-advantages. This would be especially harmful in highly dynamic industries, where firms need to be quick in introducing new products to the market. Therefore, we expect a negative interaction between dynamism and informal protection. Based on this reasoning, we can formulate the following hypotheses:

H2a: The association between formal appropriation mechanisms and the likelihood to engage in coopetition is positively moderated by industry dynamism.

H2b: The association between informal appropriation mechanisms and the likelihood to engage in coopetition is negatively moderated by industry dynamism.

2.2.1.2 Competition intensity

Extant research indicates that competition intensity is a relevant factor that affects firms' partnering behavior (Huizingh, 2011) and their choice of strategic protection (Cassiman & Veugelers, 2002). In competitive industries, firms that do not collaborate may quickly find themselves at a disadvantage. Collaborating with rivals enables firms to gain access to a broader set of relevant resources and knowledge, which in turn allows them to enhance their performance and subsequently market position (Gnyawali & Park, 2009). They can then hedge against strong industry competitiveness, and prevent being outperformed (Enkel et al., 2009; Ritala, 2012). Furthermore, firms attach higher importance to appropriation mechanisms in industries characterized by high degree of competitive pressure because the need to protect knowledge may be higher given the risk of exploitation and a bigger chance of simultaneous innovation by rival firms (Hagedoorn & Ridder, 2012; Kultti et al., 2006; Wu, 2012). If sensitive knowledge spills over to competitors unintentionally, this can be detrimental, as the rival will use it to its own advantage.

In order to diminish competition, firms often choose to use formal appropriation mechanisms such as patents in a way that prevents their rivals from patenting the same invention first (Hall et al., 2014). Cohen et al. (2000), as well as Walsh et al. (2016) already established that such strategic utilization of patenting is in fact one of the most common ways for firms to use patents. This enables firms to build so-called patent fences around their inventions, keeping

others from inventing the same, which acts as a source of competitive advantage for the focal firm (Somaya, 2012; Walsh et al., 2016). Coopetition partners can hedge against high competition intensity in an industry together (Ritala, 2012). This could for instance be done by forming a patent thicket – a dense web of overlapping patents that offers even more effective protection, as it impedes search and innovation efforts from other firms in the market (Gątkowski et al., 2020; von Graevenitz et al., 2011). In forming such a thicket, partners thus establish a more beneficial industry position for themselves through preventing others from introducing certain technologies and innovations.

Besides a blocking function, patents and other types of formal IP protection bear another advantage with regards to coopetition in highly competitive environments. Ritala (2012) points out that strong competition in an industry often ties up a large amount of the focal firm's resources, potentially harming this firm's ability to manage a coopetitive relationship due to resource limitations. As formal mechanisms provide legal protection for a firm's IP, firms face less of a risk of exploitation by partners even when they have limited managerial capacity. Moreover, as argued earlier, firms using formal appropriation tend to be less innovative in general (Anton & Yao, 2004; Zaby, 2010), meaning that they might not require an overly strict risk management regime in the first place. Moreover, if a firm lacks innovation potential, especially in a competitive environment the pressure to catch up with rivals is high. To ensure survival, firms that are not very innovative are more inclined to engage in coopetition to bridge the gap.

When considering the use of informal mechanisms, however, the risks of engaging in coopetition might be even more detrimental in competitive settings. In particular, informal IP mechanisms do not provide any legal protection of inventions, and when unintended knowledge spillovers occur, partners can imitate innovations without any legal consequences.[13] Informal mechanisms are more effective compared to patents in protecting tacit knowledge, which cannot easily be codified (Hall et al. 2014). The exchange of tacit knowledge in a

[13] Here, it is important to note that trade secret laws exist (Lippoldt & Schultz, 2014). However, it might be difficult to impose these laws within a collaborative setting, where knowledge sharing is essential for success (Contigiani et al., 2018; Slowinski et al., 2006). Moreover, the enforcement of trade secret laws in case of infringement may be very cost-intensive, making it difficult or impossible for firms to afford (Crass et al., 2019).

collaborative setting requires trust between the partners (Raza-Ullah & Kostis, 2020), however, increased competitiveness may undermine trust between rivals (Ang, 2008; Czakon & Czernek, 2016). Distrust in turn keeps firms from engaging in coopetition because they fear opportunistic behavior from their partners and unintended knowledge leakage (Raza-Ullah et al., 2014; Ritala & Hurmelinna-Laukkanen, 2013). Firms that rely on informal IP protection are generally considered to be more innovative, as tacit knowledge is often linked with more radical innovations (Seidler-de Alwis & Hartmann, 2008). Such firms are not necessarily in need for a collaboration partner, as they are already leaders in their field. The potential benefits to be derived from coopetition do not outweigh the risks associated with competitor collaboration, as leading firms cannot gain much from partnering with a firm of inferior market position that is inclined to behave opportunistically.

In summary, we propose that a strong competitive intensity in the industry increases the risks inherent to coopetition, because rival firms are working on similar products at the same time. Firms' tendency to engage in coopetition when relying on formal appropriation increases under circumstances of high competition intensity because there is a need to gain a competitive advantage over rivals in the market. Firms can use patents to block competitors from working on similar inventions, and by partnering up with rivals, they can also build patent thickets. We therefore expect that as firms are more inclined to engage in coopetition when they protect their IP with formal mechanisms, this effect becomes even stronger in competitive industries. If a firm uses informal mechanisms, however, we reason that they are protecting tacit knowledge and therefore generally are considered to be more innovative. The exchange of tacit knowledge requires trust, but prior research highlights that increased industry competitiveness leads to distrust, preventing firms from coopeting. Moreover, firms face higher risks of exploitation as their IP is not protected by law and subsequently there are no legal consequences for partners who imitate this knowledge. Given these substantial risks, we expect that firms using informal IP protection are less inclined to engage in coopetition, especially with increasing industry competitiveness. All in all, we can thus formulate the following hypotheses:

H3a: The association between formal appropriation mechanisms and the likelihood to engage in coopetition is positively moderated by competition intensity.

H3b: The association between informal appropriation mechanisms and the likelihood to engage in coopetition is negatively moderated by competition intensity.

2.3 Data, methods and variables

This study makes use of data collected through the Dutch Community Innovation Survey (CIS). The CIS is a harmonized survey of firms' innovation activities, collected biannually in member states of the Organization for Economic Co-operation and Development (OECD). In the Netherlands, Statistics Netherlands (CBS; Centraal Bureau voor de Statistiek) collects the data. Our dataset is compiled from the CIS 1998, 2000, 2010 and 2012, because information on firms' use of informal appropriation mechanisms is only available in the CIS 2000 and 2012. As we are interested in the effect of both types of IP appropriation, we can only rely on those two survey waves. We use the 1998 and 2010 surveys to construct control variables that we incorporate into the analysis with a time lag.

Our final sample consists of 2,337 observations of 2,207 innovating firms from both 2000 and 2012 time-periods, implying that 65 firms are included in both periods. All firms in the sample are innovators defined as those that "*implemented a new or significantly improved product or process during the period under review*" (Eurostat, 2005, p.47)[14]. We make a conservative selection because non-innovators are not expected to use IP protection for innovations.[15]

The CIS, as a secondary source of data, has several advantages over primary data, such as providing information about a large number of firms from various industries. Table 2.1 lists the industries that are included in the analysis and their respective Standard Business Classification (SBI) codes (Column I), the share of sample firms that report coopetition engagement (Column V), and the share of firms that report use of formal and informal appropriation mechanisms (Columns VII & IX). Coopetition takes place most frequently in the electronics & electrical and energy & extraction sector. In all sectors, a larger share of firms reports the use of informal appropriation mechanisms compared to the formal

[14] The Oslo Manual (Eurostat, 2005) provides the baseline definitions for all the items in the Community Innovation Survey.
[15] We address potential selection bias in Section 2.3.2.

ones. Firms operating in machinery & equipment, chemical & pharmaceuticals and electronics & electrical frequently use informal mechanisms alongside the formal mechanisms.

2.3.1 Variables

Dependent variables. *Coopetition* is binary, taking value (1) if a firm indicates in the survey in year t that it collaborates with competitors, and (0) if not.[16] To construct the informal and formal appropriation mechanism variables we use the question in the CIS 2000 and CIS 2012 survey that asks to indicate whether firms applied any of the following: patents, trademarks, copyrights, design rights, secrecy, complexity, and lead-time. Our measures of *formal* and *informal appropriation* are binary and take value (1) if a firm indicated the use of at least one formal or informal mechanism respectively, and (0) otherwise.[17]

Independent variables. *Industry dynamism* is the sum of sales of new-to-the-market innovations divided by the sum of total sales per industry (Belderbos, Carree, Diederen, et al., 2004). *Competitive intensity* in the market is constructed by adding responses to six questions asked in the CIS 2012 survey that ask firms to assess to which degree they were affected by: (1) competition in price, (2) competition in quality and reputation, (3) lack of demand, (4) innovation by competitors, (5) market domination by incumbents and (6) high entry costs. The answers per question range from 0 (not applicable) to 3 (high hindrance). We average the scores per firm, and subsequently compute the industry average. This measure has a high internal consistency (Cronbach's $\alpha = 0.82$) and is the same for both time-periods included in this study, because the questions used for the construction of the measure were only asked in the CIS 2012.[18]

[16] The questions pertaining to collaboration refer to a two-year time window, e.g. in the 2000-survey the period is from 1998 to 2000, and in the 2012-questionnaire from 2010 until 2012.

[17] In one of the checks, we created a count variable for both formal and informal appropriation, which considers the number of different mechanisms used. Formal appropriation can range between 0 (no formal instruments used) and 4 (all four types used), while informal appropriation can take on values between 0 and 3. The use of count variables and the linear probability model results in larger confidence intervals for the key variables of interest.

[18] The time invariant nature of our measure of competition intensity is a limitation that we address in the supplementary analysis. We test the robustness of our findings by using alternative measures of competition.

Table 2.1: Coopetition and IP protection by industry

Industry	SBI Code '93	Number of firms	%	Coopetition	%	Formal IP	%	Informal IP	%	Both IP	%
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**
Food/beverages/tobacco	16	145	6.57	15	10.34	79	54.48	108	74.48	72	49.66
Textiles/clothing	19	38	1.72	<10		21	55.26	26	68.42	16	42.11
Wood/paper	21	49	2.22	<10		22	44.90	30	61.22	15	30.61
Chemicals/pharmaceuticals	24	159	7.20	18	11.32	97	61.01	124	77.99	86	54.09
Rubber/plastics	25	77	3.49	<10		39	50.65	58	75.32	33	42.86
Metals	27, 28	161	7.29	16	9.94	73	45.34	110	68.32	60	37.27
Electronics/electrical	30, 31, 33	110	4.98	17	15.45	73	66.36	82	74.55	60	54.55
Machinery/equipment	29	172	7.79	<10		115	66.86	137	79.65	105	61.05
Vehicles	34, 35	62	2.81	<10		33	53.23	34	54.84	21	33.87
Energy & extraction	14, 23	57	2.58	<10		30	52.63	35	61.40	21	36.84
Water supply/waste/recycling	37, 41, 90	167	7.57	19	11.38	83	49.70	97	58.08	63	37.73
Wholesale trade	51	293	13.28	27	9.22	151	51.54	186	63.48	124	42.32
Transportation/postal services	64	94	4.26	12	12.77	13	13.83	56	59.57	12	12.77
Printing/publishing/media	22	62	2.81	<10		26	41.94	29	46.77	15	24.19
Financial intermediation	67	61	2.76	<10		11	18.03	34	55.74	<10	
Other producer services	74	331	15.00	47	14.20	119	35.95	201	60.73	93	28.10
Other	45, 50, 52, 55	169	7.66	23	13.61	52	30.77	89	52.66	40	23.67

N = 2,207; SBI stands for "Standaard Bedrijfsindeling" and gives the industry code used by the Statistics Netherlands to identify the sector a firm operates in; due to data privacy reasons, we are not able to report frequencies of less than 10 observations

Control variables. The models include several control variables that have been shown to affect firms' likelihood to engage in coopetition. *R&D intensity* is a firm's R&D expenditures per employee and accounts for firm's innovation input. *Firm size* is the logarithm of the number of employees. *Obstacles to the innovation process* is constructed as sum of scores on the CIS survey questions that ask firms to indicate to what extent their innovation process has been "seriously delayed", "stopped in the meantime" or "not started at all", due to lack of qualified personnel, lack of knowledge of the technology, lack of financing, high innovation costs, and market uncertainty. We divide the sum of scores by the maximum possible score, making this variable bounded between zero and one. Firms that encountered hurdles may seek coopetition to share for instance risks and costs (Schmiele & Sofka, 2007). *Extent of prior collaboration* (*Collaboration*$_{t-2}$) of firms is the count of different types of partners a firm collaborates with other than competitors. The CIS lists six different partner types besides rivals, namely: (1) firms that belong to own enterprise group, (2) suppliers, (3) customers, (4) private research institutes, (5) universities, and (6) public (governmental) research institutes. Following Laursen and Salter (2006), all partner types are added up, such that this variable takes value zero if a firm collaborates with no other partner, and takes value six if it collaborates with all potential other partner types. We also include a quadratic term of the extent of prior collaboration. *Innovation performance* of a firm is new-to-market sales divided by the number of employees taken with a two-year lag (1998; 2010). *Past coopetition* (*Coopetition*$_{t-2}$) takes value (1) if the firm engaged in coopetition in 1998 and 2010 respectively, else (0). Prior engagement in coopetition may affect firms' use of appropriation mechanisms. Moreover, coopetition may be persistent through repeat alliances with competitors, enabling them to manage the tensions inherent to coopetition (Estrada & Dong, 2020; Park et al., 2014). The time-variant firm-level control variables are included with a time lag of one collection period with respect to our dependent variable (i.e., 1998 and 2010 respectively). *Part of a foreign multinational enterprise* (MNE) is a dummy, which takes value (1) if the headquarters of the firm's company group is outside the Netherlands, else (0). Firms that belong to a group are able to make use of that group's resources, potentially enhancing their attractiveness as partners (Lhuillery & Pfister, 2009). In order to account for the differences between manufacturing and service industries, we include a *service dummy* that takes value (1) if a firm is a service firm,

and (0) if not (Belderbos, Carree, Diederen, et al., 2004). *Formal* and *informal industry IP standards* is the proportion of innovating firms in an industry that uses formal or informal IP mechanisms respectively. Following Crass et al. (2019), we count the number of firms that use formal or informal IP in an industry and divide each by the total number of innovators in that industry. The industry-wide effectiveness of IP mechanisms such as patents and secrecy has been shown to determine a firm's choice of formal and informal IP appropriation measures. For example, a traditionally high level of patenting within an industry encourages all firms in that industry to patent and conversely, more industry-wide use of secrecy or complexity may encourage a firm to employ such informal mechanisms (Crass et al., 2019; Hall et al., 2013; Kultti et al., 2007).

2.3.2 Empirical approach

We estimate a generalized structural equation model (GSEM) consisting of three equations.[19] Table 2.2 illustrates the dependent variable of each equation (Columns I, II & III), and the independent variables that are included respectively. We consider three versions of equation III, where the first version includes only the direct effects of formal and informal IP and the control variables. We employ two other versions when considering the moderation effects of environmental dynamism and competition intensity. In that case, equation III also includes either the interaction terms related to environmental dynamism or competition intensity (see Table 2.2).

The system of equations I – III is identified if the exclusion restrictions on the model are fulfilled (Wooldridge, 2013, p. 539). Equations I and II each contain an exclusion restriction – a variable that is not included in equation III – *formal industry IP standards* in equation I and *informal industry IP standards* in equation II. Early work has already documented that a firm's propensity for IP mechanisms differs depending on the industry a firm operates in, because formal and informal appropriation mechanisms are not equally effective in all industries. For instance, firms in pharmaceutical or chemical industries have a higher propensity to patent because of an increased effectiveness of such mechanisms in these environments (Cohen et al., 2000, pp. 2 & 16; Levin et al., 1987, pp. 797 & 818). Moreover, patent thickets can be a commonly used strategy in an

[19] For technical details on GSEM, please refer to the STATA manual on structural equation modeling (StataCorp, 2017).

industry, such that "*patenting is relatively more attractive*" (Crass et al., 2019, p. 119). In general, prior research has shown that for instance an effective patent system increases patenting activities (Kultti et al., 2007), while strong trade secret systems reduce patenting activities (Png, 2017). Other scholars have argued that firms rate the importance of formal and informal IP mechanisms in line with how they are rated in their industry. This means that if the industry standard is formal (informal) IP, then firms rate formal (informal) mechanisms as more important (Hall et al., 2013). Following this line of reasoning, we infer that the specific type of industry IP standard is a driver of a firm's IP appropriation mechanism(s) and hence the variables *formal industry IP standards* and *informal industry IP standards* appear in equation I and II, respectively.[20]

Table 2.2: List of variables per equation

	Formal IP_t	Informal IP_t	$Coopetition_t$
	I	**II**	**III**
Formal IP_t			✓
Informal IP_t			✓
Industry $dynamism_t$	✓	✓	✓
Formal IP_t*Industry $dynamism_t$			(✓)
Informal IP_t*Industry $dynamism_t$			(✓)
Competition intensity	✓	✓	✓
Formal IP_t*Competition intensity			(✓)
Informal IP_t*Competition intensity			(✓)
Industry formal IP_t	✓		
Industry informal IP_t		✓	
R&D $intensity_{t-2}$	✓	✓	✓
Ln(Firm $size)_{t-2}$	✓	✓	✓
Obstacles to $innovation_{t-2}$	✓	✓	✓
Part of foreign MNE_t	✓	✓	✓
Service $dummy_t$	✓	✓	✓
Innovation $performance_{t-2}$	✓	✓	✓
$Coopetition_{t-2}$	✓	✓	✓
$Collaboration_{t-2}$			✓
$Collaboration_{t-2}$ squared			✓

[20] Conditional Mixed Process (CMP) is an alternative approach to estimate a system of (non-linear) equations. This estimator was developed among others by Roodman (2011) and allows modelling the correlations between the error terms. CMP is appropriate when "*there is simultaneity but instruments allow the construction of a recursive set of equations*" (Roodman, 2011, p. 161). However, this condition is not met in our case.

The industry IP standards are excluded from equation III. In fact, we presume that industry IP standards are not driving the act of coopetition. The decision to engage in coopetition is primarily driven by a firm's need to enhance innovation, to make the innovation process more effective or to gain other synergies. At an industry level the use of formal mechanisms reflects the general strategic nature or effectiveness of IP rather than the firm level incentive to engage in coopetition. Similarly, at an industry level, informal mechanisms represent the general strategic tendency and effectiveness to prevent any disclosure of firms' innovation performance (see e.g. Hall et al., 2014). Therefore, industry IP standards should not be seen as indicators of an industry's innovativeness, but rather as the best way innovation in a specific industrial setting is protected. This underlines our assumption that industry standards are not associated with a firm's idiosyncratic incentive to engage in coopetition.

In order to correct for potential selection bias caused by focusing on only innovating firms, we make use of a two-stage approach as suggested by Heckman (1979). We estimate a first-stage probit model that explains the probability that a firm is an innovator (see e.g. Belderbos et al., 2018). Following prior research, we include firm size, export orientation and industry dummies as covariates in this probit model (Belderbos et al., 2018; Veugelers & Cassiman, 1999; Zobel et al., 2017).[21] Firm size is based on the number of workers a firm employs and accounts for the fact that large firms often have more resources to spend on innovating (Veugelers & Cassiman, 1999; Zobel et al., 2017). Moreover, export orientation is a dummy that equals (1) if a firm's most important market (in terms of sales) is outside of the Netherlands, and (0) otherwise. Belderbos et al. (2018) emphasize that internationally competing firms are often under more pressure to renew their products, meaning they are more likely to be innovators. Industry dummies pick up any industry-specific effects such as the general level of innovativeness. In a second step, we test for the presence of selection effects by including the Inverse Mill's Ratio (IMR) of

[21] Due to inconsistencies in the CIS questionnaires, we cannot make use of additional variables to estimate a firm's propensity to be an innovator like firm age, such as suggested by Belderbos et al. (2018) or Zobel et al. (2017).

the innovation equation in the appropriation and coopetition equations that are outlined in earlier in this section.[22]

2.3.3 Descriptive statistics

Table 2.3 tabulates the spread of firms using formal and informal appropriation (overall and the individual mechanisms), as well as engaging in coopetition. Some 1,037 (47%) firms make use of formal appropriation mechanisms, and 1,436 (65%) employ informal ones. 845 (38%) firms use both formal and informal IP protection simultaneously. In order to gain a more detailed understanding of the IP appropriation in coopetition, we also compare the use of IP protection mechanisms by coopeting and non-coopeting firms. Out of the 248 coopeting firms, 144 (58%) use formal, and 181 (73%) use informal mechanisms; 120 (48%) firms employ both simultaneously. Of the 1,959 non-coopeting firms, 893 (46%) use formal IP protection, and 1,255 (64%) use informal mechanisms, while 725 (37%) use both formal and informal appropriation simultaneously. We learn from these numbers that in general firms that coopete use both formal and informal appropriation mechanisms more often. When looking at the use of the individual appropriation mechanisms in more detail, we see in Table 2.3 that – among both coopetitors and non-coopetitors – patents and trademarks are the most popular formal mechanisms, and lead-time is the most frequently used informal instrument.

The mean variance inflation factor (VIF) of our variables is 1.30, which is well below the threshold of 10 (Wooldridge, 2013, p. 94), suggesting limited multicollinearity. Yet, we estimate the models including the interactions to test Hypotheses 2 and 3 separately, because industry dynamism and competition intensity are highly correlated (see Table 2.4).[23] Another notably high correlation is that between formal and informal industry IP standards. This does not pose any problems, however, as they are not included in the same model directly. Rather, they are used as covariates in equations I and II, respectively.

[22] The IMR is insignificant in all equations, indicating that no selection effects are present. Therefore, we do not further report the IMR in any of our main and supplementary analyses.

[23] Including both interaction terms in one model simultaneously provides qualitatively the same results. However, only the interaction between industry dynamism and informal IP mechanisms remains significant while of the rest of the results are no longer significant. As this is likely caused by multicollinearity, we choose to keep the interaction models separate.

Table 2.3: Frequencies of coopetition & use of IP protection (overall and individual mechanisms)

	Overall		Coopetitors		Non-coopetitors	
	Obs.	%	Obs.	%	Obs.	%
	I	**II**	**III**	**IV**	**V**	**VI**
Coopetition						
No	1,959	88.76				
Yes	248	11.24				
Formal IP						
No	1,170	53.01	104	41.94	1,066	54.42
Yes	1,037	46.99	144	58.06	893	45.58
Informal IP						
No	771	34.93	67	27.02	704	35.94
Yes	1,436	65.07	181	72.98	1,255	64.06
Formal & Informal IP						
No	1,362	61.71	128	51.61	1,234	62.99
Yes	845	38.29	120	48.39	725	37.01
Formal mechanisms						
Patents	604	27.37	92	37.10	512	26.14
Design rights	472	21.39	62	25.00	410	20.93
Trademarks	699	31.67	96	38.71	603	30.78
Copyrights	298	13.50	48	19.35	250	12.76
Informal mechanisms						
Secrecy	761	34.48	103	41.53	658	33.59
Complexity	886	40.14	118	47.58	768	39.20
Lead-time	1,158	52.47	157	63.31	1,001	51.10
N	**2,207**		**248**		**1,959**	

Note: *N* = individual innovating firms

Table 2.4: Descriptive statistics and correlations

Variables	Mean	SD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Coopetition$_t$	0.113	0.316														
(2) Formal IP$_t$	0.467	0.499	0.08*													
(3) Informal IP$_t$	0.655	0.476	0.06*	0.32*												
(4) Ind. dynamism$_t$	0.378	0.240	-0.04	0.15*	0.15*											
(5) Competition intensity	0.520	0.054	-0.06*	0.22*	0.16*	0.61*										
(6) Ind. formal IP$_t$	0.424	0.191	-0.04	0.38*	0.23*	0.46*	0.51*									
(7) Ind. informal IP$_t$	0.627	0.146	-0.04	0.32*	0.27*	0.48*	0.52*	0.86*								
(8) R&D intensity$_{t-2}$	0.024	0.096	0.06*	0.12*	0.07*	0.07*	0.07*	0.10*	0.10*							
(9) Ln(Firm size)$_{t-2}$	4.860	1.253	0.13*	0.13*	0.08*	-0.03	-0.06*	-0.00	0.01	0.04						
(10) Obstacles to innovation$_{t-2}$	0.087	0.162	0.08*	0.06*	0.10*	0.11*	0.07*	0.06*	0.09*	0.03	0.11*					
(11) Part of foreign MNE$_t$	0.434	0.496	0.00	0.00	0.01	0.07*	0.11*	-0.01	0.01	-0.02	0.05*	0.03				
(12) Service dummy$_t$	0.437	0.496	0.04*	-0.19*	-0.12*	-0.60*	-0.57*	-0.37*	-0.41*	-0.04	0.03	-0.07*	-0.06*			
(13) Innovation performance$_{t-2}$	1.468	7.444	0.05*	0.09*	0.03	0.09*	0.08*	0.13*	0.13*	0.00	0.05*	0.02	0.01	-0.09*		
(14) Coopetition$_{t-2}$	0.125	0.331	0.21*	0.05*	0.08*	0.00	-0.06*	-0.04	-0.02	0.10*	0.16*	0.14*	-0.04	0.03	-0.01	
(15) Collaboration$_{t-2}$	1.318	2.257	0.17*	0.16*	0.16*	0.11*	0.09*	0.15*	0.16*	0.16*	0.27*	0.26*	0.01	-0.11*	0.11*	0.50*

Note: N = 2,337; * p < 0.05

2.4 Results

Table 2.5 reports the results of the estimated system of equations I, II and III. Column I shows the results from a model in which formal appropriation mechanisms used is a dependent variable, and Column II from a model in which informal appropriation mechanisms is the dependent variable.[24] Columns III, IV and V represent the results from the models in which coopetition is the dependent variable.

The sign and significance of the estimated coefficient on the formal IP (Table 2.5, Column III) is in line with Hypothesis 1a, while the estimated coefficient on the informal IP is statistically insignificant. The interaction between the formal IP appropriation and industry dynamism is positive and weakly significant, while that between industry dynamism and the informal appropriation mechanisms is negative and significant (Column IV, Table 2.5). The interaction term of competition intensity with formal IP is not significant, and with informal IP is negative and weakly significant (Column V, Table 2.5). The magnitude of the interaction effect in non-linear models is not equal to the marginal effect of the interaction term (Ai & Norton, 2003; Zelner, 2009) and the sign and statistical significance cannot directly be inferred from the point estimates. In order to do so, we compute the marginal effects. Figures A2.1 (see Appendix) present the interaction plots. To assess the differences, we contrast the two sets of estimated effects and plot those in Figures 2.1, 2.2 and 2.3.[25]

The solid line in Figure 2.1 shows the discrete marginal effect of using formal IP for various levels of industry dynamism. The upward sloping line indicates that as the industry dynamism is increasing, so does the difference in coopetition propensity between firms that use and do not use formal appropriation mechanisms. This is in line with H2a. With the confidence interval above zero for the dynamism scores above 0.3, the graph provides evidence that the use of formal IP is related to the likelihood to engage in coopetition for firms operating in more dynamic industries.

[24] The coefficients reported in Columns I and II are the same for the systems with and without interaction terms.

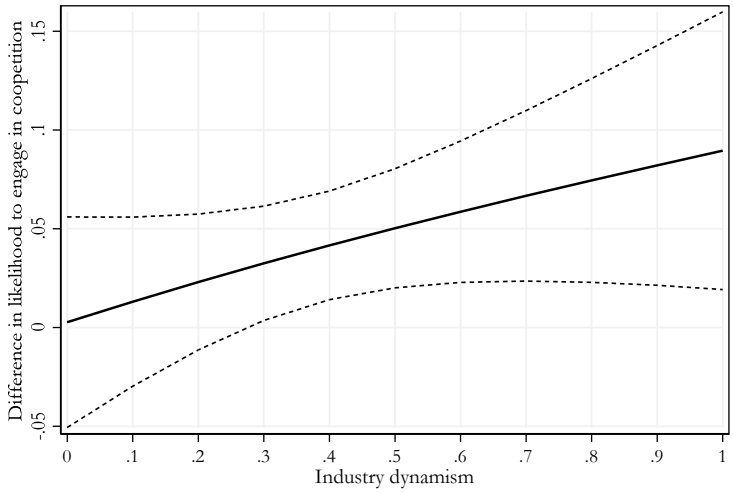
[25] The terminology varies across disciplines: management literature often refers to these values as 'contrasts of effects' or 'contrasts of predictive margins', while in economics the use of 'marginal' or 'partial effects' is more common.

Table 2.5: GSEM estimation results

Dependent variable	*Formal IP*	*Informal IP*	*Coopetition*	*Coopetition*	*Coopetition*
	I	**II**	**III**	**IV**	**V**
Formal IP_t			0.204**	0.014	-0.615
			(0.079)	(0.143)	(0.747)
Informal IP_t			0.104	0.404**	1.444†
			(0.084)	(0.145)	(0.794)
Industry $dynamism_t$	0.043	0.023	-0.202	0.122	-0.197
	(0.160)	(0.165)	(0.206)	(0.335)	(0.205)
Formal IP_t*Industry $dynamism_t$				0.563†	
				(0.324)	
Informal IP_t*Industry $dynamism_t$				-0.908**	
				(0.341)	
Competition intensity	0.216	0.662	-1.609†	-1.607†	-0.622
	(0.755)	(0.703)	(0.848)	(0.851)	(1.429)
Formal IP_t*Competition intensity					1.607
					(1.438)
Informal IP_t*Competition intensity					-2.639†
					(1.545)
Industry formal IP $standards_t$	2.560***				
	(0.177)				
Industry informal IP $standards_t$		2.311***			
		(0.233)			
R&D $intensity_{t-2}$	1.410**	0.641†	0.452	0.457	0.454
	(0.483)	(0.380)	(0.284)	(0.283)	(0.238)
Ln(Firm size) $_{t-2}$	0.138***	0.071**	0.086**	0.084**	0.085**
	(0.023)	(0.023)	(0.029)	(0.029)	(0.029)
Obstacles to $innovation_{t-2}$	0.127	0.535**	0.312	0.301	0.304
	(0.170)	(0.181)	(0.213)	(0.214)	(0.213)
Part of foreign MNE_t	-0.014	0.024	0.053	0.057	0.056
	(0.057)	(0.056)	(0.073)	(0.074)	(0.073)
Service $dummy_t$	-0.153*	-0.022	0.073	0.070	0.071
	(0.073)	(0.072)	(0.094)	(0.094)	(0.094)
Innovation $performance_{t-2}$	0.006	-0.001	0.008*	0.008*	0.008*
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
$Coopetition_{t-2}$	0.137	0.268**	0.518***	0.516***	0.518***
	(0.087)	(0.090)	(0.109)	(0.109)	(0.109)
$Collaboration_{t-2}$			0.134**	0.134**	0.134**
			(0.041)	(0.041)	(0.041)
$Collaboration_{t-2}$ squared			-0.012*	-0.012*	-0.012*
			(0.005)	(0.005)	(0.005)
Intercept	-1.967***	-1.806***	-1.237**	-1.335**	-1.732*
	(0.387)	(0.213)	(0.454)	(0.467)	(0.748)
Log likelihood			*-3,543.8*	*-3,540.3*	*-3,542.1*

Note: N = 2,337; Robust standard errors in parentheses; † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; The estimates of equations I and II are the same for all systems. The estimates of the different versions of equation III are displayed in Columns III, IV and V.

Figure 2.1: Average marginal effect of formal IP at different levels of industry dynamism

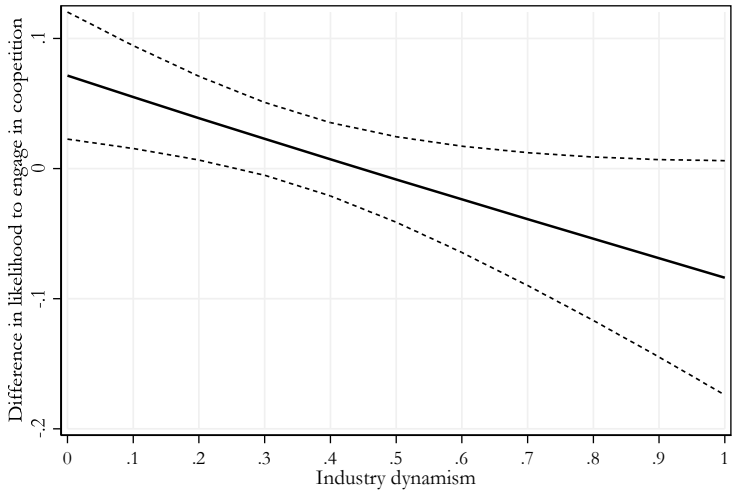


Notes: Short-dashed line illustrates the 95%-confidence interval of formal appropriation used, and dotted line that of formal appropriation not used. At dynamism levels between 0 and approximately 0.3 – where confidence interval includes 0 – differences between use and non-use of formal mechanisms are insignificant.

Figure 2.2 shows the discrete marginal effect of using informal IP for various levels of industry dynamism. The downward sloping line indicates that firms that rely on informal IP are more (less) likely to engage in coopetition in less (more) dynamic markets than those that do not rely on informal IP, consistent with H2b. The confidence interval is above zero for the dynamism scores below 0.3. When the level of dynamism is high (between 0.8 and 1.0), the marginal effect is only weakly significant.[26] These findings indicate that the significant differences are mostly present at more extreme values of industry dynamism.

[26] While the confidence interval in Figure 2.2 contains 0, further tests have shown that the difference between users and non-users of informal IP mechanisms is significant at a 10% significance level.

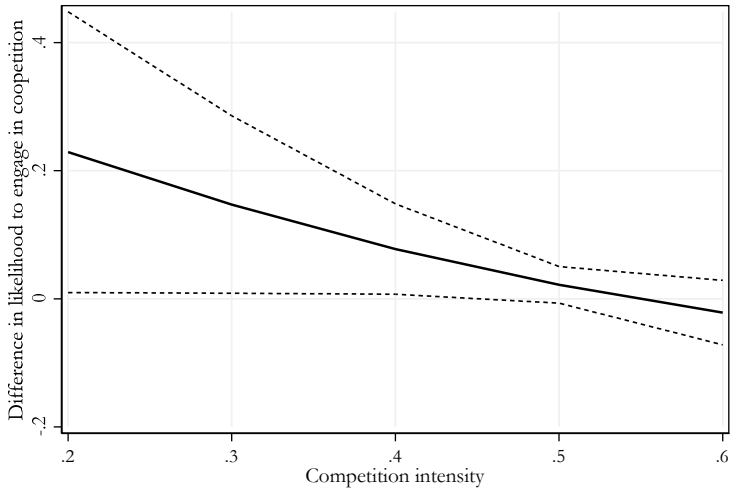
Figure 2.2: Average marginal effect of informal IP at different levels of industry dynamism



Notes: Short-dashed line illustrates the 95%-confidence interval of informal appropriation used, and dotted line that of informal appropriation not used. At dynamism levels between 0.3 and approximately 0.7 – where confidence interval includes 0 – differences between use and non-use of informal mechanisms are insignificant. Between 0.8 and 1, the difference is statistically significant ($p < 0.1$).

Figure 2.3 shows the discrete marginal effect of using informal IP for various levels of competitive intensity. We observe that – with declining effect sizes – there are significant differences in firms' likelihood to coopete at low levels of industry competition intensity (values between 0.2 and 0.4). The downward slope suggests that firms that rely on informal IP are more (less) likely to engage in coopetition in less (more) competitive markets than those that do not rely on informal IP, consistent with H3b. As the competition intensity increases, the probability to engage in coopetition is decreasing for firms relying on informal mechanisms, while it is increasing for those not relying on such tools (see also Figure A2.1). At higher levels of competition intensity, the marginal effects are not statistically significant.

Figure 2.3: Average marginal effect of informal IP at different levels of competition intensity



Notes: Short-dashed line illustrates the 95%-confidence interval of informal appropriation used, and dotted line that of informal appropriation not used. At competition intensity between 0.5 and approximately 0.6 – where confidence interval contains 0 – differences between use and non-use of informal mechanisms are insignificant.

Among the control variables, formal and informal industry IP standards have positive and significant coefficients in Columns I and II, respectively. This supports our reasoning regarding the exclusion restrictions discussed in Section 2.3.2. Moreover, past coopetition has a positive and significant coefficient in the informal appropriation mechanisms model but is insignificant in the formal appropriation one. Firms with higher R&D intensity are more inclined to choose formal and informal IP protection. The propensity of firms to use formal and informal appropriation is higher, the larger the size of the firm. Furthermore, firms that experienced obstacles to their innovation process previously, are more inclined to make use of informal IP protection. Service firms are less prone to use formal appropriation. The propensity of firms to collaborate with their competitors is higher, the larger the size of the firm (Columns III, IV & V, Table 2.5). The effect of the extent of prior collaboration has an inverted-U-shape, meaning that it is beneficial for the likelihood to engage in coopetition to also collaborate with other types of partners but that this effect reverses at a certain

point. Moreover, firms that coopeted in the past are also more prone to coopete again.

2.4.1 Supplementary analyses

We additionally considered coopetition with firms in different countries, as laws and strength of protection can differ in different institutional contexts. We created two new variables, namely *coopetition with firms in countries with a strong appropriation regime* and *coopetition with firms in countries with a weak appropriation regime*. While the former consists of countries such as the U.S. and countries in the EU, the latter rather includes countries such as India and China. In countries with weak laws and regulations for the protection of IP, the risk of unintended knowledge spillovers and exploitation is even higher (Oxley, 1999). In particular, Schmiele and Sofka (2007) suggest that firms engaged in international coopetition need to shift from using informal appropriation mechanisms to formal ones.

Generally, less than 2% of firms in our sample collaborates with rivals in countries with a weak IP regime like India. Interestingly, we observe that firms engaging in coopetition in such countries seem not to have a preference between formal and informal mechanisms. Moreover, despite a strong IP legislation provided, firms cooperating with rivals in countries such as the U.S. still rely on informal appropriation more frequently than on formal tools.[27]

In the analysis, we find that with regards to appropriation and coopetition with firms in countries with weak IP regimes, most coefficients of interest are insignificant (see Table A2.1 in the Appendix). This can be explained by the low number of firms actually coopeting in such countries. As shown in Column III in Table A2.1, only the use of formal IP appropriation positively (significantly) affects a firm's propensity to engage in coopetition, meaning that for instance for India, firms are more likely to coopete if they protect their IP with e.g. patents.

When instead considering collaboration with rivals in countries with a strong IP protection regime, we find that also here, using formal appropriation mechanisms increases the likelihood to engage in coopetition (see Table A2.2, Column III). When investigating the moderating role of both industry dynamism

[27] Due to the low number of coopetitors in weak IP regimes, we cannot display the frequencies. CBS does not allow this because of data privacy reasons.

and competitive intensity, and considering the use of informal IP, the results are similar to those in the main analysis of this chapter, i.e., we find negative, significant interactions (see Table A2.2, Columns IV & V).

2.4.2 Robustness checks

We conduct some sensitivity analyses to investigate the robustness of our findings.[28] Firstly, we estimate a more extensive specification using data from the 1998/2000 survey by including a broader set of control variables. In addition to the variables used in the study at hand, we included variables that measure incoming and outgoing information spillovers, measures of different types of constraints hindering firms from achieving innovation, and measures for external search breadth and depth.[29] Overall, the pattern of findings of the model with an extended set of control variables is similar to the ones reported in Table 2.5.

Secondly, we run the analysis with alternative competition measures. We construct the Herfindahl-Hirschman index (HH), Price Cost Margin (PCM) and profit elasticity (PE) based on Boone et al. (2013)[30], drawing on the Production Statistics database that is provided by CBS. This dataset contains information on firm expenditures on the intermediate inputs such as energy, costs of goods sold, marketing costs, rent expenses, as well as labor costs. Using alternative competition measures results in larger confidence intervals on the estimates of the interaction terms and has a drawback that they are only available for the manufacturing firms in our sample.

2.5 Discussion

In this study, we examine the relationship between coopetition and appropriation mechanisms employed by firms. In addition, we focus on the moderating role of environmental dynamism and competition intensity. Our findings are in line with prior studies that found that there is a positive association between firms' formal IP protection and their engagement in coopetition (Estrada et al., 2016; Ritala & Hurmelinna-Laukkanen, 2013). This

[28] Results of these robustness checks are available upon request.

[29] These additional variables are not available in the later survey.

[30] These measures are significantly correlated with our survey-based measure of competition: HH (0.06, $p < 0.05$), PCM [a lower PCM indicates more intense coopetition] (-0.25, $p < 0.05$); PE (0.51, $p < 0.05$). The significant correlation coefficients indicate that our survey-based competition measure picks up the competitive intensity in an industry.

indicates that firms are generally more likely to collaborate with rivals when their IP is legally protected by patents for instance. We find that in dynamic industries, firms are more inclined to engage in competitor collaboration when they use formal IP protection. Contrary to this, when using informal appropriation mechanisms, the propensity to engage in coopetition declines. In deriving our hypotheses, we have argued that protection mechanisms signal whether a firm may seek coopetition to close a knowledge gap vis-à-vis its competitors. Our analyses suggest that in industries where product turnover is fast, informal mechanisms may not be as effective as formal ones. For instance, lead-times might not be an effective means of IP protection anymore, as products change very quickly and have relatively short time-to-market. Rather, firms may be more prone to engage in coopetition under such circumstances if they have formal appropriation in place. Our results nuance the role of IP in the context of coopetition when contrasted with prior findings. For instance, Holbrook (2006) reports that formal protection mechanisms such as patents take some time before they are granted, which may render them less effective in dynamic industries. If that is true, formal IP might be more effective in e.g. the pharmaceutical industry, which is a rather slow-changing market, as product development can take a lot of time and is very costly (Arundel & Kabla, 1998). Short lead-times have been argued to offer advantages in fast changing markets because informal appropriation mechanisms in general do not require any time until they are granted, making them more effective in markets with quick product turnover (Boldrin & Levine, 2013).

While formal mechanisms are most often associated with patents, which take some time before being granted, trademarks and copyrights are usually granted faster than patents and may be effective in dynamic industries with the fast speed of technological change. Furthermore, firms could diminish the speed at which innovations are introduced to the market altogether, by establishing a patent thicket, i.e. a dense web of overlapping patents set up to slow down the commercialization of new technologies providing them with an advantage to their competitors (Shapiro, 2000).

We find that informal protection mechanisms in a dynamic environment reduce a firm's propensity to coopete. Thus, firms are less likely to collaborate with their competitors in such environments when having informal mechanisms in place, as firms may already have short lead-times for their innovations. They

are thus able to keep up with the quick pace and might not see the need to collaborate with a competitor, especially if these firms are more innovative than those that rely predominantly on formal IP protection (Anton & Yao, 2004; Zaby, 2010).

We find that firms' propensity to engage in coopetition in highly competitive industries also declines when the company makes use of informal IP protection. As highlighted by Hall et al. (2014), in competitive industries, various firms could be in the process of innovating the same product simultaneously. In such cases, formal mechanisms such as patents can be used to block competitors and prevent them from inventing the same product. However, informal mechanisms such as secrecy are less suitable, as they do not help blocking rivals. In highly competitive markets, firms are less prone to engage in coopetition, and this effect seems to become even stronger in combination with informal IP protection. This could further exacerbate if companies are afraid of unintentional knowledge spillovers within the coopetitive relationship. Such knowledge would not be legally protected with informal mechanisms and could be exploited by the rivals (partners), which may be especially detrimental to the firm's position in (competitive) industries (Anton & Yao, 2004; Zaby, 2010). Therefore, when having informal mechanisms in place to appropriate IP, firms are less eager to engage in coopetition, as the risks might simply outweigh the benefits, especially in competitive industries.

Additionally, we shed some light on how experience with coopetition affects firm efforts to appropriate and protect their knowledge. Park et al. (2014) argue that a firm's coopetition experience allows it to gain a better understanding of how to manage the tensions induced by coopetition. The authors reason that coopetition experience enables firms to diminish the negative effects of coopetition, e.g. by using IP protection (Holgersson, 2018). With respect to coopetition experience, we find that firms that previously engaged in coopetition are more likely to make use of informal protection mechanisms than those that did not coopete. This means that those firms are more prone to protect their IP with secrecy, lead-time or complexity. Moreover, we observe that firms who previously engaged in coopetition are indeed also more likely to do so again. This highlights that – besides the management of IP within coopetition – other factors drive firms to coopete repeatedly. Coopetition research points out that firms also engage in competitor collaboration to share costs and risks related to

the industry (Gnyawali & Park, 2009; Hagedoorn, 1993; Pellegrin-Boucher et al., 2013), which in turn might provide incentives to engage in repeated coopetition activities. In addition to this, we find that firms operating in industries with an effective IP protection system in place are also more likely to choose formal and informal appropriation tools. This is in line with findings of the IP management research, which suggests that firms are indeed likely to use patents in an effective patenting system (Kultti et al., 2007) and secrecy in effective trade secret systems (Png, 2017). Interestingly, we also find that firms are more likely to coopete with partners from countries with a weak IP regime, if they rely on formal IP instruments. This is in line with the idea that firms using such appropriation mechanisms might not possess very valuable knowledge, which in turn would reduce the risk of being exploited. Moreover, in line with our reasoning earlier, firms using informal mechanisms are likely to be more innovative and less in need of a collaboration partner. Specifically, the additional risks induced by rapidly changing, uncertain environments and by strong competition might keep firms from opening-up their innovation processes to international partners.

2.5.1 Theoretical contributions

Our study responds to a call to explore the connection between protection mechanisms and the choice for partner types (Laursen & Salter, 2014). In particular, we investigate the association between the choice of formal and informal IP appropriation mechanisms and coopetition. By doing so, we advance the current state of literature in several ways.

Firstly, we extend literature by investigating the link between two previously disconnected fields of research – IP protection and coopetition. While there is quite some literature studying the role of IP protection in the context of open innovation, most of it considers general aspects of collaboration, rather than focusing on specific partner types. Particularly, the aspect of coopetition has been overlooked, while others indicate that coopetition is a very specific type of R&D collaboration worthy of more attention from management scholars (Cygler et al., 2018; Gnyawali & Ryan Charleton, 2018).

Secondly, in addition to investigating the general link between IP protection and firms' propensity to engage in coopetition, we also consider the role of contextual factors. By taking into account environmental dynamism and competition intensity, we provide a more detailed picture of this relationship.

We show that the association between IP protection and coopetition engagement is not straightforward, but rather is influenced by such external factors.

Thirdly, we do not merely consider IP protection as one single construct but rather employ measures to separate formal and informal ways of protection. As shown by Hall et al. (2014), firms differ in their preferences of protection mechanisms, which indicates the necessity to make a clear distinction. In addition to that, we find that many studies investigate one or two specific IP protection mechanisms, such as patents and secrets. While this aims at distinguishing between formal and informal protection, we believe that it does not provide a complete picture. We introduce a broader, more generalizable measure, taking into account the fact that firms can make use of more than one form of protection simultaneously. Therefore, we deem it necessary to include measures for both formal and informal protection that are able to pick up a broader set of protection instruments.

2.5.2 Managerial implications

The practical implications provided by this research are twofold. First, we show that IP protection and coopetition are associated with each other. This finding signals that firms care about their own competitive advantage vis-à-vis their partners, which in our study are their direct competitors. We conclude from this that firms do engage in coopetition to learn from partners while at the same time protecting their knowledge base. In case firms would engage in these partnerships to just limit industry level competition and form cartels, we would not expect IP protection to be driving the decision to engage in coopetition. Thus, we find evidence that coopetition is not just meant to establish a framework to act in cartel-like relationships. This is relevant for policy makers, as the appreciation and acceptance of coopetition hinges on the fact that these ties are beneficial to society rather than leading to collusion (Duso et al., 2014).

Second, firms' strategic decision-making may benefit from our results. We provide a picture of what firms do nowadays to set certain preconditions before entering into ties with competitors. This may inspire firms to adjust their alliance formation practices. By taking into account the dynamism and competitiveness of various industries, we provide input to even further enhance the decision-making process. This should lead to firms deriving more benefits from

coopetition, and establish protection of IP appropriately, ultimately helping them gain and sustain a competitive advantage.

2.5.3 Limitations and future research

While we provide a first glance at the role of contextual factors in the relationship between coopetition and IP protection, future research in the field should help create a more detailed picture. We highlight some limitations to our study and point out potential future research avenues, both arising from those limitations and our findings. Generally, we face the same issues as many studies that use CIS data. First, it is a survey-based data collection method, entailing potential biases such as self-selection. As firms respond to the survey voluntarily, we might not be able to work with a fully random sample. Furthermore, the questions in the CIS are not designed for the purpose of our study, but the questions fit a rather broad variety of research projects. This means that we often face restrictions in terms of variable construction, measurement and consistency, for instance. Due to such restrictions, the study at hand uses data from 1998/2000 and 2010/2012, as those are the only two collection waves that contain information on both formal and informal IP protection. An implication of all this is of course that additional insights on this topic would greatly benefit from primary data collection efforts.

Besides, a common issue in studies concerned with strategic decision making is caused by endogeneity (Hamilton & Nickerson, 2003). In the chapter at hand, endogeneity might stem from the fact that the reliance on IP mechanisms may increase a firm's propensity to coopete, but at the same time, coopeting firms might have a higher need for appropriation mechanisms because they aim to capture the value created in the collaboration. In this chapter, we therefore refer to associations between the IP mechanisms and coopetition, rather than imposing causality. However, we suggest future research to study this in more depth.

In addition to the limitations related to the methods employed in this chapter, we would also like to reflect on the generalizability. Since the data used in the analyses is collected from Dutch firms, it is important to contextualize our arguments with regards to laws and regulations for IP mechanisms in the Netherlands. European countries such as the Netherlands have strong patent and trade secret laws in place, which aim to regulate the legal protection of

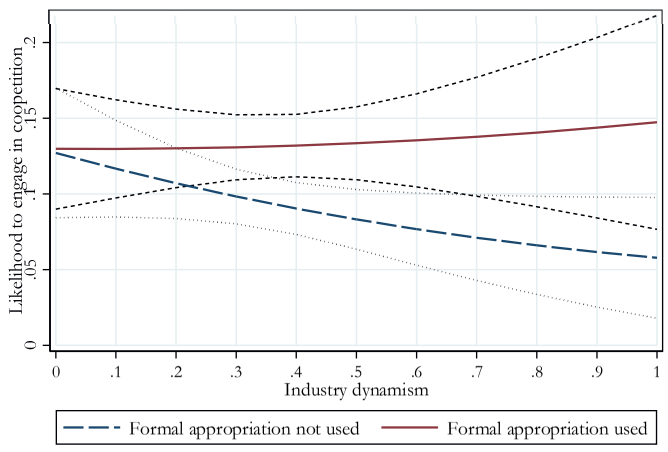
codified and tacit IP, respectively (see e.g. Crass et al., 2019; Lippoldt & Schultz, 2014). While we aim to touch upon this by means of our supplementary analysis, the generalizability of this chapter to contexts characterized by different IP regimes remains limited.

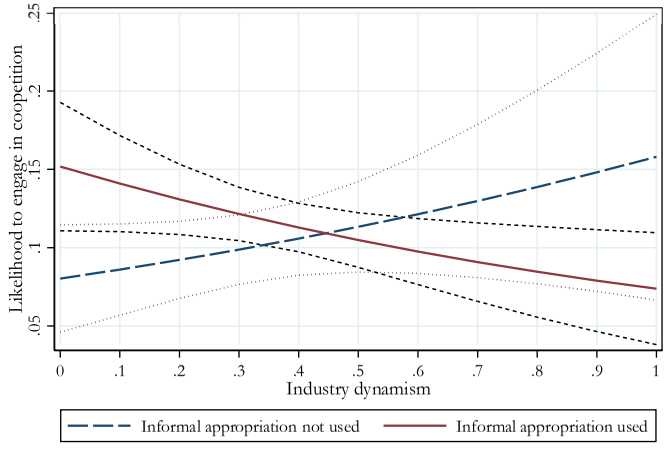
Therefore, we suggest that there are still various research avenues to be explored. Schmiele and Sofka (2007) indicate that there are differences in choice of protection mechanisms. Following up on this, we have already provided an initial idea of inter-country differences. However, we think this could be extended. Therefore, future research could for instance investigate the role of other moderating factors, such as geographic aspects, in more detail. In addition to that, besides investigating additional boundary conditions, next studies could also focus on data from different countries. Since the CIS is collected within all OECD member states, a cross-country comparison would be feasible. This would be interesting as it takes into account the structures and regulations of a firm's home market.

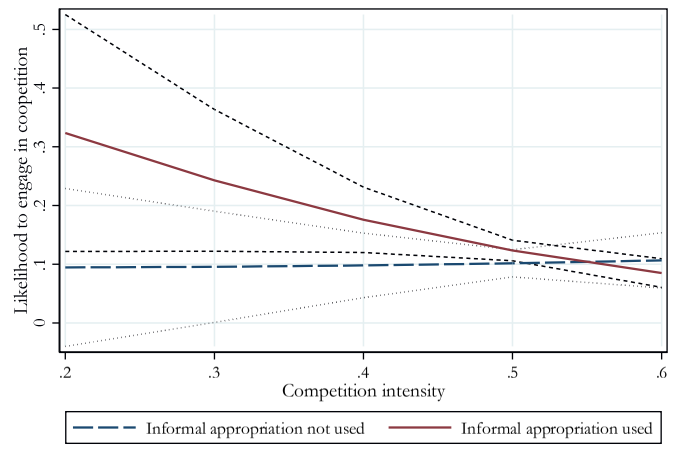
2.6 Conclusion

In this chapter, we aim to shed more light on the relation between firms' reliance on formal and informal appropriation mechanisms and their propensity to engage in coopetition. In doing so, we manage to advance the open innovation literature, as well as research in the fields of IP and coopetition. Our findings show that firms relying on formal and informal mechanisms have a different propensity to engage in coopetition, depending on the dynamism and competitive intensity of their operating market. We reason that the appropriation mechanisms can be seen as proxies for a firm's innovativeness and consequently for its need to collaborate with rivals to keep up with fast changing markets and competitive pressures. With this study, we follow calls from prior research to investigate the relationship between IP usage and choice of collaboration partner. Moreover, we provide insights into the specific relation between IP appropriation strategies and competitor collaboration, which has – to the best of our knowledge – not widely been investigated in previous coopetition literature. Nevertheless, we suggest various avenues to be considered by future research such that the role of IP mechanisms in coopetition can be understood in more detail.

Figure A2.1: Marginal effects of (not) using IP appropriation at different levels of industry dynamism and competition intensity







Notes: Short-dashed line illustrates the 95%-confidence interval of formal/informal appropriation use, and dotted line that of non-use. Where confidence intervals overlap for a large part, the differences between using and not using formal/informal appropriation are insignificant. The contrasts plotted in Figure 2.1 illustrate the difference between the solid and the long-dashed lines, i.e., solid line minus long-dashed line.

Table A2.1: Main results of coopetition in countries with weak IP regimes

			Weak IP regime		
Dependent variable	*Formal IP*	*Informal IP*	*Coopetition*	*Coopetition*	*Coopetition*
	I	**II**	**III**	**IV**	**V**
Formal IP_t			0.508*	0.085	-0.267
			(0.215)	(0.443)	(1.806)
Informal IP_t			0.063	0.340	1.969
			(0.219)	(0.476)	(2.101)
Industry $dynamism_t$	0.043	0.023	0.818†	0.557	0.808†
	(0.160)	(0.165)	(0.472)	(1.105)	(0.459)
Formal IP_t*Industry $dynamism_t$				0.929	
				(0.792)	
Informal IP_t*Industry $dynamism_t$				-0.595	
				(0.842)	
Competition $intensity_{2012}$	0.216	0.662	-0.628	-0.674	1.150
	(0.755)	(0.703)	(1.893)	(1.897)	(4.206)
Formal IP_t*Competition $intensity_{2012}$					1.470
					(3.280)
Informal IP_t*Competition $intensity_{2012}$					-3.551
					(3.790)
Industry formal IP $standards_t$	2.560***				
	(0.177)				
Industry informal IP $standards_t$		2.311***			
		(0.233)			
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Intercept	-1.967***	-	-3.200**	-3.055**	-4.154†
	(0.387)	1.806***	(1.024)	(1.067)	(2.258)
		(0.368)			
Log likelihood			*-2,912.9*	*-2,912.3*	*-2,912.6*

Note: N = 2,337 with coopetition = 1 for N_{weak} = 27 and N_{strong} = 251; Robust standard errors in parentheses; † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001; The estimates of equations I and I are the same for all systems. The estimates of the different versions of equation III are displayed in Columns III, IV and V, where the dependent variable is coopetition in weak IP regimes, and in Columns VI, VII and VIII, where the dependent variable is coopetition in strong IP regimes; Controls are the same as in original analyses.

Table A2.2: Main results of coopetition in countries with strong IP regimes

			Strong IP regime		
Dependent variable	*Formal IP*	*Informal IP*	*Coopetition*	*Coopetition*	*Coopetition*
	I	**II**	**III**	**IV**	**V**
Formal IP_t			0.176*	0.045	-0.471
			(0.080)	(0.144)	(0.759)
Informal IP_t			0.096	0.390**	1.515†
			(0.085)	(0.146)	(0.807)
Industry $dynamism_t$	0.043	0.023	-0.289	0.133	-0.278
	(0.160)	(0.165)	(0.209)	(0.338)	(0.209)
Formal IP_t*Industry $dynamism_t$				0.398	
				(0.329)	
Informal IP_t*Industry $dynamism_t$				-0.902**	
				(0.345)	
Competition $intensity_{2012}$	0.216	0.662	-1.640†	-1.641†	-0.373
	(0.755)	(0.703)	(0.856)	(0.858)	(1.444)
Formal IP_t*Competition $intensity_{2012}$					1.274
					(1.463)
Informal IP_t*Competition $intensity_{2012}$					-2.801†
					(1.571)
Industry formal IP $standards_t$	2.560***				
	(0.177)				
Industry informal IP $standards_t$		2.311***			
		(0.233)			
Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Intercept	-1.967***	-	-1.136*	-1.268***	-1.776*
	(0.387)	1.806***	(0.457)	(0.470)	(0.756)
		(0.368)			
Log likelihood			*-3,521.7*	*-3,518.7*	*-3,520.0*

Note: N = 2,337 with coopetition = 1 for N_{weak} = 27 and N_{strong} = 251; Robust standard errors in parentheses; † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001; The estimates of equations I and I are the same for all systems. The estimates of the different versions of equation III are displayed in Columns III, IV and V, where the dependent variable is coopetition in weak IP regimes, and in Columns VI, VII and VIII, where the dependent variable is coopetition in strong IP regimes; Controls are the same as in original analyses.

Chapter 3

Coopetition, knowledge spillovers and firm innovation: The role of informal IP protection[31]

What is the effect of coopetition – simultaneous collaboration and competition – on knowledge spillovers and firms' innovation performance, and what role does informal protection of intellectual property play? On the one hand, by engaging in coopetition, partners can achieve common benefits such as distributing the risks and costs of research and development, and, importantly, share knowledge. On the other hand, coopetition has been portrayed as inherently risky, because coopetitors have a high probability to encounter opportunistic behavior if one of the partners strives for its own benefits. Addressing calls in the coopetition literature to investigate these tensions more closely, this chapter draws on the knowledge-based view and transaction cost economics and studies how engaging in coopetition affects knowledge flows, as well as product innovation performance, and the role of informal appropriation mechanisms (secrecy, complexity, and lead-time) within these relationships. Using the 2000, 2004 and 2012 waves of the Mannheim Innovation Panel, we find that engaging in coopetition enhances incoming knowledge flows, and positively impacts firm innovation. However, the use of informal appropriation mechanisms negatively moderates these relationships. Moreover, we are able to disentangle knowledge spillovers as one of the main underlying mechanisms inherent to coopetition for innovation by showing that it plays a mediating role.

[31] This chapter is based on joint work with Paul Hünermund and Boris Lokshin. We thank (seminar) participants at Maastricht University, at the 2020 virtual EURAM Conference and at the 2020 virtual Academy of Management Conference for their input.

3.1 Introduction

In an environment characterized by increased competition and shorter innovation cycles, firms face the challenge to gain and sustain their competitive advantage. Engaging in collaborative forms of innovation is one response in the face of such challenges (Chesbrough, 2003; Drechsler & Natter, 2012; Laursen & Salter, 2014). This approach allows firms to gain access to partners' resources and specific market knowledge, as well as share risks and costs of new product and process development. In this context, especially the concept of coopetition – collaboration between competitors – has received increasing scholarly attention (Fernandez, Chiambaretto, et al., 2018; Gnyawali & Park, 2009; Pellegrin-Boucher et al., 2013).

Research findings concerning the effect of coopetition on firm innovation performance are mixed (Ritala & Hurmelinna-Laukkanen, 2013). The reason for this ambiguity is rooted in the very nature of coopetition. While it enables competing firms to create value together, it poses the challenge of appropriation of (jointly) created value. An obvious risk associated with coopetition is that within this type of partnership, participants have a high chance of encountering opportunistic behavior. Opportunistic behavior (or opportunism) describes a partner's "*self-interest seeking with guile*", meaning that said partner is likely to "*mislead, disguise, obfuscate, and confuse*" to enhance their own performance and position (Williamson, 1985, p. 181). In particular, opportunism can diminish trust (Williamson, 1993), which can be defined as "*positive expectations about another's motives with respect to oneself in situations entailing risk*" (Das & Teng, 1998, p. 494). In the case at hand, this means that a focal firm expects its coopetition partner to not act opportunistically. The high risk of opportunism, however, hampers the willingness to share resources such as knowledge, because knowledge can spill over unintentionally and be exploited by the opportunistic partner (Nieto & Santamaría, 2007; Raza-Ullah & Kostis, 2020).

Opportunistic behavior may be especially detrimental for coopetitors because partners make themselves vulnerable by committing strategically important resources when collaborating with their rival (see e.g. Le Roy et al., 2018). The threat of opportunism poses a challenge to protecting innovative efforts while simultaneously attempting to capture the benefits that result from coopetition and joint innovative efforts (Dahlander & Gann, 2010; Helfat & Quinn, 2011; Huizingh, 2011). Hence, it seems especially critical for firms that

engage in coopetition to secure their intellectual property (IP) by drawing on formal and informal appropriation mechanisms (Hurmelinna-Laukkanen & Puumalainen, 2007; Zobel et al., 2017).

Firms can manage these risks and control the outflow of information and knowledge to a certain degree with the help of formal appropriation mechanisms such as patents, trademarks, copyrights, and design rights or informal mechanisms such as secrecy, complexity, and lead-time (Hall et al., 2014; Holgersson, 2018). Generally, Hall et al. (2014) point out that firms employ more informal than formal instruments to protect their intellectual property. While formal mechanisms allow for the legal protection of IP, they are often costly and time-consuming to acquire and require a certain level of information disclosure. In order to prevent knowledge from spilling over, firms often opt to rely on informal mechanisms instead (Hall et al., 2013, 2014; Holgersson, 2013). This is especially relevant in the context of coopetition, where partners are simultaneously rivals, who have an incentive of exploiting each other's resources to enhance their own competitive position. By using secrecy for instance, firms actively hold back information (Hall et al., 2014).

While relying on informal mechanisms can thus provide protection for a firm's IP, holding back knowledge may also signal a lack of trust towards the partner. Prior research has identified trust as *"key to successful […] alliances*" (Das & Teng, 1998; Parkhe, 1998, p. 417) because trust allows both partners to share resources without needing to fear any exploitative, self-interest seeking behavior. Trust has been argued to be important for knowledge sharing in the context of coopetition (Raza-Ullah & Kostis, 2020; Lascaux, 2020). Conversely, signaling distrust and refraining from committing resources to the relationship, will likely trigger the tit-for-tat response of the coopetition partner, reciprocating in the like actions (Nielsen & Nielsen, 2009). This in turn will diminish the benefits to be achieved through the creation of novel resource combinations.

While the exchange of resources such as knowledge has been identified as one of the main motives for coopetition (Bengtsson & Kock, 2014; Garette et al., 2009; Ritala, 2012; Ritala & Hurmelinna-Laukkanen, 2009), there is a fine line between knowledge sharing and protecting. This results in knowledge spillovers in coopetition being described as a double-edged sword, presenting firms with the dilemma of protecting and sharing knowledge at the same time (Estrada,

2018; Fernandez & Chiambaretto, 2018).[32] While the use of informal IP protection appears beneficial with regards to a focal firm's risk management, it prevents knowledge from spilling over and thus being shared, which can ultimately harm performance.

To the best of our knowledge, however, the role of informal appropriation has not been investigated in the context of coopetition. This is surprising, as appropriation mechanisms enable firms to gain a competitive advantage through their innovation activities (Milesi et al., 2013). Therefore, such mechanisms are prone to be affected by the firm's choice of tools that accompany its innovation process (Zobel et al., 2017). To address this gap, and to improve the understanding of the outlined tensions inherent to coopetition for innovation, we address the following research question: *how does the use of informal IP protection mechanisms affect the relationship between engaging in coopetition and knowledge spillovers, as well as a firm's innovation performance?* [33]

We contribute to the coopetition literature in three ways. First, we establish knowledge spillovers as a mechanism linking coopetition and firms' innovation performance. In doing so, we reconcile some of the mixed findings regarding the relationship between coopetition and innovation in prior studies. Second, we identify a boundary condition to this effect. We show that while coopetition in general is positively related to innovation performance, when firms rely on informal IP mechanisms such as secrecy, lead time and complexity, this relationship becomes insignificant or even negative. We theorize that the use of informal IP mechanisms signals distrust towards the coopetition partner and limits the knowledge spillovers by the very nature of this kind of protection mechanism. Third, we perform a mediation analysis following more modern methods (e.g. Imai, Keele, & Tingley, 2010; Imai, Keele, & Yamamoto, 2010)

[32] This paradox between joint value creation through knowledge spillovers and individual value appropriation is also illustrated in the seminal work by Bloom et al. (2013), who find that the positive effect of knowledge spillovers on firm performance is much larger than the negative effect of individual appropriation of the knowledge. This illustrates the relevance and potential benefits of knowledge sharing in coopetitive relationships.

[33] Chapter 1 defines firm innovation as "*the introduction of a good or service that is new or significantly improved*" (Eurostat, 2005, p. 48). We acknowledge that IP may also play an important role for process innovators. In the remainder of this chapter, we also refer to innovation performance as "product innovation" or "innovation".

that allow taking non-linearity into account and provide a more robust inference on the causal mechanisms in non-linear models.

The remainder of this chapter is structured as follows: Section 3.2 positions the concept of coopetition and provides theoretical background and derivation of the hypotheses. Section 3.3 explains the methods and Section 3.4 presents the findings, while Section 3.5 discusses contributions to the existing literature. Section 3.6 provides the conclusions.

3.2 Theoretical background and hypotheses

Firms engage in collaboration with others in order to be able to accelerate their innovation processes and research and development (R&D) activities, such that they can keep up with competitive pressures (Chesbrough, 2003). In fact, alliances often are seen as a way to gain access to a broader set of resources and different competences (Eisenhardt & Schoonhoven, 1996; Hennart, 1991; Lavie, 2006; Mitsuhashi & Greve, 2009). This allows firms to create novel resource combinations using their own, internal knowledge and resources mixed with their partners' (Harrison et al., 2001). Moreover, resources acquired by firms through alliances allow them to share costs or to gain access to novel products and innovation processes (Eisenhardt & Schoonhoven, 1996). This notion of collaboration for resource access and exchange is captured under the resource-based view (RBV) (Barney, 1986). Barney (1991) points out that each firm consists of a unique set of resources and skills, which are difficult to imitate. Yet, this also means that each firm's internal resource base is limited. By collaborating with each other, firms gain access to their partner's unique set of resources, which allows them to enhance their own innovation processes (Chesbrough, 2003; Vanhaverbeke & Cloodt, 2014). In order for collaboration to be successful, partners thus need to commit strategically important resources to the partnership (Lunnan & Haugland, 2008).

Grant (1996) argues that a firm's strategically most important resource is in fact knowledge and implements an extension of the RBV which is centered around knowledge as a resource: the knowledge-based view (KBV). The KBV describes the importance of knowledge sharing in collaborative relationships. As underlined by Vanhaverbeke and Cloodt (2014), the KBV provides an interesting theoretical lens for open innovation, where firms collaborate to gather the necessary knowledge to develop new products. Seminal work by

Kogut and Zander (1992) emphasizes that firms grow and improve performance by recombining their own knowledge and know-how with that of other firms. In line with this notion, Kale and Singh (2007) highlight the relevance of learning in alliances, as well as internalizing and leveraging knowledge for alliance- and firm-success. Thus, as firms' own knowledge bases are often limited, they engage in collaboration in order to gain access to a broader set of knowledge and to get an insight into their partners' competencies (Belderbos, Carree, Diederen, et al., 2004; Chiambaretto & Fernandez, 2018; Lavie, 2006; Miotti & Sachwald, 2003; Tether, 2002). Accordingly, engaging in collaboration is seen as a means for firms to extend their knowledge base to be able to gain and sustain a competitive advantage (Choi, 2020; Gnyawali & Park, 2009; Indradewa et al., 2015; Kale & Singh, 2007; Kogut & Zander, 1992).

Over the past 20 years, firms have increasingly adopted a coopetition strategy for innovation (Fernandez, Chiambaretto, et al., 2018; Ritala & Hurmelinna-Laukkanen, 2009). Coopetition has been described as a paradox of combining value created through collaboration on the one hand, and appropriating this value as competitors on the other hand (Gnyawali & Ryan Charleton, 2017; Ryan Charleton et al., 2018). One explanation for the mixed findings regarding the effects of coopetition on firm (innovation) performance lies in the tensions between value creation and value appropriation, which are fundamental to the concept of coopetition. Those tensions arise from the fact that in coopetition, competing firms need to pool and share resources in order to jointly create value (Gnyawali & Park, 2009; Mitchell et al., 2002). In line with the KBV, in order to collaborate successfully, firms commit knowledge – their strategically most important resource – to the coopetitive relationship (Bengtsson & Raza-Ullah, 2016; Lascaux, 2020). Consequently, knowledge sharing is one of the main mechanisms by which collaborations with rivals exert an effect on performance. However, firms face the risk of their committed resources being exploited by their collaboration partner, as they are simultaneously competitors (Cygler et al., 2018; Gnyawali & Ryan Charleton, 2017; Ryan Charleton et al., 2018).

3.2.1 Coopetition and knowledge spillovers

While alliances in general allow firms to gain access to their partners' resources and knowledge, coopetition research emphasizes the particular role of

knowledge and knowledge sharing in collaboration between rivals (see e.g. Bacon et al., 2020; Estrada et al., 2016; Fernandez & Chiambaretto, 2016; Gast et al., 2019). Among others, Bengtsson and Kock (2014), as well as Lascaux (2020) underline the need for committing strategically important resources such as knowledge to the coopetitive relationship. Raza-Ullah and Kostis (2020), as well as Ritala and Hurmelinna-Laukkanen (2013) point out that knowledge from competitors is highly relevant for firms because they have specific information about products and markets, and face similar challenges, as they operate in the same industry. By joining forces, coopetitors are able to learn from each other such that they can handle difficulties that are directly related to the operating environment (Ritala & Hurmelinna-Laukkanen, 2009). In addition to that, Bouncken and Fredrich (2016) highlight that in fact these "*resource and market similarities provide valuable learning opportunities and complements to the simplified compatibility, feasibility, and understanding of knowledge and thus the transfer among coopetitors*" (p. 1753). Therefore, as competing firms work on similar projects, they are also able to absorb and interpret each other's knowledge and competencies more easily within a partnership (Gast et al., 2019; Ritala & Hurmelinna-Laukkanen, 2009). This facilitates the pooling of complementary resources that are necessary for successful product innovation (Estrada et al., 2016; Tether, 2002). In particular, the resemblance of competitors' knowledge bases makes it easier to exchange and combine both codified as well as tacit knowledge, which is especially relevant for product innovation (Chiambaretto & Fernandez, 2018; Estrada et al., 2016).

We therefore expect that firms engage in coopetition to create value together. This is achieved by pooling and sharing complementary resources, where knowledge is one of the key resources committed to the relationship. Competitors are attractive collaboration partners, because they possess similar product- and industry-specific skills and expertise. This similarity also facilitates capturing value of and integrating rivals' knowledge (Estrada, 2018; Estrada et al., 2016). As firms view coopetition as a learning opportunity and recognize the relevance of coopeting for their own innovation performance (Bouncken & Fredrich, 2016), we expect that they are likely to render the incoming knowledge spillovers from their rivals as highly valuable. Based on this line of reasoning, we formulate the following hypothesis:

H1: Engaging in coopetition is positively related to incoming knowledge spillovers from competitors.

3.2.2 Relational and appropriation risks in coopetition

Nevertheless, knowledge sharing in coopetition has often been described as a double-edged sword: on the one hand, it is necessary for successful collaboration, while on the other hand firms risk unintended spillovers of core knowledge (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2018). While the KBV underlines the benefits of engaging in collaboration with competitors, the perspective of the transaction cost economics (TCE) provides a theoretical foundation for the risks inherent to coopetition (Estrada et al., 2016; Oxley, 1997; Park & Russo, 1996; Ryan Charleton et al., 2018; Teece, 1986; Williamson, 1979, 1981). Specifically, we focus on two types of risks: relational and appropriation risks. Relational risks denote the "*hazard of unsatisfactory cooperation in the context of strategic alliances*" (Das & Teng, 2001, pp. 450–451), which refers to the chance that a partner behaves opportunistically and the resulting negative consequences for the collaboration (Liu et al., 2008; Nooteboom et al., 1997). This is in line with the notion of the TCE, which underlines that indeed some firms "*pursue their own interests at the expense of others*" (Das & Teng, 2001, p. 452; Williamson, 1979, 1985). Coopetition scholars particularly emphasize the occurrence of opportunistic partner behavior when rivals collaborate for innovation (Estrada et al., 2016; Fernandez, Le Roy, et al., 2018; Ritala & Hurmelinna-Laukkanen, 2013; Tidström, 2014). Therefore, relational risk – and thus opportunism – is especially common in coopetitive relationships because partners remain rivals who compete for market share and competitive advantage (Fernandez & Chiambaretto, 2016).

Especially knowledge is subject to opportunism and exploitation within coopetition (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2018). Appropriation risks describe the particular hazards related to the unintentional transfer of knowledge within strategic alliances (Oxley, 1997). Often, so-called learning races take place in alliances, where the faster learner exploits its partner's knowledge and exits the alliance once it has achieved its own goals, disregarding its partner's interests (Dagnino & Padula, 2002). Accordingly, the knowledge provided to the collaboration is likely to be exploited by one of the partners such that they can enhance their own

competitive position and outperform the other partner (Fernandez & Chiambaretto, 2018; Hamel, 1991). The appropriability hazard is specifically high in coopetitive alliances because partners will use appropriated knowledge in order to develop competing products (Fernandez & Chiambaretto, 2018). Furthermore, exploitation of IP is particularly prevalent in coopetition because the transfer of knowledge and its integration are relatively straightforward, since competitors have a similar background (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2016). Moreover, unintended information spillovers are especially likely to occur in coopetitive relationships, where intentional knowledge sharing takes place at the same time (Estrada et al., 2016). Yet, unintentional spillovers have the potential to greatly harm innovation capabilities of both parties involved in the coopetition (Lhuillery & Pfister, 2009; Nieto & Santamaría, 2007).

3.2.2.1 The role of informal IP protection mechanisms

The notions of relational as well as appropriation risks as part of the TCE underline that partner opportunism can lead to major hurdles for successful collaboration (Cygler et al., 2018; Estrada, 2018; Estrada et al., 2016; Gnyawali & Ryan Charleton, 2018; Zaheer et al., 1998). Firms can only create a sustainable competitive advantage if they prevent any unintended usage of their knowledge by external parties. In order to deal with the risks of opportunism and exploitation in coopetition, firms can make use of IP protection mechanisms (Estrada et al., 2016; Holgersson, 2018).[34] Research concerned with appropriation mechanisms underlines that, generally, firms use more informal than formal mechanisms, as those mechanisms are often easier to implement, since they require fewer financial resources and time to use (Hall et al., 2014; Neuhäusler, 2012). Moreover, existing literature also emphasizes that informal mechanisms are especially suited to protect tacit knowledge (Arora, 1997; Hall

[34] As outlined earlier, there are two types of IP protection mechanisms: formal and informal. Formal mechanisms (patents, copyrights, trademarks, design rights) are legal instruments to control knowledge outflow to external parties (Estrada et al., 2016; Hall et al., 2014), while informal mechanisms (secrecy, complexity, lead-time) guard knowledge by making it difficult to imitate and by diminishing information spillovers altogether (Hall et al., 2014).

et al., 2014).[35] In fact, if firms make use of secrecy or have extremely complex processes, it becomes difficult for the partner to "observe" the tacit knowledge.

Hence, firms rely on informal IP mechanisms to avoid unintended leakage of explicit, but especially of tacit knowledge, which is highly relevant for innovation (Estrada et al., 2016). Nevertheless, the use of informal mechanisms might essentially prevent any knowledge from spilling over to the partner (Hall et al., 2014). In their very nature, secrets for instance keep knowledge from being shared. Nielsen and Nielsen (2009) point out that if one firm in a partnership does not share knowledge, it signals that the firm might be unwilling to commit resources to the alliance. This may lead to the partner also displaying less willingness to share anything (Nielsen & Nielsen, 2009). In line with this notion, Bengtsson and Raza-Ullah (2016) point out that indeed both trust and reciprocal knowledge exchange are essential aspects with regards to competitors' willingness to engage in collaboration. Here, trust is the focal firm's expectation that its collaboration partner will not behave opportunistically (Gulati, 1995; Zaheer et al., 1998). Accordingly, trust "*encourages firms to commit strategically important resources in joint activities*" (Raza-Ullah & Kostis, 2020, p. 370), which based on the KBV is knowledge (Grant, 1996). Hence, interfirm trust facilitates knowledge sharing between a focal firm and its collaboration partners (Das & Teng, 2002; Lavie, 2007; Zaheer et al., 1998). This follows from the fact that where trust is in place, firms do not necessarily need other control or protection mechanisms (Gulati, 1995). Nevertheless, Williamson (1993) emphasizes that trust is undermined by opportunistic behavior, which is especially prevalent in coopetitive relationships (Fernandez & Chiambaretto, 2018; Tidström, 2014, 2018). A lack of trust, in turn, can substantially hamper alliance success, as firms avoid resource and knowledge sharing (Das & Teng, 1998; Nieto & Santamaría, 2007; Parkhe, 1998; Raza-Ullah & Kostis, 2020). Raza-Ullah and Kostis (2020) point out that, firms need to be aware of the risks by keeping a certain level of distrust. Such distrust will make companies impose specific safety measures in order to diminish the risk of exploitation, which might, however, reduce

[35] Grant (1996) underlines the importance of distinguishing between tacit and explicit knowledge, i.e., between "knowing how" and "knowing about". While explicit knowledge is revealed by its communication, tacit knowledge can only be observed but not directly passed on (Grant, 1996).

efficiency of knowledge exchange (Raza-Ullah & Kostis, 2020; Zaheer et al., 1998).

Following the above line of reasoning, we conclude that the use of informal IP protection as safeguard against the relational and appropriation risks negatively affects knowledge spillovers within the coopetitive relationship. Specifically, we expect that firms using such mechanisms signal a lack of trust, which harms the knowledge flows. Moreover, the very nature of informal protection mechanisms prevents information from spilling over to the partner, which in turn also reduces the partner's willingness to commit knowledge to the collaboration. Based on this, we formulate the following hypothesis:

H2: The relationship between coopetition and incoming knowledge spillovers is negatively moderated by the focal firm's reliance on informal appropriation mechanisms.

3.2.3 Coopetition and product innovation

As we established earlier, knowledge can be seen as a firm's most important strategic resource (Grant, 1996). This renders knowledge sharing (in the form of spillovers) one of the essential driving factors behind successful coopetition for innovation (Estrada et al., 2016; Ilvonen & Vuori, 2013). In particular, prior research emphasizes that access to a broader set of knowledge enables firms to enhance their innovation performance (Laursen & Salter, 2006), because the own knowledge can be recombined with external knowledge (Kogut & Zander, 1992). Furthermore, Ritala et al. (2015) point out that knowledge sharing is beneficial for firms' innovation performance, as it also allows firms to improve their knowledge acquisition capabilities. The better firms are able to acquire and integrate knowledge from external sources, the more they can develop their innovation competencies (Laursen & Salter, 2006; Ritala et al., 2015; Zhou & Li, 2012). This supports the conclusions of Kamaşak and Bulutlar (2010), who find that the collection of knowledge is indeed beneficial for a firm's innovation performance. Especially knowledge sourced from competitors is highly relevant for enhancing a firm's innovation performance, as it is usually product- and industry-specific (Bengtsson & Kock, 2014; Raza-Ullah & Kostis, 2020; Ritala, 2012). Consequently, it can be integrated and applied relatively easily and immediately (Estrada et al., 2016).

Yet, in accordance with the RBV, it is important to also consider other factors – besides knowledge – that might play a role in the value creation in

coopetition. In particular, sharing costs and risks could lead to less uncertainties for the involved parties, potentially freeing some managerial capacity to focus on innovation (Gnyawali & Park, 2009; Hora et al., 2018; Ritala, 2012). Moreover, enhancing R&D processes by aligning them with their partners can also improve innovation performance (Gnyawali & Park, 2009; Mitchell et al., 2002). Here, for instance R&D employees and managers might also be shared and relocated (Basterretxea et al., 2019). In addition to that, small firms can gain access to larger groups of customers by collaborating with bigger rivaling firms, for example (Chiambaretto, Bengtsson, et al., 2020; Hora et al., 2018). Furthermore, Chiambaretto et al. (2020) emphasize that specifically large firms make use of coopetition to reduce both their costs and time-to-market. Therefore, while the KBV assigns a major role to knowledge sharing, it is important to acknowledge potential other underlying mechanisms that allow firms to coopete successfully such that they can enhance their innovation performance.

Therefore, firms are often willing to collaborate with rivals because of the anticipated benefits such as cost-sharing and faster time-to-market, despite the high risks inherent to coopeting (Bouncken & Kraus, 2013). Accordingly, the expectation that the joint value creation in the collaboration ultimately results in higher technological diversity and thus increased innovation performance provides an incentive to engage in coopetition. This is especially the case if firms are able to appropriate most of the value created in the collaboration for themselves (Gnyawali & Ryan Charleton, 2017). Following this logic, we expect coopetition to be positive for a firm's product innovation performance, and formulate the following hypothesis:

H3: Engaging in coopetition is positively related to a firm's product innovation performance.

As argued before, while we expect that knowledge spillovers within the coopetition relationship portray the main mechanism for the positive effect of coopetition on innovation performance, we acknowledge that additional channels also play a role. Hence, we expect the following:

H4: The relationship in H3 is partly mediated by the incoming knowledge spillovers.

3.3 Data, methods and variables

We test our hypotheses on a sample of firms drawn from the Mannheim Innovation Panel (MIP), which is the German contribution to the Community Innovation Survey (CIS). The CIS is a harmonized survey of firms' innovation activities, collected biannually[36] in member states of the European Union. The MIP is administered by the Center for European Economic Research (ZEW; Leibniz-Zentrum für Europäische Wirtschaftsforschung), the Fraunhofer-Institute for System and Innovation Research (ISI) and the Institute for Applied Social Sciences (infas) and consists of German firms from a wide set of industries.[37] A full overview of the included industries is provided in Table 3.1. Columns II and III tabulate the overall frequencies of firms in the respective industries, while Columns IV and V indicate the number of coopetitors compared to non-coopetitors in each industry. Furthermore, Columns VI and VII display the number of firms per industry that rely on informal mechanisms compared to those that do not. Here, we can see that in the pharmaceuticals, electronics or automotive industries, the propensity for informal IP mechanisms is high. Generally, the firms in our dataset differ in size, with an average firm size of about 526 employees. The variety of firms in the sample enhances the generalizability of results. This underscores advantages of using the MIP, as opposed to performing a primary data collection.

The data are specifically suited for the research at hand because the MIP contains variables on firms' collaboration activities and innovation performance, as well as reliance on informal IP mechanisms. Our sample consists of MIP waves 2000, 2004, and 2012 because the information about informal IP protection is only available in these years.[38]

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[36] While the MIP as such is collected annually, the survey that is in line with the harmonized CIS questionnaire standards is collected biannually (Peters & Rammer, 2013). This is the version we are focusing on in this study.

[37] The MIP covers all manufacturing industries, as well as service industries in which a large amount of innovation activity is anticipated to occur (Bammens & Hünermund, 2020; Peters & Rammer, 2013)-

[38] As the selected waves cover a relatively long timeframe of up to 12 years, we additionally test for "poolability" of the data, i.e., whether patterns in coopetition behavior remain similar. We do so by testing whether the coefficients in the model differ significantly throughout the years 2000, 2004 and 2012. Using a Wald-test, we find that there indeed is a significant difference ($p < 0.001$), indicating that the patterns in the data change between the years. When running the

Table 3.1: Coopetition engagement and use of informal IP protection per industry

Industry	NACE (Rev. 2.0)	Obs.	%	Coopetition		Informal IP	
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**
				Yes	*%*	*Yes*	*%*
Food/beverages/tobacco	10, 11, 12	313	2.80	2	0.64	115	36.74
Textiles/clothing	13, 14, 15	370	3.31	8	2.16	133	35.95
Wood/paper	16, 17	276	2.47	8	2.90	117	42.39
Chemicals/pharmaceuticals	20, 21	348	3.11	23	6.61	235	67.53
Rubber/plastics	22	252	2.25	5	1.98	122	48.41
Glass/ceramics/concrete	23	166	1.48	7	4.22	89	53.62
Metals	24, 25	711	6.35	32	4.50	352	49.51
Electronics/electrical	26, 27	628	5.61	51	8.12	447	71.18
Machinery/equipment	28, 33	852	7.62	52	6.10	507	59.51
Vehicles	29, 30	454	4.06	35	7.71	306	67.40
Furniture/other manufacturing	31, 32	377	3.37	28	7.43	203	53.85
Energy/mining/oil	5, 6, 7, 8, 9, 19, 35	317	2.83	14	4.42	100	31.55
Water supply/waste/recycling	36, 37, 38, 39	466	4.17	7	1.50	120	25.75
Wholesale trade	46	231	2.07	4	1.73	74	32.04
Transportation/postal services	49, 50, 51, 52, 53, 79	996	8.90	26	2.61	235	23.59
Printing/publishing/media	18, 58, 59, 60	465	4.16	10	2.15	162	34.84
IT-services/telecommunications	61, 62, 63	574	5.13	35	6.10	304	52.96
Financial intermediation	64, 65, 66	440	3.93	16	3.64	146	33.18
Consulting/advertising	69, 70, 73	598	5.35	45	7.53	259	43.31
Technical engineering	71, 72	755	6.75	64	8.48	435	57.62
Other producer services	74, 78, 80, 81, 82	997	8.91	36	3.61	328	32.90
Other	1, 34, 40, 41, 42, 43, 45, 47, 55, 67, 68, 77, 86, 90, 92, 93, 94, 95, 96	603	5.39	25	4.15	146	24.21

Note: *N* = 11,189; NACE stands for "Nomenclature statistique des activités économiques dans la Communauté Européenne".

analyses separately on the data of the respective years, we qualitatively find the same results. Therefore, to avoid loss of information, we nevertheless combine the data from 2000, 2004 and 2012 in one sample.

The final sample has 13,248 observations from 11,189 firms, that indicate a share of turnover accounted for by product innovation. Out of those, 1,575 (14%) are included in two survey waves and 242 (2%) in all three; 9,372 firms (84%) are present in only one of the three waves.

3.3.1 Variables

Dependent variables. We measure *incoming knowledge flows* as the importance that firms assign to knowledge sourced from competitors. Survey respondents rate how important competitors are as an information source for innovation on a four-point Likert scale: 1 (low importance), 2 (medium importance) and 3 (high importance); 0 means the firm did not source external knowledge from competitors. Second, firm *product innovation performance* is the share (coded in the range 0 to 1) of sales due to new or significantly improved products in the total turnover.

Independent variables. *Coopetition* is binary, taking value (1) if a firm indicates in the survey in year t that it collaborates with competitors, and (0) if not.[39] Informal mechanisms are secrecy, complexity, and lead-time. The survey asks firms to indicate which mechanism(s) they used to protect their IP and to rank each mechanism's importance on a four-point Likert scale: (1) low importance, (2) medium importance, (3) high importance; (0) means the mechanism was not used. We then take an average of the importance scores for each of the three mechanisms. For ease of interpretation, we rescale the variable to range between 0 (not used/at all important) to 1 (very important).

Control variables. We control for *firm size* by including the natural logarithm of the number of employees. Benefits and risks derived from coopetition differ for small and large firms (Chiambaretto, Bengtsson, et al., 2020). We include a dummy variable to account for firms being *part of a larger company group*, because being part of a corporate group could provide access to a wider set of resources (Lhuillery & Pfister, 2009). This variable takes value (1) if

[39] The MIP requests firms to indicate whether they have collaborated with competitors and other types of partners, such as customers, and suppliers, etc. for innovation throughout the last two years. For example, the 2012-survey asks whether firms have engaged in coopetition between 2010 and 2012. Belderbos et al. (2004) point out that the effect of R&D efforts such as collaboration is often delayed with respect to innovation as an outcome. By covering a period of year t until t-2, this variable accounts for a time-lag between occurrence of the collaboration and the outcome (innovation).

the firm is in fact part of a group, and (0) if not. Another relevant aspect in research with German firms is to account for firm location within Germany, due to potential differences in economic development between East[40] and West Germany (Schmiele & Sofka, 2007). Therefore, we include a dummy (*East*) that takes value (1) if the company is situated in East Germany, and (0) otherwise.

Additionally, we control for a firm's use of formal IP protection mechanisms, because firms often mix IP protection strategies and use both patents and secrecy for instance (Hall et al., 2014). Similar to informal IP protection, we account for the importance of formal mechanisms throughout the two most recent years and the collection year. This importance is rated on the following scale: (1) low importance, (2) medium importance, (3) high importance; (0) means the mechanism was not used. We then take an average of the importance scores for each of the four mechanisms and combine them into one measure. For ease of interpretation, we rescale the variable to range between 0 (not used/at all important) to 1 (very important). According to prior research, firms often cooperate with other partner types, by forming a collaboration portfolio (Belderbos et al., 2006; Chiambaretto & Fernandez, 2016). We include a dummy variable (*Collaboration*), which takes value (1) if the focal firm collaborates for innovation with suppliers, customers or universities next to coopeting, and (0) otherwise.

Additionally, we include control variables at the industry level. *Industry dynamism* accounts for the speed at which product innovations are introduced to the market (i.e. the "*speed of technological change*" (Belderbos, Carree, Diederen, et al., 2004, p. 1248)) and can have an impact on how firms apply IP, as they often need to deal with additional risks and uncertainties in such fast-changing contexts.[41] Moreover, we account for the level of *informal IP protection within the industry* as the extent of knowledge sharing in a dyadic relationship is a function of incoming and outgoing knowledge flows. The outgoing and incoming knowledge flows may be interdependent, and partly determined by the use of

[40] East Germany consists of the following federal states: Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt, Thuringia.

[41] In Chapter 2, we suggest that firms' decisions to engage in coopetition and their use of IP protection are also affected by the competitive intensity of the industry. When including a measure for competition intensity, we lose around 4000 observations, but the findings of interest remain similar. In order to avoid such a big loss of observations, we decided not to include competition intensity as a control variable here.

informal IP protection by a focal firm's partner. While we do not have information on the partner's IP protection strategy on the firm-level, we construct an average use of informal IP by a focal firm's potential partners within a narrowly defined industry at the 3-digit NACE level.

Besides the time-variant industry variables, we include a set of *industry dummies* at the two-digit level and a set of *year dummies*. These pick up, respectively, any other industry-specific characteristics, such as the general level of innovativeness of an industry and macro-trends that affect all firms in the sample over time.

3.3.2 Empirical approach

To test Hypotheses 1 and 2, we estimate an ordered probit model, to account for the ordinal nature of the dependent variable. To test Hypothesis 3, we follow Papke and Wooldridge (1996) and estimate a fractional logit model because innovation performance is a fraction, measured as a share of new product sales in total turnover.

To disentangle how much of the total effect of coopetition on innovation is explained by knowledge spillovers, compared to other possible mechanisms such as cost and risk sharing, we perform a mediation analysis[42]. The aim of this analysis is to separate the mediation effect on the path *coopetition* → *incoming knowledge spillovers* → *product innovation performance*, from the remaining direct effect, *coopetition* → *product innovation performance*. We follow a newer stream of literature on mediation analysis that clarifies the criteria for identification of causal mechanisms in non-linear settings (Bammens & Hünermund, 2020; Imai et al., 2011; Imai, Keele, & Yamamoto, 2010).[43]

[42] We do not include incoming knowledge flows when regressing innovation performance on coopetition variable in order to reduce the risk of endogeneity, because incoming knowledge spillovers are themselves affected by coopetition. The aforementioned problem of incoming knowledge flows potentially being endogenous is tackled by means of a sensitivity analysis, which is described in a later section. The mediation approach identifies the total effect of coopetition on product innovation performance.

[43] This literature stands in contrast to the older literature on mediation analysis, which is based on (predominantly) linear structural equation models under treatment effect homogeneity (Baron & Kenny, 1986). Non-linearity is particularly relevant in our case because we have ordinal and fractional dependent variables. For estimation purposes, we use the R-package "mediation" (Tingley et al., 2014), which relies on simulation methods to compute non-linear mediation effects.

3.3.3 Descriptive statistics

Table 3.2 displays the descriptive statistics for the variables included in the analysis. The average sales due to new products is about 11%. Around 5% of sample firms coopete. The low level of engagement in coopetition is consistent with earlier reported values (Estrada et al. 2016). We see that, on average, the value of incoming knowledge spillovers from competitors is rather low (μ = 0.860). When excluding zeros, the mean rises to 1.758, meaning that firms that do have incoming knowledge flows from rivals attach low to medium importance to them. Furthermore, 11% of firms have other partner types besides rivals in their portfolio and 40% of firms are part of a company group. Generally, about 84% of firms in the sample are SMEs with less than 250 employees.

Table 3.2 also tabulates the means of the variables for coopetitors and non-coopetitors, respectively. The means of all variables except the East dummy are significantly higher for firms that engage in coopetition. Coopeting firms have significantly more incoming knowledge flows and higher product innovation performance, which is in line with the notion that firms engage in coopetition to share resources such as knowledge and improve their innovation performance. Furthermore, coopeting firms rank informal IP protection as more important than firms that do not collaborate with rivals.

Table 3.2: Descriptive statistics for coopeting and non-coopeting firms

	Full sample				**Split sample**		
Variable	Mean	SD	Min	Max	Mean (C)	Mean (NC)	Difference (p-value)
Knowledge spillovers	0.860	1.016	0	3	1.750	0.816	0.000
Product innovation performance	0.110	0.211	0	1	0.281	0.102	0.000
Coopetition	0.046	0.210	0	1	1.000	0.000	–
Importance informal IP	0.266	0.343	0	1	0.563	0.252	0.000
Ln(Firm size)	3.831	1.696	0	13.010	4.940	3.777	0.000
Importance formal IP	0.135	0.231	0	1	0.302	0.127	0.000
Collaboration	0.110	0.312	0	1	0.655	0.083	0.000
Part of group	0.391	0.488	0	1	0.559	0.383	0.000
East Germany	0.343	0.475	0	1	0.328	0.344	0.432
Industry informal IP	0.270	0.159	0	1	0.365	0.265	0.000
Industry dynamism	0.030	0.062	0	0.737	0.055	0.028	0.000

Note: N = 13,248; $N_{Coopetitors}$ = 612; $N_{Non\text{-}coopetitors}$ = 12,636; (C) = Coopetitors, (NC) = Non-coopetitors; Last column illustrates p-values for a two-sided t-test on mean differences.

Table 3.3 tabulates firms' use of IP protection mechanisms, distinguishing between coopetitors and non-coopetitors. As shown in Column I, among the 11,189 individual firms in our sample, 533 engage in coopetition, of which 459 use informal IP protection. This marks roughly 86% of coopeting firms using informal IP, while only 42% of non-coopetitors do so (Columns II & IV). Lead-time is the most frequently chosen mechanism among coopeting firms, closely followed by secrecy (Column I). In particular, 78% of coopetitors use short lead-time advantages, and 72% make use of secrets (Column II). 50% of coopeting firms use complex processes to protect their IP (Column II). Generally, firms that collaborate with rivals make more use of any type of informal IP than those that do not engage in coopetition (Columns II & IV).

Table 3.3: Frequency of informal IP protection use by coopetitors and non-coopetitors

	Coopetitors	%	Non-coopetitors	%	Total
	I	**II**	**III**	**IV**	**V**
Informal IP					
No	74	13.88	6,180	58.00	6,254
Yes	459	86.12	4,476	42.00	4,953
Secrecy					
No	148	27.77	7,060	66.25	7,208
Yes	385	72.23	3,596	33.75	3,981
Complexity					
No	269	50.47	7,898	74.12	8,167
Yes	264	49.53	2,758	25.88	3,022
Lead-time					
No	117	21.95	6,741	63.26	6,858
Yes	416	78.05	3,915	36.74	4,331
Total	**533**	**100.00**	**10,656**	**100.00**	**11,189**

Table 3.4 presents the correlations between the variables of interest. The mean variance inflation factor (VIF) is 2.27, well below the commonly adopted threshold of 10 (Wooldridge, 2013, p. 94), suggesting limited multicollinearity.

Table 3.4: Correlations

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Incoming knowledge spillovers										
(2) Product innovation	0.33*									
(3) Coopetition	0.19*	0.18*								
(4) Informal IP	0.43*	0.40*	0.19*							
(5) Ln(Firm size)	0.24*	0.06*	0.14*	0.21*						
(6) Formal IP	0.35*	0.30*	0.16*	0.65*	0.27*					
(7) Collaboration	0.27*	0.30*	0.39*	0.36*	0.22*	0.30*				
(8) Part of group	0.17*	0.08*	0.08*	0.15*	0.42*	0.15*	0.13*			
(9) East Germany	-0.04*	0.02*	-0.01	-0.06*	-0.19*	-0.09*	-0.03*	-0.11*		
(10) Ind. Informal IP	0.20*	0.30*	0.13*	0.46*	0.06*	0.39*	0.27*	0.04*	-0.02*	
(11) Industry dynamism	0.10*	0.18*	0.09*	0.10*	0.03*	0.08*	0.12*	0.07*	-0.01	0.19*

Note: N = 13,248; * $p < 0.05$

3.4 Results

Table 3.5 shows the results of our tests of Hypotheses 1 and 2. Coopetition is positively related to the incoming knowledge spillovers, in line with H1 (Column I, Table 3.5). Moreover, this relationship is negatively moderated by informal IP protection (Column II, Table 3.5). The magnitude of the interaction effect in non-linear models is not equal to the marginal effect of the interaction term (Ai & Norton, 2003; Zelner, 2009) and hence we cannot directly infer the sign and statistical significance of this point estimate. We compute and plot the marginal effects. Figure A3.1 (see Appendix) presents the interaction plots. To assess the differences, we contrast the two sets of estimated effects and plot those in Figure 3.1.[44]

Table 3.5: Informal IP, knowledge spillovers and innovation performance

Dependent variable	*Incoming knowledge spillovers*	*Incoming knowledge spillovers*	*Product innovation performance*	*Product innovation performance*
	I	**II**	**III**	**IV**
Coopetition	0.368***	1.237***	0.252***	0.855***
	(0.0406)	(0.0693)	(0.0654)	(0.124)
Importance informal IP		1.227***		1.636***
		(0.0426)		(0.0655)
Coopetition*importance informal IP		-1.631***		-1.037***
		(0.116)		(0.178)
Control variables	*Yes*	*Yes*	*Yes*	*Yes*
Year dummies	*Yes*	*Yes*	*Yes*	*Yes*
Industry dummies	*Yes*	*Yes*	*Yes*	*Yes*
Intercept	*Yes*	*Yes*	*Yes*	*Yes*

Note: N = 13,248; Bootstrapped standard errors in parentheses (50 replications)[45]; Control variables: Ln(Firm size), Collaboration, Part of group, East Germany, Importance formal IP, Industry informal IP, Industry dynamism; Industry dummies: 22 categories as listed in Table 3.1 (baseline: Food/beverages/tobacco); Year dummies: 2004 and 2012 (baseline: 2000); Models I and II contain three intercepts respectively, one for each outcome category (baseline: 0); *** p<0.01, ** p<0.05, * p<0.1

[44] As also mentioned in Chapter 2, the terminology varies across disciplines: management literature often refers to these values as 'contrasts of effects' or 'contrasts of predictive margins', while in economics the use of 'marginal' or 'partial effects' is more common.

[45] In order to obtain more reliable standard errors, we make use of bootstrapping. Bootstrapping resamples the standard errors multiple times such that they become more accurate, as they converge to the true sampling distribution (Guan, 2003).

We plot the average marginal effects of coopetition on each of the four levels of incoming spillovers at different values of importance of informal IP (horizontal axis) based on the model in Column II (Table 3.5). In Figure 3.1, the solid line shows the discrete marginal effect of coopetition, and the dotted lines represent the 95% confidence interval. The values on the vertical axis of each of the four graphs is the difference in probability between coopeting firms and those that do not coopete to receive a certain level of spillovers (no, low-, medium-, high-value).[46] The downward sloping line in the lower two panels indicates that as the importance of informal IP for a firm is increasing, the likelihood that a coopeting firm receives spillovers of medium or high value is decreasing compared to a non-coopeting firm. For both outcomes (medium- and high-value), up to an importance of informal IP equal to ca. 0.7, the difference is positive and significant, but with declining effect sizes. In other words, there is a significant difference between coopetitors and non-coopetitors in the probability to receive medium- or high-value knowledge spillovers and this probability is decreasing for coopetitors (see also Figure A3.1).

For values of the importance between 0.7 and 0.8, the confidence interval includes zero, which means that there is no significant difference between coopetitors and non-coopetitors in the probability to receive medium- or high-value knowledge spillovers. Between values of informal IP between 0.9 and 1.0, the likelihood to receive valuable knowledge spillovers is significantly smaller for coopetitors than for non-coopetitors. Conversely, the upward sloping line in the upper left panel indicates that, ceteris paribus, as the reliance on informal IP increases, the difference in probability not to receive incoming spillovers between coopetitors and non-coopetitors increases.[47]

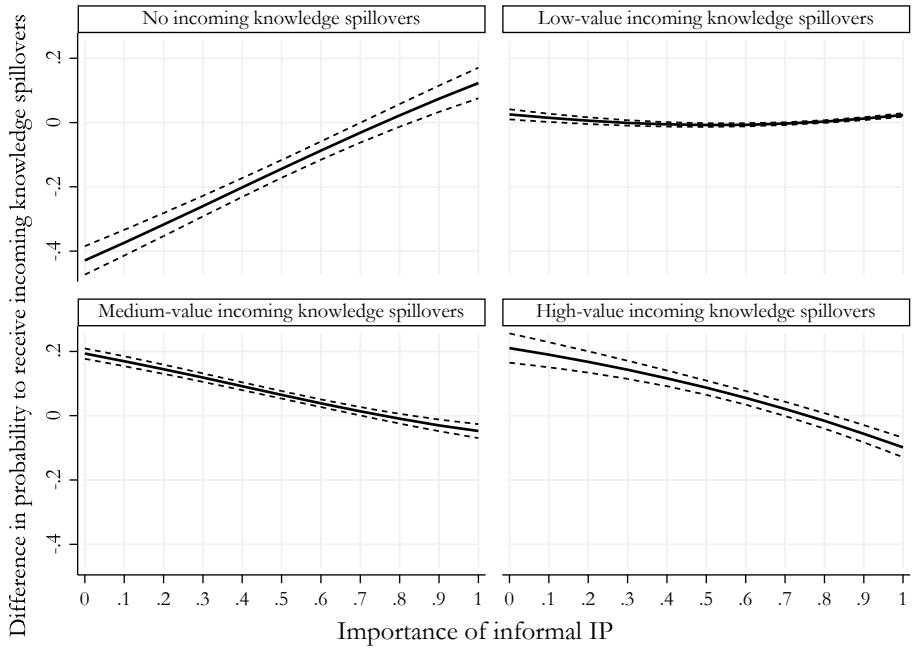
Between 0.7 and roughly 0.8, the confidence interval includes zero, meaning there is no significant difference between coopetitors and non-coopetitors. For values of importance of informal IP above 0.8, the difference between coopeting and non-coopeting firms is significant and positive. The top-right panel of Figure 3.1 shows there is no significant difference between coopetitors and non-

[46] In the case of "no incoming knowledge spillovers" this means that we compare the probability that a coopeting firm does not receive any knowledge from competitors with that of a non-coopeting firm.

[47] In other words, coopeting firms are more likely to receive incoming knowledge spillovers than non-coopetitors.

coopetitors with regards to the likelihood of receiving low-value knowledge spillovers. The plots in Figure 3.1 lend support for H2, suggesting that the more important coopeting firms rate informal IP protection, the less valuable they perceive the knowledge they receive from their partner.

Figure 3.1: Average marginal effect of coopetition at different levels of informal IP



Notes: Solid line: difference between coopeting and non-coopeting firms; dashed line: pointwise 95% confidence intervals; vertical axis of each plot displays the difference in the probability to receive no, low-, medium, and high-value knowledge spillovers, respectively.

In line with Hypothesis 3, we find that the effect of coopetition is positive on innovation performance (Column III, Table 3.5).[48] H3 is concerned with the

[48] Previous literature suggests that it might be interesting to distinguish between incremental (new-to-firm) and radical (new-to-market) product innovation (see e.g. Ritala & Hurmelinna-Laukkanen, 2013). Following this notion, we re-ran the analysis using both incremental and radical product innovation performance as dependent variables. Similarly to Laursen and Salter (2006), both are measured as a percentage of total sales. Interestingly, we find a similar pattern

total effect of coopetition on innovation, where we do not disentangle the underlying mechanisms inherent to coopetition, and therefore do not distinguish between the sharing of knowledge and other resources. Since we argued earlier that incoming knowledge flows exert a positive effect on innovation, a moderation of the relationship between coopetition and knowledge sharing by informal IP also suggests a moderation of the relationship between coopetition and innovation performance. In order to test for this, we additionally introduce informal IP protection to the model with product innovation as dependent variable and observe that the coefficient of the interaction term is negative and significant (Column IV, Table 3.5).

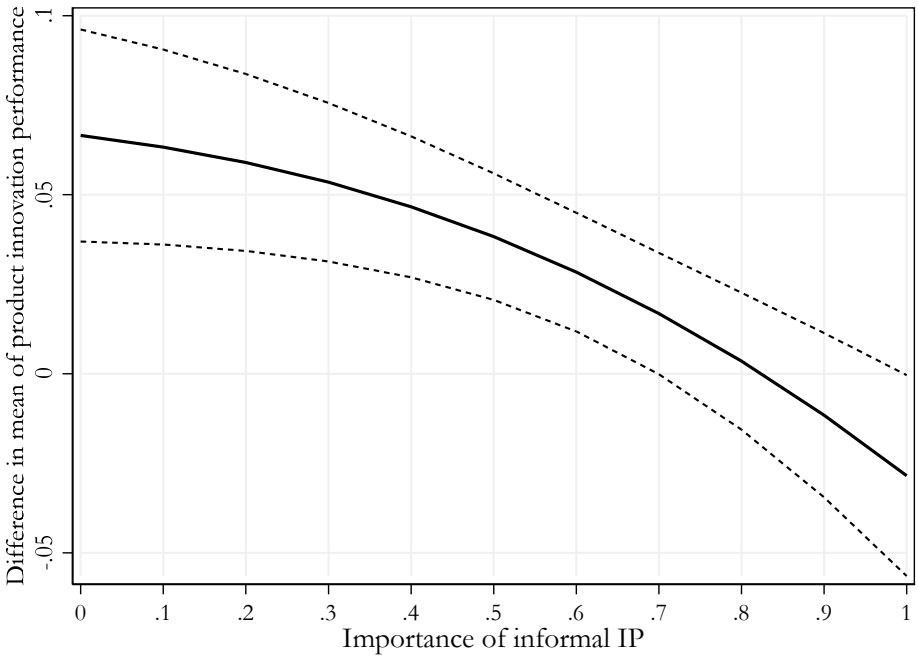
Similar to the analysis of H2, here, we also make use of a non-linear model. Therefore, we calculate the marginal effects and plot them in Figure 3.2. We plot the average marginal effect of coopetition on product innovation performance at different levels of informal IP. Figure 3.2 shows that for values of informal IP up to roughly 0.7, the effect of coopetition on innovation performance is positive but decreases. At higher levels of importance of informal IP protection, the confidence interval contains zero, indicating no significant differences in product innovation performance between coopetitors and non-coopetitors.

We perform a mediation analysis to test Hypothesis 4. The results of this analysis are reported in Table 3.6. Making use of the R-package "mediation" developed by Imai et al. (2011), we find that about 50% of the effect of coopetition on product innovation is mediated by incoming knowledge spillovers (Column I, Table 3.6).[49] This is in line with H4 that suggests a partial mediation by knowledge spillovers. Moreover, the significant direct effect reported in Column I provides additional support for H3 (positive effect of coopetition on product innovation), even when disentangling the mechanism of knowledge spillovers.

for both outcomes, where the effect of using informal IP in coopetition seems slightly stronger for radical innovations than for incremental ones.

[49] Performing a mediation analysis as suggested by Baron and Kenny (1986) shows that knowledge spillovers partially mediate the relationship between coopetition and innovation. Nevertheless, we choose to rely on the approach by Imai, Keele, and Tingley (2010), as it is better suited for the non-linear relationships we are investigating.

Figure 3.2: Average marginal effect of coopetition at different levels of informal IP



Notes: Solid line: discrete marginal effect of coopetition; dashed line: pointwise 95% confidence intervals

Besides the main effect, we are also interested in the role of informal IP protection within this setting because of its expected moderating effect with regards to knowledge spillovers. We compare the effect of "low importance of informal IP" with "high importance of informal IP". In particular, we make use of the values at the 25th and the 75th percentile; 0 and 0.56 respectively. We find that the mediation effect is moderated by informal IP protection. Specifically, when importance of informal IP is higher, the estimated mediation effect is smaller compared to when the informal IP is lower in importance (Columns I & II, Table 3.6), and the effects are significantly different from each other ($p < 0.001$). Furthermore, we find that the direct effect of coopetition on product innovation performance is not moderated by informal IP, as the coefficients between the "low" and the "high" group do not significantly differ from each other ($p = 0.456$).

Table 3.6: Results – Mediation analysis

	Unmoderated mediation	*Informal IP protection*	
		= 0	*= 0.56*
	I	**II**	**III**
Mediation Effect	0.014***	0.035***	0.013***
	[0.01; 0.02]	[0.03; 0.04]	[0.01; 0.02]
Direct Effect	0.015*	0.035**	0.020**
	[0.003; 0.03]	[0.01; 0.06]	[0.004; 0.04]
Total Effect	0.029***	0.070***	0.032***
	[0.02; 0.04]	[0.05; 0.10]	[0.02; 0.05]

Note: N = 13,248; 95% confidence intervals are bootstrapped (1000 replications) and reported in squared brackets. All estimations include our set of control variables. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Overall, these results confirm that incoming knowledge spillovers are an important mechanism that drives the positive effect of coopetition on product innovation. Moreover, the direct effect itself is positive, indicating that coopetition positively relates to a firm's innovation performance, even when the effect of knowledge spillovers is already accounted for. In addition to that, we do not find a significant difference between the direct effect at low levels and high levels of the importance of informal IP. This suggests that in fact the direct effect is not moderated by informal IP protection, which is also in line with the expectation of a partial mediation (H4). Consequently, we can conclude that there are further underlying mechanisms to coopeting that are unrelated to knowledge spillovers. We argued earlier that for instance cost and risk sharing, as well as a reduction in time-to-market are mechanisms that allow coopetition partners to enhance their innovation performance. Naturally, those are not affected by informal IP protection because they do not rely on knowledge sharing per se.

Among the control variables, we find that with increasing firm size, incoming knowledge spillovers become more valuable but innovation performance decreases. Moreover, other types of collaboration partners increase knowledge spillovers as well as innovation performance. Despite potential economic disadvantages, firms located in East Germany have a higher innovation performance. They also receive more valuable knowledge spillovers from rivals. In addition to that, industry dynamism positively impacts a firm's innovation performance. Furthermore, firms that rate formal IP mechanisms as important receive more incoming knowledge spillovers and have a higher

innovation performance. The use of informal IP by other firms in the industry positively affects both knowledge spillovers, as well as innovation performance.

3.4.1 Robustness checks

We perform several robustness checks.[50] First, we re-run the analysis on a sample containing only innovators, i.e. firms that "*implemented a new or significantly improved product or process during the period under review*" (Eurostat, 2005, p. 47). This restriction leads to a loss of about 50% of observations. The pattern of the findings remains similar, despite lower statistical power of the models[51]. We prefer the analysis on a larger group of firms because we are interested in how coopetition interplays with informal IP in affecting knowledge spillovers and not all coopeting firms that receive spillovers ultimately introduce innovations.

Second, unobserved heterogeneity may bias our results, specifically if there are unobserved factors that potentially affect both coopetition and innovation performance. In order to account for that, we run an additional analysis of how coopetition affects innovation including a lagged dependent variable.[52] By controlling for the lagged dependent variable, we proxy for these unobserved differences in innovation ability (Lechner, 2015). Another advantage of incorporating the lagged dependent variable is that it serves as a first-order correction to potential reversed causality (Carree et al., 2019). Including lagged product innovation performance as additional independent variable, leads to a loss of about 50% of observations. The coefficient of the lagged dependent variable is significant and the estimates from this model as well as the marginal effects plots display a similar pattern as our initial findings. However, due to the lower statistical power, the standard errors of the estimated coefficients become larger.

[50] Results of all robustness checks are available upon request.

[51] In particular, we observe that in this sample coopetition is significantly, positively related to incoming knowledge spillovers, and that informal IP negatively moderates that relationship. Moreover, the effect of coopetition on innovation performance is positive, but insignificant. This lack in statistical power can potentially be explained by the loss in observations, as well as the specific selection of only innovators.

[52] Often, this bias caused by unobserved heterogeneity can also be counteracted by performing a fixed effects regression (Lechner, 2015). However, due to the fact that firms respond to the MIP on a voluntary basis, firms are often not included throughout multiple survey years (Peters & Rammer, 2013). This causes our panel to be very unbalanced, which prevents us from including a specific fixed effect for each firm.

Third, we employ different operationalizations of the IP protection variables. Specifically, we use two different measures: (a) a binary for informal protection, that takes value (1) if a firm uses any of the according mechanisms, and (0) if otherwise; (b) a count variable, where informal IP can take values ranging from 0 (none) to 3 (all three mechanisms used). Even with those different measures, we find qualitatively similar outcomes as in the main analyses.

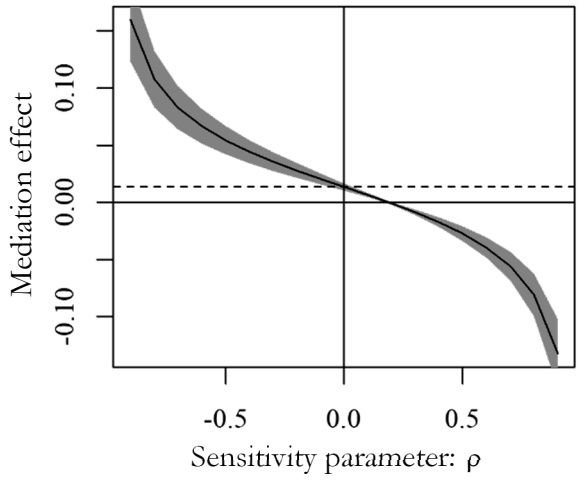
Fourth, in order to assess the robustness of the mediation analysis, we perform a sensitivity analysis. In particular, Imai et al. (2011) point out that in order for the mediation effect to be identifiable, the assumption of *sequential ignorability* needs to be met, which implies that the error terms of the mediator and the outcome models are uncorrelated. However, there might be unobserved factors that exert an influence on both incoming knowledge flows and product innovation performance, which would violate this assumption. Despite sequential ignorability as such being untestable, Imai, Keele, and Yamamoto (2010), as well as Imai, Keele, and Tingley (2010) developed a sensitivity analysis to evaluate the robustness of the results to violations of the assumption. Specifically, this sensitivity analysis introduces a non-zero error correlation ρ (sensitivity parameter) between mediator and outcome, thereby effectively rendering the mediator endogenous. The sensitivity analysis then repeats the mediation analysis assuming different values for ρ, and subsequently assesses whether the estimated mediation effect would still remain significant and thus the qualitative conclusions unchanged (Imai et al., 2011).[53] The results of all analyses are outlined in Section 3.4.

As can be seen in Figure 3.3, the mediation analysis seems to be relatively sensitive to violations of the sequential ignorability assumption, as for error correlations of 0.2 or higher, the estimated mediation effect would vanish. While thus the results of the mediation analysis might shed additional light on the underlying mechanisms with respect to coopetition for innovation, the sensitivity analysis shows that they need to be considered with caution. Therefore, we render it more logical to not include incoming knowledge

[53] Due to restrictions in the "mediation" R-package, we have to perform the sensitivity analysis by using linear models (Tingley et al., 2014).

spillovers in the outcome equation and rely on the estimation of the total effect of coopetition, as we do in the beginning of Section 3.4.

Figure 3.3: Sensitivity analysis of the estimated mediation effect



Notes: Sensitivity analysis for steps of 0.5 in sensitivity parameter ρ. Grey areas depict 95% confidence intervals (bootstrapped, 1000 replications). The dashed line depicts the point estimate under sequential ignorability. The sensitivity analysis was conducted using the "medsens" function of the R-package "mediation" (Tingley et al., 2014), which does not yet allow for ordered probit or GLM models. Therefore, we rely on linear mediation results for assessing sensitivity.

3.5 Discussion

This chapter investigates how coopetition affects incoming knowledge spillovers from competitors and product innovation performance. Specifically, we are interested in the role that informal IP protection plays within these relationships. Our findings are in line with prior studies that find a positive effect of coopetition on product innovation performance (see e.g. Gnyawali & Park, 2009). Moreover, we find that engaging in coopetition increases the value of incoming knowledge spillovers, which supports existing research on alliances that draws on the KBV (see e.g. Choi, 2020; Indradewa et al., 2015). However, we also emphasize the ambiguity in previous coopetition research with regards to the effects of collaborating with competitors. In particular, we note that the

outcomes of coopetition are usually not straightforward but rather need to be considered in light of firm-specific characteristics (Chiambaretto, Bengtsson, et al., 2020; Ritala, 2012).

As underlined by Estrada et al. (2016), taking into account a firm's knowledge management strategies is especially important when investigating coopetition. We reason that, on the one hand, IP protection mechanisms should provide a safe environment that encourages knowledge sharing in a controlled manner, but on the other hand, especially informal mechanisms might signal distrust and limit necessary knowledge spillovers. Trust, however, is essential for coopetition success because without trust, firms are not willing to share resources that are necessary to create value together (Das & Teng, 1998; Nieto & Santamaría, 2007; Parkhe, 1998; Raza-Ullah & Kostis, 2020). This might ultimately result in alliance failure. In addition to that, we draw on the concept of reciprocity to explain that a firm is reluctant to share knowledge if its partner does not commit any resources to the relationship (Nielsen & Nielsen, 2009). This is especially the case in collaboration between rivals, where the risk of opportunistic partner behavior is exacerbated, and firms need to sustain their competitive edge over their partners (Ryan Charleton et al., 2018). While firms thus may aim to protect their knowledge with informal IP mechanisms from being exploited to be able to collaborate safely (and successfully), our findings show that the use of such tools might actually have the opposite effect.

After establishing that coopetition is beneficial for incoming knowledge spillovers and for product innovation, we additionally disentangle the effect of information inflow from other mechanisms inherent to collaborating with competitors. Specifically, we observe that incoming knowledge spillovers partially mediate the effect that coopetition has on product innovation performance. This reinforces the idea that knowledge sharing is one of the main underlying mechanisms to successful coopetition with regards to innovation performance. This mediation is also negatively moderated by informal IP protection, which supports our line of reasoning throughout this chapter. In particular, informal IP protection mechanisms thus seem to hinder knowledge spillovers rather than enhance them. We additionally observe that the direct effect of coopetition on product innovation is also significant; coopetition thus enhances a firm's innovation performance when the effect of knowledge sharing is regarded separately and thus filtered out. This highlights the fact that

coopetition is not only driven by the potential for valuable knowledge spillovers, but that other mechanisms inherent to the partnership also help firms to develop new products. This is in line with prior research that points out aspects such as the sharing of R&D costs or market risks to contribute to successful coopetition (Gnyawali & Park, 2009; Hagedoorn, 1993; Pellegrin-Boucher et al., 2013). Following logically from this, we also do not find a significant moderating effect of informal IP protection on the effect of coopetition on innovation. This supports the assumption that there are mechanisms driving the success of coopetition for innovation that are unrelated to knowledge sharing. While IP protection mechanisms are thus relevant to shield knowledge from being exploited, they seem less important in protecting other relevant resources.

3.5.1 Theoretical contributions

By means of this study, we contribute to the existing body of coopetition literature in multiple ways. We find that the use of informal IP protection reduces the value of incoming spillovers in coopetition. This is a novel finding, as research often argues that IP protection mechanisms as such are expected to enhance the collaboration, because they provide a safer and more controlled environment for knowledge sharing (Holgersson, 2018). The pattern of findings in our analyses supports the contention that informal IP may diminish knowledge sharing overall, rather than just avoiding the unintended spillovers. We explain this finding by drawing on the concept of trust and argue that informal IP mechanisms signal a certain level of distrust, which in turn causes partners to refrain from sharing knowledge. This enables us to shed some light on the ambiguity as to why some firms coopete more successfully than others. Moreover, this finding emphasizes the relevance of distinguishing between the different types of IP protection mechanisms and specifically of focusing on informal ones. In making this distinction, we partially respond to a call from Laursen and Salter (2014), who ask for future research to further explore the connection between the choice and use of IP protection mechanisms and various types of partners.

Being able to specifically investigate informal IP protection also allows us to contribute to the limited body of coopetition literature studying knowledge management. In fact, research considering IP protection mechanisms and especially the role of informal IP protection is scarce. With this study, we answer

to a call for future work to venture into this field (Estrada et al., 2016). This chapter thus further extends the current base of coopetition and knowledge management literature because we have information on the use of and importance attributed to informal IP protection by a variety of firms over multiple years. This in turn helps to deepen the understanding of the tensions inherent to competitor collaboration, and how those can (or cannot) be managed.

Furthermore, we also contribute to existing research by means of our methodology. Particularly, the mediation analysis is a rather unusual approach in the current body of management literature. Despite its novelty, the chosen method is much more in line with the build-up of our models and measures, as it can account specifically for non-linearity. Well-established approaches such as suggested by Baron and Kenny (1986) fail to do so. By using the techniques developed by Imai and colleagues (Imai, Keele, & Tingley, 2010; Imai, Keele, & Yamamoto, 2010), we contribute to the current set of management literature and emphasize the relevance of methods that also allow for non-linearity to achieve more precision in analyses and studies.

3.5.2 Managerial implications

In addition to the theoretical contributions, our study also has important practical implications. First, we point out the relevance of knowledge flows in coopetition for innovation. This emphasizes the need for companies to commit knowledge to the relationship if they aim to achieve innovation. In fact, we identify knowledge spillovers as one of the main underlying mechanisms behind successful coopetition. Firms therefore need to acknowledge that coopeting requires knowledge sharing from both parties. Second, we stress the need for firms to be aware of and potentially reconsider their IP protection strategy. While IP mechanisms are aimed to protect a firm's knowledge from being exploited, we show that informal tools can actually hamper knowledge sharing in coopetition, which can be detrimental for coopetition success. Firms thus need to understand that having IP mechanisms in place does not automatically provide the means to coopete and achieve innovation. All in all, the findings in this chapter can enable managers to make well-informed decisions. By taking into account their reason to engage in coopetition – knowledge access or other underlying mechanisms like cost-sharing – and subsequently the firm's IP

protection strategy, our findings can help firms assess whether a coopetition strategy is beneficial for them.

3.5.3 Limitations and future research

While we aim to ensure robustness throughout our study, this chapter still faces a few limitations. Generally, research conducted using CIS data potentially suffers from biases such as self-selection bias. Firms respond to the survey voluntarily, meaning that the sample might not be fully random. Additionally, the questionnaire aims at serving a wide variety of studies rather than this specific project. Therefore, we face a few restrictions with respect to the consistency of questions and measures included. In fact, we are only able to use three waves of the MIP, resulting in a heavily unbalanced panel. Moreover, the data does not provide any information about a firm's partners' characteristics. This might be relevant, however, especially with regards to the knowledge sharing within coopetition. As pointed out by Nielsen and Nielsen (2009), if one partner holds back information, the other one will also do so. Thus, knowing the partner's IP strategy could provide more insights into the different processes inherent to and outcomes of coopetition.

Moreover, it is important to reflect on the potentially limited generalizability of this chapter. Similar to Chapter 2, the firms in this study are located in a European country with strong laws for IP protection (Crass et al., 2019; Lippoldt & Schultz, 2014). Consequently, the findings in this chapter may not be applicable to other contexts. In order to address this limitation, future research could investigate whether there are differences in the role of IP protection and knowledge sharing between domestic and non-domestic coopetition. While international coopetition can provide market access and novel resources (Lhuillery & Pfister, 2009), IP laws can differ between countries, potentially rendering some mechanisms ineffective (Oxley, 1999). In addition to this, this chapter only considers coopetition at time *t*, rather than over time. Yet, prior research shows that it is especially relevant to consider collaborations throughout time, as they may only have a delayed effect on innovation (Belderbos et al., 2015). Furthermore, Belderbos et al. (2012) point out that firms tend to create routines in repeat-alliances given their success. The data used in this chapter does not allow for an investigation of such alliance persistence or one specific alliance over time as it does not provide any information about the

particular collaboration partners, other than general type. However, the establishment of routines and building up alliance experience over time could be especially interesting from a coopetition lens, as repeat alliances might enhance trust and reduce opportunism. While Gulati (1995) has investigated this on a general alliance level, we know that coopetition is a special type of collaboration, as the risks of exploitation are especially prevalent. Therefore, it would be interesting to study whether the effect of accumulated trust might be even stronger in the case of collaboration between rivals.

3.6 Conclusion

In this chapter, we aim to shed more light on the role of coopetition with respect to both knowledge spillovers and product innovation. We are particularly interested in how the reliance on informal IP protection mechanisms affects those relationships. In doing so we aim to extend the scarce body of coopetition literature that investigates IP protection mechanisms (and here, especially informal ones) and knowledge management. Our findings indicate that generally coopetition is beneficial for both knowledge spillovers, as well as product innovation performance. However, the use of informal IP protection can be detrimental to those relations. Moreover, we highlight that knowledge sharing is one of the main underlying mechanisms to coopetition for innovation. With this study, we follow calls from prior research to consider knowledge management and especially the role of (informal) IP protection mechanisms in coopetition. We identify and underline that such mechanisms may be harmful, despite their protective purpose. This emphasizes the need for firms to carefully consider their protection and knowledge sharing strategies before engaging in coopetition. Despite the insights provided in this chapter, we encourage future research to investigate the role of knowledge sharing and knowledge protection in coopetition in more detail and under various different circumstances.

Appendix

Table A3.1: Complete set of results

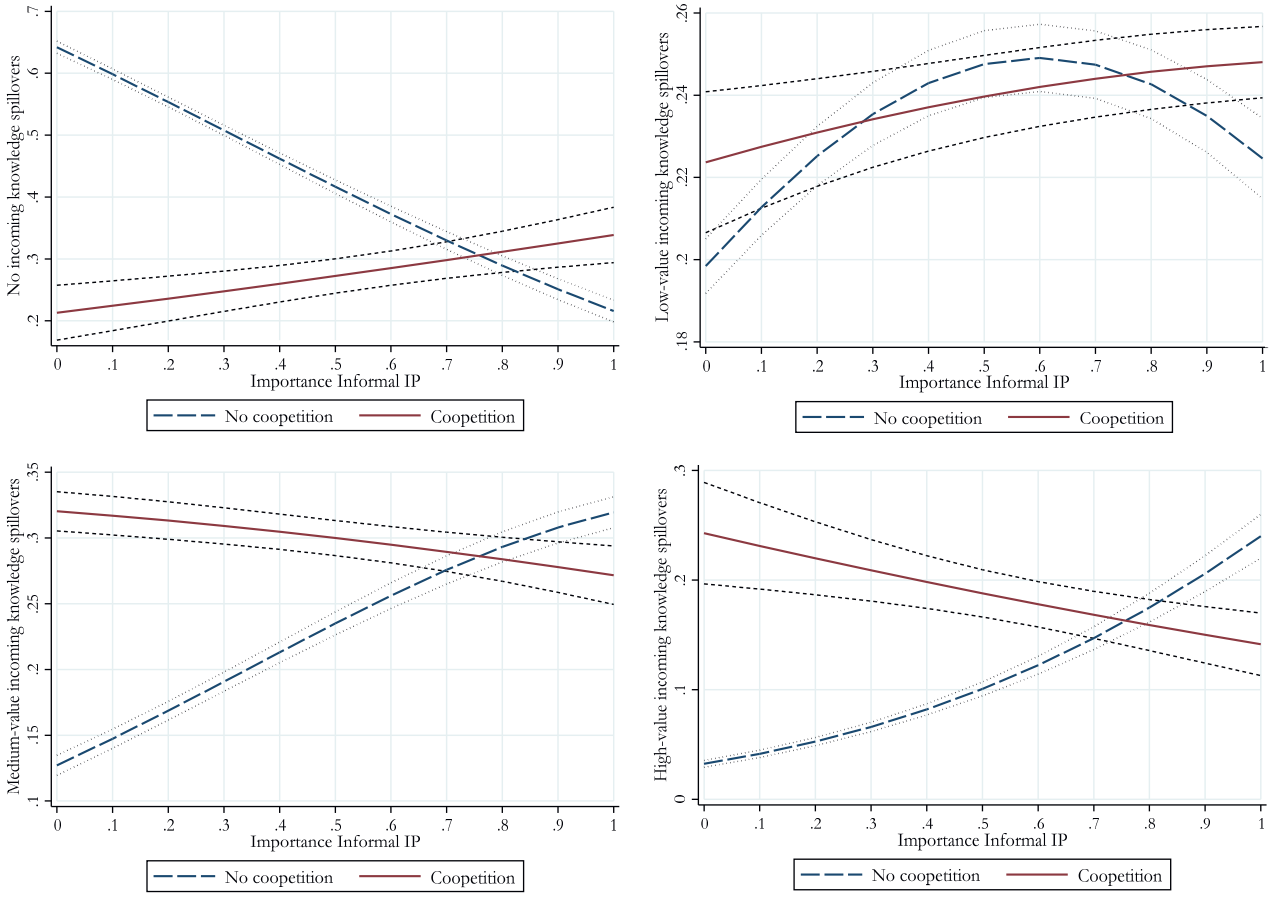
Dependent variable	*Incoming knowledge spillovers*	*Incoming knowledge spillovers*	*Product innovation performance*	*Product innovation performance*
	I	**II**	**III**	**IV**
Coopetition	0.368***	1.237***	0.252***	0.855***
	(0.0406)	(0.0693)	(0.0654)	(0.124)
Importance informal IP		1.227***		1.636***
		(0.0426)		(0.0655)
Coopetition*importance informal IP		-1.631***		-1.037***
		(0.116)		(0.178)
Ln(Firm size)	0.0725***	0.0676***	-0.0746***	-0.0826***
	(0.00723)	(0.00721)	(0.0127)	(0.0124)
Collaboration	0.356***	0.217***	0.730***	0.538***
	(0.0309)	(0.0342)	(0.0534)	(0.0455)
Part of group	0.0692**	0.0520**	0.0834*	0.0576
	(0.0273)	(0.0241)	(0.0459)	(0.0476)
East Germany	0.0428**	0.0556***	0.196***	0.203***
	(0.0185)	(0.0198)	(0.0390)	(0.0401)
Importance formal IP	1.419***	0.620***	1.703***	0.734***
	(0.0406)	(0.0524)	(0.0660)	(0.0903)
Industry informal IP	0.877***	0.280***	2.696***	1.835***
	(0.126)	(0.0837)	(0.155)	(0.170)
Industry dynamism	-0.00167	0.0375	1.090***	1.160***
	(0.162)	(0.171)	(0.329)	(0.307)
Year dummies				
2004	0.105***	0.0848***	0.0108	-0.0267
	(0.0234)	(0.0245)	(0.0458)	(0.0542)
2012	-0.470***	-0.491***	-0.893***	-0.905***
	(0.0292)	(0.0321)	(0.0517)	(0.0528)
Industry dummies				
Textiles/clothing	-0.232**	-0.284***	0.298	0.212
	(0.0953)	(0.0836)	(0.218)	(0.179)
Wood/paper	-0.103	-0.162**	0.438	0.361*
	(0.0809)	(0.0808)	(0.276)	(0.186)
Chemicals/pharmaceuticals	-0.289***	-0.291***	0.0389	0.0399
	(0.0907)	(0.0675)	(0.194)	(0.173)
Rubber/plastics	-0.0910	-0.152*	0.293	0.209
	(0.0897)	(0.0810)	(0.215)	(0.202)
Glass/ceramics/concrete	-0.123	-0.164*	0.150	0.111
	(0.113)	(0.0891)	(0.234)	(0.206)
Metals	-0.136	-0.196***	0.156	0.0844
	(0.0884)	(0.0595)	(0.216)	(0.180)
Electronics/electrical	-0.203***	-0.266***	0.643***	0.571***
	(0.0782)	(0.0660)	(0.207)	(0.175)
Machinery/equipment	-0.258***	-0.296***	0.478**	0.447***
	(0.0787)	(0.0658)	(0.209)	(0.163)

Table A3.1 continued

Vehicles	-0.208**	-0.225**	0.467**	0.467***
	(0.0823)	(0.0877)	(0.223)	(0.163)
Furniture/other manufacturing	0.00807	0.00967	0.569***	0.578***
	(0.0826)	(0.0788)	(0.195)	(0.176)
Energy/mining/oil	-0.343***	-0.373***	-0.324	-0.370*
	(0.115)	(0.0949)	(0.213)	(0.221)
Water supply/waste/recycling	-0.190**	-0.256***	-0.0761	-0.136
	(0.0934)	(0.0886)	(0.220)	(0.244)
Wholesale trade	-0.0574	-0.104	0.305	0.222
	(0.0945)	(0.0707)	(0.266)	(0.183)
Transportation/postal services	-0.319***	-0.384***	0.0290	-0.00898
	(0.0937)	(0.0676)	(0.211)	(0.168)
Printing/publishing/media	-0.0238	-0.0748	0.404*	0.346*
	(0.0852)	(0.0784)	(0.227)	(0.186)
IT-services/telecommunications	-0.222***	-0.335***	1.055***	0.938***
	(0.0785)	(0.0748)	(0.211)	(0.178)
Financial intermediation	0.0999	0.0369	0.719***	0.658***
	(0.0893)	(0.0806)	(0.206)	(0.173)
Consulting/advertising	-0.192**	-0.276***	0.605***	0.523***
	(0.0916)	(0.0665)	(0.214)	(0.177)
Technical engineering	-0.180**	-0.280***	0.423**	0.309*
	(0.0851)	(0.0676)	(0.193)	(0.164)
Other producer services	-0.245***	-0.326***	0.360*	0.281*
	(0.0747)	(0.0616)	(0.205)	(0.163)
Other	-0.480***	-0.519***	-0.0571	-0.0735
	(0.0886)	(0.0678)	(0.221)	(0.173)
$Intercept_1$	0.470***	0.429***		
	(0.0897)	(0.0677)		
$Intercept_2$	1.113***	1.107***		
	(0.0913)	(0.0662)		
$Intercept_3$	2.006***	2.022***		
	(0.0890)	(0.0630)		
Intercept			-3.268***	-3.299***
			(0.214)	(0.168)
N	*13,248*	*13,248*	*13,248*	*13,248*

Note: Bootstrapped standard errors in parentheses (50 replications); $Intercept_1$, $Intercept_2$ and $Intercept_3$ represent the intercepts for the respective categories (1-3) of the dependent variable in columns I and II, where 0 is the baseline category; *** p<0.01, ** p<0.05, * p<0.1

Figure A3.1: Marginal effects of (no) coopetition at different levels of importance of informal IP protection



Note: Short-dashed line illustrates the 95%-confidence interval of coopetition, and dotted line that of non-coopetition. Where confidence intervals overlap for a large part, the differences between coopetition and no coopetition are insignificant. The contrasts plotted in Figure 3.1 illustrate the difference between the solid and the long-dashed lines, i.e., solid line minus long-dashed line.

Chapter 4

Coopetitive portfolios and firm innovation: A crisp-set Qualitative Comparative Analysis[54]

To develop innovation, firms often form multiple alliances with various types of partners, finding themselves at the head of an alliance portfolio. The presence of alliances with competitors in an alliance portfolio leads to the creation of a "coopetitive portfolio" in which competitors can either create synergies with the other types of partners, enhancing the propensity to introduce innovations or, on the contrary, raise conflicts, limiting the development of new products. In this paper, we aim at finding different coopetitive portfolio configurations that enhance a firm's propensity to introduce innovations. We make use of a crisp-set Qualitative Comparative Analysis (csQCA) analysis on a sample of 921 Dutch firms in the period 2010-2016. We show that alliances with competitors (coopetition) are complementary with alliances with customers in spurring innovation. In addition, our analysis reveals that in coopetitive portfolios, collaboration with suppliers is complementary to that with universities. Indeed, when ties with universities are present in a coopetitive portfolio, suppliers must be present as well to improve innovation performance. By distinguishing between small and large firms, as well more and less dynamic industries, we show that the potential of a coopetitive portfolio to enhance the chances to introduce innovations differs depending on the focal firm's size and industry.

[54] This chapter is based on joint work with Anne-Sophie Fernandez and Paul Chiambaretto. We thank participants at the 2021 virtual EURAM Conference and at the 2021 virtual AIMS (Association Internationale de Management Stratégique) Conference for their input.

4.1 Introduction

To enhance their innovation performance, firms often rely on multiple alliances with various types of partners (Tomlinson, 2010; Un et al., 2010), and find themselves handling alliance portfolios (Belderbos et al., 2006; Wassmer, 2010). When these alliance portfolios include both competing and non-competing partners, we can characterize them as coopetitive portfolios (Chiambaretto & Fernandez, 2016, 2018). Coopetitive portfolios allow firms to gain access to a richer variety of complementary and similar resources and knowledge than traditional alliance portfolios, enabling them to spur innovation performance (see e.g. Duysters et al., 2012; Lee et al., 2017; Wassmer & Dussauge, 2011).

However, such portfolios are also potentially riskier, because the presence of direct competitors in a portfolio can be sub-additive, causing conflicts between them and other partners, negatively impacting the efficacy of the overall portfolio and thus the company's innovation performance (Castro & Roldán, 2015; Wassmer & Dussauge, 2012). Indeed, collaboration between rivals is characterized by high risks of opportunism that generates multiple tensions between the coopetitors (Estrada et al., 2016; Fernandez & Chiambaretto, 2016; Gast et al., 2019) but also with the rest of the portfolio. The presence of competitors in a portfolio can exacerbate the underlying processes, creating particular dynamics that may either increase or decrease the chance of successfully developing innovation (Chiambaretto & Fernandez, 2018; Park et al., 2014).

While recent contributions have argued that firms that only rely on coopetition or only on alliances with non-competitors cannot achieve optimal levels of innovation performance and that coopetition must be combined with other relational modes (Fernandez et al., 2021; Park et al., 2014; Turner et al., 2022; Wu, 2014; Yu et al., in press), the question of the optimal configuration of coopetitive portfolio in fostering innovation performance remains open. It is thus important to understand with what types of partners alliances with competitors should be combined.

Prior research further notes that the relationship between coopetition and innovation is subject to various boundary conditions such as firm size (Chiambaretto, Bengtsson, et al., 2020) and industry dynamism (Ritala, 2012; Weerawardena et al., 2006). Firstly, small and large firms value the benefits that

can be derived from collaborating with rivals but also the risks inherent to this type of partnership in a different way (Chiambaretto et al., 2020). In a similar vein, alliance portfolio research underlines that small- and medium-sized enterprises (SMEs) and large firms rely differently on external resources and source from different partners to innovate (Dooley et al., 2016; Subramanian et al., 2018). Consequently, small and large firms might configure their coopetitive portfolios in a distinct manner when they want to innovate (Bengtsson et al., 2014; Yang et al., 2014).

Secondly, various alliances can be used as a way to cope with the strong dynamism of an industry (Greve et al., 2014; Park & Mezias, 2005). Firms in more dynamic markets aim to gain access to a new and diverse set of resources (Tatarynowicz et al., 2016). In particular, coopetition can be considered a viable strategy in dynamic environments, which are characterized by high uncertainty and fast product turnover (Belderbos, Carree, Diederen, et al., 2004; Chiambaretto & Fernandez, 2016). Industry dynamism seems to play an important role with regards to how a firm's coopetitive portfolio affects its innovation performance but research investigating this remains scarce to this date.

To contribute to the limited amount of literature considering coopetitive portfolios and their effect on innovation performance – particularly in light of firm size and industry dynamism – we aim to answer the following question: *When companies ally with their competitors, which other types of firms should they partner with to enhance their innovation performance, and how does this differ for SMEs and large firms, and in low and high dynamic industries?* Put differently, taking into account the focal firm's size or industry context, this chapter aims at finding different coopetitive portfolio configurations that enhance a firm's propensity to introduce innovations.

From a methodological standpoint, we use a set-theoretic approach referred to as Qualitative Comparative Analysis (QCA) on a sample of 921 Dutch firms with a coopetitive portfolio (i.e., an alliance portfolio with at least one alliance with competitors) to analyze different coopetitive portfolio configurations and study how these configurations affect innovation performance. The choice for the QCA method is motivated by its ability to assess the impact of different combinations of variables on a given outcome, hence taking potential interrelations between the focal variables into account (Ganter & Hecker, 2014;

Ragin, 1999, 2008; Speldekamp et al., 2020). This approach enables us to identify different causal paths[55] (i.e., coopetitive portfolio configurations) that increase the propensity of a firm to innovate. In addition, by setting up various sub-sample analyses, we study the influence of firm size and industry dynamism on the coopetitive portfolio configurations that foster innovation.

The contributions of this chapter are threefold. First, this research contributes to the scarce amount of literature that studies coopetition at the portfolio level. Prior coopetition research often considers coopetition on a dyadic level or coopetition-only portfolios (see e.g. Rouyre & Fernandez, 2019; Yami & Nemeh, 2014), which does not provide an exhaustive image of how the decision to engage in coopetition affects firm performance. We show that indeed coopetition alone is not necessarily beneficial for firms, but that other partner types should be added to enhance the chances of introducing innovation. Second, we shed light on how different partner types interact with one another in a coopetitive portfolio, meaning that we illustrate complementarity or sub-additivity of other partner types with competitors, but at the same time allow for different combinations of partners to yield innovation. We are able to do so by following recent management literature that suggests to make use of a QCA approach, which is a rather novel methodology to be employed to assess firms' strategic decision making and performance implications (see e.g. Santos, 2021). We therefore extend the current body of management literature and add on to a new stream of contributions in the field. Third, this research reveals that the coopetitive portfolio configurations that increase firms' innovation propensity are not the same for SMEs and large firms, and differ along the dynamism of the industry in which the firm operates. This result is in line with the growing literature that argues that there is no "one size fits all" approach of coopetition and that coopetition should be strategized, implemented and managed differently according to different firm or industry factors (Bagherzadeh et al., 2022; Chiambaretto et al., 2020; Ritala, 2012).

The remainder of this chapter is structured as follows: first, we dive deeper into the concept of coopetition, and specifically coopetitive portfolios for

[55] In QCA literature, it is common to refer to "causal paths" when talking about the solutions suggested by the analysis. Throughout this chapter, we follow this terminology. Nevertheless, by no means do we intend to imply causality in an econometric sense when using the term "causal paths".

innovation. Second, we elaborate on the research design and data analysis strategy. Third, we outline the findings of our analyses and discuss these in light of existing literature. We develop a set of propositions that follow our interpretation of the results. In addition to that, we emphasize the theoretical contributions and managerial implications of our study, before summarizing the key aspects of our research in the conclusion.

4.2 Theoretical background

4.2.1 Direct competitors in an alliance portfolio: a double-edged sword strategy

Alliance portfolios enable firms to create synergies and gain access to a variety of resources (Castro & Roldán, 2015; Faems et al., 2012). Collaborating with direct competitors and including them in the alliance portfolio can be especially interesting for a focal firm since rivals simultaneously possess complementary and compatible knowledge and resources with regards to both products and markets, which is particularly interesting to develop innovation capabilities (Chiambaretto et al., 2020; Frankort, 2016; Gnyawali & Park, 2009; Quintana-Garcia & Benavides-Velasco, 2004). This is in line with the reasoning that the prospect of complementary and compatible resources drives firms to engage in collaboration (Miotti & Sachwald, 2003; Mitsuhashi & Greve, 2009), as is often outlined by means of the resource-based view (RBV) or its extension the knowledge-based view (KBV). As competitors operate in the same industries and have similar products, collaborating can lead to increased efficiency, while at the same time, risks and costs can be shared (Bengtsson & Kock, 2000; Gnyawali & Park, 2009). Therefore, especially the knowledge and resource exchange can help firms create value together and improve their innovation performance (Frankort, 2016; Mitchell et al., 2002).

However, collaboration between competitors also entails high risks of opportunistic behavior that generate multiple tensions between the partners (Fernandez et al., 2014). In coopetition, partners remain competitors, so they are tempted to reduce their involvement in the joint value creation process to the minimum level while trying to individually capture the highest share of the value jointly created (Chiambaretto, Maurice, et al., 2020; Ritala & Hurmelinna-Laukkanen, 2018). Therefore, opportunistic behavior is a pertinent risk, which is often stressed by the transaction cost economics (TCE) perspective

(Fernandez, Le Roy, et al., 2018; Ritala & Hurmelinna-Laukkanen, 2013; Tidström, 2014). It highlights that opportunistic partner behavior can result in major obstacles within the collaboration (Gnyawali & Ryan Charleton, 2018; Zaheer et al., 1998).

These risks of opportunism especially generate knowledge tensions between the coopetitors. In particular, knowledge committed to the relationship might spill over unintentionally (Estrada et al., 2016; Fernandez & Chiambaretto, 2016; Gast et al., 2019). Estrada et al. (2016) point out that competitors can easily integrate such leaked knowledge because of the similarity in resource background, potentially damaging the focal firm's competitive advantage. Especially in alliance portfolios, a focal firm does not always have control about the entirety of knowledge flows. In fact, knowledge might spill over to a competitor not only directly but also through other partners such as suppliers. Consequently, the risk of such unintentional spillovers of information is even higher in a portfolio setting. Moreover, innovation can be harmed due to a lack of resource commitment to the partnership, caused by a lack of trust between coopetitors (Nieto & Santamaría, 2007; Raza-Ullah & Kostis, 2020). In light of the distrust, one of the coopetition partners might not be willing to share crucial knowledge, relevant to the collaboration success. Based on reciprocity, the other partner may consequently also refrain from committing knowledge to the relationship (Nielsen & Nielsen, 2009). Hence, the risks inherent to coopetition can substantially harm value creation.

Including direct competitors in a portfolio of alliances can therefore be considered a double-edged strategy. Their presence can generate valuable synergies but also tensions that can spread throughout the portfolio and either enhance or hamper a firm's innovation performance. The question becomes with which other types of partners a focal firm should ally when it has direct competitors in its portfolio to benefit from their presence while minimizing the risks/tensions.

4.2.2 Coopetitive portfolio configurations

Alliances in a portfolio are usually interdependent and interact with each other (Parise & Casher, 2003; Wassmer & Dussauge, 2012), meaning that both the benefits but also the risks that transfer into the coopetitive portfolio are high (Chiambaretto & Fernandez, 2018). Thus, the presence of competitors in a

portfolio can have a positive impact on the innovation performance, generating synergies with the focal firm and its partners. At the same time, the presence of competitors can also be detrimental and generate tensions and conflicts in a portfolio based on the frictions inherent to coopetition itself, so that the firm may want to substitute competitors with non-competing partners.

Alliance portfolio research has shown that developing and managing alliance portfolios is difficult due to the variety of partners and the subsequent complexities (Duysters et al., 2012; Lee et al., 2017; Wassmer & Dussauge, 2012). On the one hand, one can argue that having access to different types of partners provides access to new resources and new markets that can be combined in positive ways (Mouri et al., 2012; Srivastava & Gnyawali, 2011). On the other hand, having too many partner types can generate managerial challenges and complexity, leading to conflicts (Duysters & Lokshin, 2011; Goerzen & Beamish, 2005). This complex relationship between the alliance portfolio composition and the performance becomes even harder to understand when competitors belong to the alliance portfolio. Indeed, the presence of competitors, combined with the complexities of handling an entire alliance portfolio, makes the development and management of a coopetitive portfolio even more challenging, as it will require more managerial capacities and capabilities than needed for alliance portfolios composed of non-competitors.

While we acknowledge that coopetitive portfolios as such may be riskier and more complex than portfolios consisting only of non-competing partners, the effects and specificities of such coopetitive alliance portfolios for innovation remain unclear. In fact, so far, only a limited number of contributions have studied the innovation performance of coopetition at the portfolio level. Park et al. (2014) and Wu (2014) indicate that there is a U-shaped relationship between the percentage of coopetitive alliances in a portfolio and innovation. In the same line, recent contributions such as Fernandez et al. (2021), Turner et al. (2022) or Yu et al. (in press) confirm that relying exclusively on coopetition or exclusively on alliances with non-competitors does not allow firms to optimally develop future innovations. This suggests that there exists an optimal level of coopetition in a coopetitive portfolio such that innovation performance is maximized, and raises the question, whether certain partner combinations in a coopetitive portfolio yield more firm innovation than others. In this vein, Belderbos et al. (2006) investigate the impact of the potential complementarity or substitutability

between competitors and other partner types on productivity growth. They find that combining customers and competitors enables firms to create synergies and promote productivity growth. Competitors and universities, however, are shown to be substitutes, meaning that combining them in an alliance portfolio could possibly hamper a firm's performance. Hence, certain combinations of partners in a coopetitive portfolio seem to be more beneficial for a firm's performance than others. The question that arises is when companies ally with their competitors, which other types of firms should they partner with to enhance their innovation performance?

4.2.3 Coopetitive portfolios: do the same configurations fit all?

Collaboration success or failure with respect to innovation is not only dependent on the type of partner, but also often affected by firm- and industry-characteristics (Ritala, 2012). Nieto and Santamaría (2010) identify that especially firm size plays a highly relevant role when considering the incentives behind the decision to engage in collaboration. The authors point out that particularly for SMEs, collaboration is a means to improve innovativeness and competitiveness because they can overcome their limited resource base. Dooley et al. (2016) and Subramanian et al. (2018) show that small and large firms rely differently on external resources and source from different partners to innovate. Consequently, the type of partners in a coopetitive portfolio differs for small and large firms when they want to innovate (Bengtsson et al., 2014; Yang et al., 2014).

In parallel, small and large firms vary in the benefits they derive and difficulties they face when collaborating with competitors (Morris et al., 2007; Chiambaretto et al., 2020). Such differences could impact the portfolio level, as there are dependencies between the different types of collaboration (Belderbos et al., 2006; Park et al., 2014; Wu, 2014). Moreover, there might be differences in the complexity that SMEs and large firms can handle. SMEs, on the one hand, can benefit from a smaller variety of partners quickly because their own resource base is rather limited (Lee et al., 2010). At the same time, SMEs might lack the managerial capacity to handle complex portfolios (Dickson et al., 2006). Large firms, on the other hand, as such possess a more diverse resource base themselves (Baum et al., 2000), and thus need a larger variety of partners to create value beyond their own resources. Furthermore, they are also able to deal with a higher level of complexity (de Leeuw et al., 2014; Duysters et al., 2012;

Faems et al., 2012). Thus, the beneficial coopetitive portfolio configurations may look different for small and large firms, where SMEs (large firms) might rather draw on less (more) complex coopetitive portfolios in order to enhance their chances of innovation.

In addition to making a distinction by firms' size, Weerawardena et al. (2006) emphasize the relevance of also considering the dynamic structure of a firm's operating market when studying collaboration for innovation, because turbulences and uncertainties can encourage firms to collaborate to gain and sustain a competitive edge. An industry can be considered as dynamic if it has a fast product turnover, i.e. the speed of technological change is high, and innovations are introduced at a rapid pace (Belderbos, Carree, Diederen, et al., 2004). Tatarynowicz et al. (2016) highlight that firm's collaboration behavior indeed differs depending on an industry's level of dynamism, where firms in more dynamic markets aim to gain access to a new and diverse set of resources. Accordingly, alliances can be used as a way to cope with the strong dynamism of an industry (Greve et al., 2014).

More particularly, alliances with competitors are relevant to deal with industry dynamism as rivals share similar resources and operate in the same markets, enabling them to share the risks associated to the uncertainty in their industry (Chiambaretto & Fernandez, 2016; Gnyawali & Park, 2011; Ritala, 2012). Moreover, competitors possess product- and industry-specific knowledge (Estrada et al., 2016; Raza-Ullah & Kostis, 2020). Consequently, engaging in coopetition allows firms to enhance the efficiency of their innovation processes, which enables them keep up with their competitors, especially in dynamic markets (Bengtsson & Kock, 2000; Gnyawali & Park, 2009; Nemeh, 2018). While coopetition on its own seems like a highly relevant strategy to cope with industry dynamism, it seems important to consider this at the portfolio level as well. Potential interdependencies between different partner types, additional complexities and access to a more diverse set of resources might affect the success of failure of coopeting. Specifically, in industries that are not overly uncertain and fast changing, firms might be able to handle and benefit from a more complex coopetitive portfolio compared to firms evolving in dynamic environments that might require simpler coopetitive portfolios.

Overall, this reasoning leads us to question whether the coopetitive portfolio configurations that increase the firm innovation differ for small and large firms, and in low and high dynamic industries.

4.3 Data and methods

To investigate the coopetitive portfolio configurations that lead to innovation, we rely on a sample of firms drawn from the Dutch contribution to the Community Innovation Survey (CIS). The CIS is a harmonized survey of firms' innovation activities, collected biannually in member states of the Organization for Economic Cooperation and Development (OECD). The Dutch version is collected by Statistics Netherlands (CBS; Centraal Bureau voor de Statistiek) and consists of firms located in the Netherlands and operating in various industries ranging from pharmaceuticals and automotives to telecommunications and advertising. The included firms also differ in size and available resources, with an average firm size of about 600 employees. Due to its large variety of firms and information on firms' innovation activities, the CIS database has extensively been used to study the impact of collaborations on innovation (see e.g. Estrada et al., 2016; Lhuillery & Pfister, 2009).

Our dataset consists of the CIS waves from 2010, 2012, 2014 and 2016, meaning that we have rather recent data at our disposal, enabling us to give relevant and up-to-date suggestions for practitioners, for example. The initial sample contains 28,802 observations from 19,523 individual firms. In order to ensure better interpretability of the effect of coopetitive portfolios on firm innovation, we exclude duplicate observations from the sample, meaning that we only include one observation per firm. In particular, we use only the first observation recorded per firm, such that if a firm is included in all four waves, we would keep only the 2010 observation, for instance.

The reason for dropping all but one observation per firm is that including multiple observations could result in an over-valuation of certain portfolio configurations, as firms might keep the same collaboration strategy throughout the years. Rather than including their portfolio in the analysis only once, by relying on multiple observations per firm, we would regard their configuration

also multiple times. This could bias the results as a specific configuration could get up to four times as much weight attached to it.[56]

As we are interested in coopetitive portfolios, we select the sample such that it contains only firms that indicate that they collaborate with competitors. This leads to a final sample containing 921 firms with a coopetitive alliance portfolio. Out of those, 753 firms (82%) indicate that they introduced innovations, and 168 (18%) that they did not. Moreover, in Table 4.1, we display the frequencies of the various configurations of firms' coopetitive alliance portfolios. We see that most firms in our sample collaborate with all partner types simultaneously (38%). Moreover, portfolios consisting of competitors, suppliers and customers are also frequently present (13%), as well as collaborating with competitors and suppliers simultaneously (14%). Portfolios including both customers and universities are chosen least frequently (4%).

Table 4.1: Frequencies of different coopetitive portfolio configurations

	Types of partners present in the coopetitive portfolio								**Total**
Competitors	✓	✓	✓	✓	✓	✓	✓	✓	
Suppliers		✓			✓	✓		✓	
Customers			✓		✓		✓	✓	
Universities				✓		✓	✓	✓	
Observations	111	127	38	62	120	79	35	349	921
%	12.05	13.79	4.13	6.73	13.03	8.58	3.80	37.89	100.00

4.3.1 Analytical strategy

To assess how different coopetitive portfolio configurations can generate innovation, we make use of a set-theoretic approach: qualitative comparative analysis. QCA is a configurational approach specifically meant "*to accommodate complex complementarities and nonlinear relationships among constructs*" (Ganter & Hecker, 2014, p. 1287). Rather than viewing each type of collaboration as a separate variable, QCA analyzes the impact of different combinations of

[56] In our dataset, we see that there are very few changes within the portfolio configurations throughout time. In particular, the yearly rate of change lays between 1% and 6%. There are only three exceptions, where the rate of change exceeds 10%. Therefore, we choose not to include more than one observation per firm.

attributes – the different types of alliances in the portfolio – on an outcome variable – firm innovation (Fiss, 2011). This enables us to account for the fact that the result of one type of collaboration often depends on a firm's other collaborations (Laursen & Salter, 2006; Santos, 2021; Wassmer & Dussauge, 2012). Additionally, QCA is well-suited for innovation studies, as it enables researchers to understand the how complex constructs affect a firm's innovation performance (Ganter & Hecker, 2014).

Prior research emphasizes that "*reality usually includes more than one combination of conditions that lead to high values in an outcome condition*" (Woodside, 2013, p. 464), meaning that there is usually an asymmetrical relationship between the different conditions and the outcome (Gilbert & Campbell, 2015). Following this line of reasoning, we rely on the QCA approach, which takes into account equifinality by allowing for various causal paths that lead to the same outcome (Meuer et al., 2015). This enables us to look beyond the mere net effects of individual variables (Gilbert & Campbell, 2015).[57] A few recent contributions have pointed out the relevance of QCA in coopetition studies that are concerned with the creation of joint value in multiparty engagements (Ricciardi et al., in press; Santos, 2021). The approach allows researchers to discover and compare multiple combinations of conditions (here: portfolio configurations) that may result in the same outcome (here: firm innovation), which cannot be demonstrated using correlation-based techniques (Kraus et al., 2016; Woodside, 2013).

There are multiple types of QCA: multi-value-, crisp- or fuzzy-set (Rohlfing, 2020). In crisp sets, the conditions (i.e. variables) are binary, meaning a case is either present or not, i.e., a firm either collaborates with a partner or it does not. Fuzzy-set QCA (fsQCA) assesses the degree to which a case is present/absent in the set, meaning it could illustrate whether firms collaborate with one partner type more intensely than with another. In contrast to this, multi-value QCA (mvQCA) is a generalization of the crisp-set QCA (csQCA) in that it allows for variables to take on multiple values rather than being dichotomous (Rihoux, 2006). Fagerholm (2016) points out that crisp sets are "*the most commonly used QCA technique*" (p. 557), especially in studies that aim to identify distinctions in kind rather than in degree. Since this chapter is concerned with studying the

[57] It lies outside the scope of this chapter to present an extensive overview of the QCA methodology. Rather, please refer to Ragin (2008), as well as Fiss (2011) for more information.

presence/absence of partner types in a coopetitive portfolio (partners are either in or out), rather than the intensity of or experience with collaboration, we decide to rely on csQCA instead of fsQCA or mvQCA.

4.3.2 Variables

Outcome. In this study, we are concerned with how the different types of collaboration within a coopetitive portfolio affect a firm's innovation performance. To assess innovation, the CIS questionnaire asks firms to indicate whether they have introduced services or goods that were new or strongly improved during the two years prior to the collection point.[58] That means, in 2010, the question is concerned with a time frame of 2008 until 2010, and so forth. The variable *firm innovation* is a binary measure, where (1) means the focal firm has introduced new products, and (0) means it did not do so.

Causal conditions. The different types of partners a focal firm collaborates with can be seen as elements in the coopetitive portfolio. To account for this, the CIS questionnaire asks a focal firm to indicate, for each type of partner, whether it collaborated for innovation throughout the past two years. Thus, the 2010-survey asks whether firms have collaborated with either of the four types between 2008 and 2010, the 2012-survey accounts for a period from 2010 until 2012, and so forth. The variables *competitors, suppliers*, *customers*, and *universities* are binary and take value (1) if a firm indicated that it in fact collaborated with the respective type of partner, and (0) otherwise. Because we only investigate coopetitive portfolios, all of our observations take the value (1) for the variable *competitors*.

Contingency factors. Besides running our main analysis on the sample of all coopeting firms, we additionally split this into sub-samples by *firm size* and *industry dynamism*. To account for firm size, we follow the definition issued by the OECD (2005, p. 17): SMEs have less than 250 employees, and large firms have at least 250 employees. Moreover, we measure industry dynamism by dividing

[58] This outcome variable contains both new-to-the-firm (incremental) and new-to-the-market (radical) innovations. When distinguishing between the two types, the csQCA does not return any solutions that meet the consistency requirement as outlined in Section 4.3.3. With regards to radical and incremental innovation, it means that the share of any coopetitive portfolio configurations that leads to either type of innovation is not significantly higher than 75%. Similarly, when defining the outcome variable based on the share of innovation sales (high vs. low, split at the median), we do not detect solutions that meet the consistency requirement either.

the sales in the industry due to radical innovations by total sales in the industry (Belderbos, Carree, Diederen, et al., 2004). Then we construct a dummy variable that measures high (1) and low (0) dynamism and use the median of industry dynamism (0.038) as cut-off point.

4.3.3 Data analysis strategy

The first step of any QCA analysis is to create a truth table of 2^k rows that illustrate "*all possible configurations of attributes that are sufficient to generate an outcome*" (Torugsa & Arundel, 2017, p. 904), where k is the number of attributes. In our analysis, the individual attributes refer to collaboration with the different partner types (suppliers, customers, universities) in addition to coopetition, resulting in a truth table of $2^3 = 8$ rows (see Table 4.2). The solutions in a truth table illustrate the most complex solutions because they all have some overlap in terms of presence or absence of the conditions (Grofman & Schneider, 2009; Skaaning, 2011). Yet, this does not provide any specific insights regarding the necessity of certain attributes in the configuration to achieve the outcome.

In order to identify the relevant coopetitive portfolio configurations, QCA makes use of Boolean algebra to reduce the solutions in the truth table so that they include only the components required for the outcome (Ault & Spicer, in press.; Fiss, 2011; Muñoz et al., in press). Intermediate solutions provide a balance between parsimony and complexity (Ragin, 2008), which makes them superior (Kraus et al., 2016). Intermediate solutions contain core and peripheral conditions (Ault & Spicer, in press.; Fiss, 2011; Santos, 2021). Core conditions are those collaborations that are necessary to achieve innovation but are not sufficient on their own; rather, they require the peripheral conditions to get to the outcome.

To determine the intermediate solutions, it is necessary to choose a consistency level and a minimum coverage threshold (Torugsa & Arundel, 2017). As we are working with crisp sets, the consistency level illustrates the share of the suggested solutions that leads to the outcome variable (Ragin, 2008). In the case at hand, this refers to the proportion of a given coopetitive portfolio configuration that leads to innovation. Following McKenny et al. (2018), we select a minimum consistency level of 0.75 for our analysis. By contrast, coverage is "*the number (proportion) of cases with Y where we also find X, relative to all cases with Y*" (Grofman & Schneider, 2009, p. 665). In this chapter, that refers to the number

of firms with innovation, for which we also find the specific coopetitive portfolio configuration, relative to all firms with innovation.

Table 4.2: Truth table

Solution	Competitors	Suppliers	Customers	Universities	Consistency	Number of firms
1	●	○	○	○	0.730	111
2	●	○	○	●	0.726	62
3	●	○	●	○	0.895	38
4	●	○	●	●	0.829	35
5	●	●	○	○	0.717	127
6	●	●	○	●	0.810	79
7	●	●	●	○	0.842	120
8	●	●	●	●	0.883	349

Note: Filled circles indicate presence of a partner in the portfolio, while empty circles display the absence of a partner. Outcome = firm innovation

Besides overall coverage, Ragin (2008, p. 67) points out that when multiple solutions lead to an outcome, it is relevant to assess the raw and unique coverage of each of the combinations to assess the empirical weight of the individual configurations. Raw coverage illustrates how much of the outcome is covered by each of the portfolio configurations. It can be calculated as the "*sum of overlap*" between each solution and the outcome divided by the "*sum of memberships in the outcome*" (i.e. the number of firms that do introduce innovation). Unique coverage only takes into account the coverage of the path that is unique to that solution and does not overlap with any other configurations (Ragin, 2008, pp. 64–66).[59]

In contrast to the minimum consistency level, we do not select a coverage threshold, due to the large number of observations in our sample. As shown in Tables 4.1 and 4.2, there are at least 35 firms per configuration, which is much higher than the minimum threshold often chosen in prior research (see e.g. Ganter & Hecker, 2014). In addition to that, Torugsa and Arundel (2017) emphasize that it is more important to achieve high consistency than high coverage.

[59] As a result of not counting the overlapping parts, unique coverage may be relatively small.

4.3.4 Descriptive statistics

An overview of the descriptive statistics of the variables described above, as well as their pairwise correlations, is provided in Table 4.3. We see that roughly 82% of firms in the sample introduce innovation. As we include only coopeting firms in the sample, this high level of innovation is plausible.[60] In addition, we observe that coopeting firms are also likely to collaborate with other partner types. Approximately 73% engage in collaboration with suppliers, 59% with customers, as well as 57% with universities, and the different partner types are positively and significantly correlated. Firm size and all types of collaboration are positively correlated, indicating that bigger firms have a higher propensity for collaboration. Industry dynamism and university collaboration are positively correlated and so are the three respective partner types and firm innovation.

Table 4.3: Descriptive statistics and pairwise correlations

	Mean	SD	(1)	(2)	(3)	(4)	(5)
(1) Innovation	0.818	0.386					
(2) Suppliers	0.733	0.443	0.077*				
(3) Customers	0.589	0.492	0.165*	0.358*			
(4) Universities	0.570	0.495	0.095*	0.214*	0.334*		
(5) Firm size	0.255	0.436	-0.007	0.128*	0.115*	0.242*	
(6) Industry dynamism	0.658	0.475	0.140*	-0.047	-0.003	0.137*	0.013

Note: We do not include descriptive statistics for competitor collaboration, as all firms in the sample coopete. N = 921; * $p < 0.05$

4.4 Results

In Table 4.4, we display the findings of our analyses. Black and white circles demonstrate the presence and absence of a condition in a coopetitive portfolio, and by means of circle size highlight core and peripheral conditions. The different columns represent the solutions provided by the csQCA that meet the consistency requirement of 0.75 ($p < 0.05$). In the subsequent sections we elaborate on the solutions displayed in the table.

[60] Despite the high level of cases with product innovation, there remains enough variation in the dependent variable as still 18% of cases do not achieve innovation. This distribution remains similar for SMEs and large firms, as well as for firms operating in low- and high-dynamic industries.

Table 4.4: Intermediate solutions for firm innovation

	Overall		Firm size			Dynamism	
			Small		*Large*	*Low*	*High*
	1	2	3	4	5	6	7
Competitors	●	●	●	●	●	●	●
Suppliers		●		●	●	●	
Customers	●	●	●	●	●	●	●
Universities	○		○		●	●	
Raw coverage	0.179	0.543	0.203	0.496	0.602	0.393	0.618
Unique coverage	0.045	0.409	0.050	0.343	0.602	0.393	0.618
Consistency	0.854	0.872	0.870	0.875	0.891	0.836	0.902
Solution coverage	0.588		0.546		0.602	0.393	0.618
Solution consistency	0.874		0.875		0.891	0.836	0.902

Black circles (●) indicate the presence of a partner type in the coopetitive portfolio, and white circles (○) indicate its absence. Large circles display core conditions, small circles indicate peripheral conditions. Blank spaces illustrate "don't care" conditions, i.e., it does not matter for firm innovation whether collaboration with those partner types takes place within this coopetitive portfolio configuration.

4.4.1 Full sample analysis

Solutions 1 and 2 present the coopetitive portfolio configurations (leading to firm innovation) based on the entire sample. We find that cooperating with competitors is not sufficient to yield innovation, but it is necessary to also cooperate with customers. However, having customers in a firm's coopetitive portfolio does not automatically generate innovation, which means that the peripheral conditions also matter. Solution 1 shows that a coopetitive portfolio including customers should not include universities when the presence of suppliers is not given. By contrast, Solution 2 reveals that when the coopetitive portfolio includes both customers and suppliers, the presence or absence of alliances with universities does not have an impact on firm innovation. Overall consistency Solutions 1 and 2 is 0.874, indicating that in more than 87% of the cases, the suggested portfolio configurations lead to innovation. Moreover, the overall solution coverage is 0.588, meaning that – relative to all firms with innovation – for more than half of the firms with innovation we also find the suggested portfolio configurations.

4.4.1.1 Coopetitive portfolios of small vs. large firms

We subsequently run the analysis on the sub-sample of SMEs (686 firms) and on the sub-sample of large firms (235 firms), respectively. Solutions 3 and 4

show the possible coopetitive portfolio configurations for SMEs to achieve innovation that meet our consistency requirements. We note that the suggested solutions for SMEs are the same as the ones we identified for the overall sample. In other words, to develop innovation, SMEs either collaborate with competitors and customers but not with universities, or collaborate with competitors, suppliers, and customers and possibly universities. The suggested configurations achieve a high consistency of 0.875 and overall coverage of 0.546, meaning that in 87.5% of the cases the solutions lead to the outcome, while the two configurations can be observed in 54.6% out of all firms that have innovation.

With regards to large firms, there is only one solution found in firms with innovation (Solution 5), which suggests that firms should collaborate with all four partner types in order to achieve innovation. The proposed configuration has a high consistency with 0.891, i.e., in 89% of the cases, large firms collaborating with all four partner types develop innovation. Moreover, the solution also has a high coverage of 0.602, meaning that more than 60% of large firms with innovation collaborate with all four partner types simultaneously.

4.4.1.2 Coopetitive portfolios of firms in low- vs. high-dynamic industries

Besides firm size, we also use industry dynamism to divide our overall sample into two sub-samples based on the procedure outlined in Section 4.3.2. The first sub-sample contains 315 firms operating in industries which score lower than the median in terms of industry dynamism. The second sub-sample contains 606 firms operating in highly dynamic industries (i.e., score higher than the median). We find one solution for each of the two samples, respectively, that meets the consistency requirement.

Solution 6 highlights that firms in low-dynamic industries with all partner types in their coopetitive portfolio achieve innovation. This means that firms engaging in coopetition also need to collaborate with suppliers, customers and universities simultaneously, in order to be able to introduce new products. The suggested configuration achieves a high consistency of 0.836, and total coverage of 0.393 meaning that in 83.6% of the cases the solution leads to the outcome, while out of all firms that have innovation, we find this configuration for 39.3%.

When looking at firms operating in high-dynamic industries, we also observe one solution (Solution 7). Table 4.4 reveals that to develop innovation in dynamic industries, firms need to include customers in addition to competitors in their portfolio, while the presence or absence of suppliers and universities does not matter. The solution has high consistency of 0.902 meaning that in more than 90% of the cases, firms with innovation collaborate with customers and competitors simultaneously. Moreover, the solution has a relatively high coverage of 0.618, which means that we find that out of those firms that do achieve innovation, we find that roughly 62% include customers in their coopetitive portfolio.

4.4.2 Supplementary analyses

In order to gain further insights into which coopetitive portfolio configurations can be found in innovating firms, we perform some supplementary analyses. Specifically, we attempt to expand the original sample of 921 firms, as we initially restricted the selection procedure rather conservatively. Therefore, instead of only considering one observation per firm, we additionally aim to make use of the time-aspect inherent to our dataset by including firms multiple times in the sample if they changed their portfolio configuration over time. This means we exclude those firms that have the same coopetitive portfolio configuration in more than one of the years they are present in the data. If a firm is present in all four survey years and collaborates with competitors and suppliers in e.g. two of those years, we only keep the firm observation in the sample one time. However, if a firm that is present in all four years collaborates with competitors and suppliers in one year, and adds customers to the portfolio in another year, we include both of those firm-observations in the sample, treating them as separate cases. This results in a final sample of 1,244 observations.

Running the main analysis on this sample, we find that firms achieve innovation if they include suppliers and customers in their coopetitive portfolio (Solution 1, Table 4.5). When further distinguishing between small and large firms, we observe that SMEs benefit from collaborating with suppliers and universities, or suppliers and customers in addition to competitors (Solutions 2 & 3, Table 4.5). Large firms, however, need to include all partner types in their coopetitive portfolios in order to achieve innovation (Solution 4, Table 4.5).

When considering the industry's dynamism, the analysis does not suggest any coopetitive portfolio configurations that meet our consistency requirements in less dynamic markets. Similar to the solutions provided for large firms, when operating in high-dynamic industries, firms achieve innovation if they include suppliers or universities, or suppliers and customers in their coopetitive portfolio (Solutions 5 & 6, Table 4.5).

Generally, we observe that besides customers, the role of suppliers and universities seems to receive more weight with regards to firm innovation. In fact, suppliers are included in each of the suggested coopetitive portfolio configurations of firms with innovation. In line with earlier findings, when universities are present in the portfolio, suppliers are too. Moreover, we find that customers and suppliers are a common combination in coopetitive portfolios.[61] In each scenario of firms with innovation, customers and suppliers are one of the suggested solutions (or part of the suggested solution as for large firms). These results strengthen our main analyses, in which we find that customers play an essential role in coopetitive portfolios for innovation. Furthermore, this supplementary analysis sheds more light on the ambiguous role of suppliers and universities discovered in the main analysis already, as we find that including suppliers in the portfolio gains additional importance, while university collaboration still seems to be dependent on the presence of supplier collaboration.

Interestingly, the findings of the analysis using this bigger sample do not exactly match the findings of the original analyses. In particular, this supplementary analysis suggests less variety of coopetitive portfolio configurations in innovating firms, but more complexity within the portfolios; all solutions in Table 4.5 contain at least three partner types. A possible explanation for this is that firms build up experience in managing alliances, potentially driving them to add more alliance partner types to their portfolio over time (Duysters et al., 2012). Furthermore, the collaboration measures are based purely on the presence or absence of a type of partner rather than the exact number of partners of one specific type. Therefore, when firms include an additional partner type in their coopetitive portfolio, they might reduce but not

[61] This finding is in line with research on persistence of alliances, which reasons that a strong alignment of those collaboration types can enable firms to reap the benefits of value chain integration (Belderbos et al., 2012).

completely abandon another one. However, this might result in an over-representation of more complex portfolios among the newly added observations.[62]

Table 4.5: Intermediate solutions for firm innovation (bigger sample)

	Overall	Firm size			Dynamism	
		Small		*Large*	*High*	
	1	2	3	4	5	6
Competitors	●	●	●	●	●	●
Suppliers	●	●	●	●	●	●
Customers	●		●	●		●
Universities		●		●	●	
Raw coverage	0.537	0.402	0.492	0.571	0.495	0.534
Unique coverage	0.537	0.073	0.163	0.571	0.096	0.135
Consistency	0.843	0.841	0.850	0.852	0.864	0.881
Solution coverage	0.537	0.565		0.571	0.630	
Solution consistency	0.843	0.853		0.852	0.875	

Note: N = 1244; Black circles (●) indicate the presence of a partner type in the coopetitive portfolio, and white circles (○) indicate its absence. Large circles display core conditions, small circles indicate peripheral conditions. Blank spaces illustrate "don't care" conditions, i.e., it does not matter for firm innovation whether collaboration with those partner types takes place within this coopetitive portfolio configuration.

4.4.2.1 Fuzzy-set QCA

Rohlfing (2020) suggests that "*researchers should only conclude that no set relation exists for the relationship of interest if no consistent relation is found with either set type*" (p. 77). Therefore, we decide to additionally perform the main analysis as fsQCA. Instead of determining presence or absence of conditions in a configuration, fuzzy sets consider the degree of membership that leads to the outcome (McKenny et al., 2018). In the case at hand, fsQCA can therefore account for high or low levels of collaboration with the different types of partners, rather than merely the presence of a partner in the coopetitive portfolio, when firms aim to achieve innovation.

[62] While this exercise provides interesting insights, we choose to keep the focus of this chapter around the conservative sample of 921 observations. Neverthelees, we acknowledge that this supplementary analysis supports the general notion of our initial findings and sheds additional light on the role of different coopetitive portfolio configurations in innovating firms.

Variables are calibrated into fuzzy sets using so-called anchors, which range between a minimum (fully out of the set) and maximum (fully in the set). A distinction between a condition being in or out of the set is made at a crossover point: anything above the crossover is considered to be more in than out of the set, and anything below the crossover is more out of than in the set (see e.g. Kraus et al., 2016; McKenny et al., 2018; Ragin, 2008, p. 32). In terms of collaboration with the different partner types, this would mean that firms with values above (below) the crossover have high (low) levels of collaboration with that partner. In order to determine the calibration anchors, we follow prior literature that suggests using the 10th percentile as minimum, the median as crossover and the 90th percentile as maximum point (Meuer et al., 2015; Santos, 2021; Torugsa & Arundel, 2017). Table 4.6 displays the specific values used for the calibration of the different partner types.

Table 4.6: Calibration anchors

Variable	Lower anchor	Crossover point	Upper anchor
Supplier collaboration	0.00	0.50	1.00
Customer collaboration	0.00	0.50	1.00
University collaboration	0.00	0.50	1.00

Note: Lower anchor = 10th percentile, crossover point = 50th percentile, upper anchor = 90th percentile

To create the fuzzy sets, we first construct a share of collaboration with each of the partner types over the amount of years a firm is included in the data set, respectively. In particular, we calculate the total sum of the binary collaboration variables and divide this sum by the amount of years to create a share of collaboration between 0 (none at all) and 1 (collaboration in each of the years). For a firm that is present in the 2010, 2012 and 2014 surveys, and collaborates with a supplier in two out of those three years, the share for supplier collaboration would be two divided by three (0.67), for instance. In this way we calculate one share of collaboration per partner type for each individual firm. Using the anchors illustrated in Table 4.6, we then calibrate the collaboration shares into fuzzy sets. Specifically, if the share of collaboration is below the crossover point, the type of collaboration partner would be considered more out

than in the set (here: the coopetitive portfolio). If the share is above the crossover point, then the partner type would be regarded as more in than out.[63]

For our analysis, we include all firms with a high level of coopetition that are present in multiple[64] of the survey waves considered for this chapter, meaning we keep all firms that appear at least twice and at most four times in the dataset. We generate the shares of collaboration for each of those firms as outlined above. As we are interested in coopetitive portfolios, we subsequently keep those firms that coopete in the sample, and specifically only those with high levels of coopetition, i.e., their share of coopetition bigger than or equal to the median (0.5). Ultimately, we keep only one observation per firm in the analysis, as the collaboration share does not change per individual firm over time. Following this selection procedure as above, we obtain a sample of 372 firms.

The fsQCA suggests that firms achieve innovation regardless of the detailed composition of their coopetitive portfolio. Therefore, no intermediate or reduced solutions can be presented for this overall sample in Table 4.7. Nevertheless, the analysis provides some further insights when we distinguish between SMEs and large firms. SMEs, on the one hand, can benefit from high levels of either customer and university collaboration, supplier and university collaboration, or supplier and customer collaboration (Solutions 1, 2 & 3, Table 4.7). Those findings emphasize the conclusion we drew in the main analysis as well: coopetitive portfolios of SMEs need not be too complex, for instance due to limited managerial capacity and financial resources. In fact, the solutions in Table 4.7 underline that only two additional partner types need to be added to coopetition. Large firms, on the other hand, achieve innovation if they include high levels of collaboration with customers in their coopetitive portfolio (Solution 4, Table 4.7). While this only displays partially what we find for large firms in the main analysis, it does put additional emphasis on the role of customers for innovation. The main analysis suggests that large innovating firms make use of all partner types in their coopetitive portfolios. Considering the degree of collaboration, however, it becomes clear that customers are the most

[63] Please refer to Longest and Vaisey (2008) for a more detailed description of the calibration procedure.

[64] We do not include those firms that only appear in one survey year as they would only be present in the extremes of the sets (either fully in or fully out), rather than displaying behavior over time.

relevant, while suppliers and universities do not matter. This is in line with the general notion of customer relevance in our main findings. With regards to industry dynamism, the fsQCA does not suggest any solutions that meet the consistency requirements. Therefore, no results are presented in Table 4.7.

Table 4.7: Intermediate solutions for firm innovation (fsQCA)

	Firm size			
	Small			*Large*
	1	2	3	4
Competitors	●	●	●	●
Suppliers		●	●	
Customers	●		●	●
Universities	●	●		
Raw coverage	0.343	0.383	0.400	0.544
Unique coverage	0.024	0.064	0.081	0.544
Consistency	0.822	0.828	0.816	0.878
Solution coverage		0.488		0.544
Solution consistency		0.827		0.544

Black circles (●) indicate the high levels of collaboration with a partner type in the coopetitive portfolio, and white circles (○) indicate low levels. All conditions are core conditions in this table. Blank spaces illustrate "don't care" conditions, i.e., it does not matter for firm innovation whether collaboration with those partner types takes on high or low levels within this coopetitive portfolio configuration. For the overall sample, all eight portfolio configurations are found in innovating firms. Therefore, no reduced solutions for the overall sample are provided here, as the introduction of firm innovation is not dependent on the coopetitive portfolio composition. In the case of low vs. high dynamism, no solutions meet the consistency requirement of 0.75.

While not all of the findings of the fsQCA match those of the csQCA, this supplementary analysis provides more insights into the portfolio constellations beneficial for SMEs and large firms. In fact, we are able to further support our initial findings with this additional evidence. Crisp sets only account for a snapshot into firms' collaboration behavior but using the fuzzy sets we are able to incorporate firms' actions over time. Particularly, we show that not just mere presence or absence matters, but rather the extent to which the type of partner is included in the coopetitive portfolio. Rohlfing (2020) highlights that for the relationship of interest, fsQCA and csQCA in fact do not necessarily lead to the same outcome. Therefore – while the findings of the fuzzy-set analysis provide

further insights – it is not surprising that they do not exactly match the results displayed by our main analyses.

4.4.3 Robustness checks

In order to ensure robustness of our findings, we perform additional analyses. First, building on previous contributions that implement robustness checks in QCA, we specifically aim to discover which portfolio configurations are present in firms that do not introduce any innovation. This assesses the robustness, as the "*set-theoretic approach assumes causal asymmetry*" (Speldekamp et al., 2020, p. 10), meaning that portfolio configurations in firms with innovation should not be present in those without innovation. However, the reverse of the configurations leading to an outcome are not necessarily the same leading to a lack of the outcome (Fiss, 2011). This means that combinations that result in no innovations being introduced are not exactly the reverse of those resulting in firm innovation. Running the main analysis with a reversed firm innovation variable[65] as outcome, we do not find any configurations that meet our consistency requirement of at least 0.75. The findings for introduction of firm innovation and no introduction of firm innovation are thus not driven by the same coopetitive portfolio configurations. Therefore, we can conclude that there is no portfolio configuration that consistently and significantly leads to both the presence and absence of innovation, which renders our original findings robust in this respect.

Second, to further assess robustness, we perform a logit regression on the full sample of firms ($N = 921$), using firm innovation as dependent variable, and the eight different configurations of the coopetitive portfolios as independent variables.[66] In doing so, we are able to determine the net effect of each portfolio configuration on innovation, allowing us to compare whether those effects are in line with the findings provided by the QCA. To identify this net effect, we construct a binary measure for each of the eight configurations, which takes value (1) if the specific configuration occurs, and (0) if not. If a firm collaborates with competitors, suppliers and customers but not universities, the specific configuration takes value (1) for instance. Generally, we find that customers play

[65] Here, (1) denotes no innovation and the variable takes value (0) if the firm introduced product innovation.
[66] The results of this analysis can be found in Table A4.1 in the Appendix.

an essential role for achieving innovation within coopetitive portfolios. This supports the findings of our main analyses and highlights the importance of customers as collaboration partner. Furthermore, the configurations including universities are insignificant, unless all other partner types are also included in the portfolio. This further emphasizes the ambiguous role of university collaboration that we also identify in the main analyses. Overall, the findings of the logit regression are in line with the main findings of our initial analyses, lending support to their robustness.

4.5 Discussion

This chapter studies the complexities of collaborating for innovation by investigating the role of coopetitive alliance portfolios for firms that introduce innovation. In particular, we emphasize that different portfolio configurations are beneficial for firm innovation. Accordingly, carefully selecting and combining the different types of partners in an alliance portfolio influences the innovation performance (Duysters et al., 2012; Lee et al., 2017). Nevertheless, research considering the configurations of coopetitive portfolios is still scarce, despite the specific tensions inherent to coopetition that may have an impact on the portfolio performance (Chiambaretto & Fernandez, 2018). With the help of crisp-set QCA, we analyze 921 coopeting firms to shed light on their coopetitive portfolio configurations. In the following, we interpret the findings of the various analyses performed, and discuss them in light of existing literature. Subsequently, we formulate propositions[67], summarizing the key take-aways of our analyses.

4.5.1 Interpretation of main findings

Our findings reveal that including customers in a coopetitive portfolio is a necessary (but not sufficient) condition for firms to be able to achieve innovation. The importance of the joint presence of competitors and customers supports the findings of Belderbos et al. (2006), who – with regards to productivity – discover that customers and competitors are complementary partners. The relevance of customers in alliance portfolios is also in line with the open innovation literature. In particular, Kang and Kang (2010) argue that

[67] Due to the exploratory nature of the QCA methodology, the formulation of propositions is a common choice in research drawing on this type of analysis (see e.g. Ferrigno et al., 2020; Speldekamp et al., 2020; Zheng et al., 2021).

customers are a main collaboration partner for firms wanting to achieve innovation, as customers know their own wants and needs. In the same vein, Dittrich et al. (2007) or Greer and Lei (2012) highlight that customers are often involved in alliance portfolios to foster the innovation process as they can provide good insights into what they like and dislike. Moreover, customer collaboration can be used as a tool to diminish risks associated to innovation. Specifically, uncertainties regarding market introduction can be diminished, as customers can provide feedback about products (Kang & Kang, 2010). Examples of firms relying on customers' knowledge in their innovation process are lead-user analysis (Franke et al., 2006; Schreier & Prügl, 2008), the usage of customer groups' insights (Antikainen et al., 2010) or the design thinking process (Beckman & Barry, 2007).

Coopetition is more concerned with sourcing input from competing firms (and thus other competing producers) rather than users. Knowledge acquired from competitors can help firms improve their innovation processes and is often product- and market-specific, further enabling them to better handle industry risks (Estrada et al., 2016; Ritala & Hurmelinna-Laukkanen, 2013). Firms collaborating with both competitors and customers are thus able to improve innovation processes using competitors' knowledge, and at the same time enhancing the actual product or service with the help of customers' insights. While the presence of competitors and customers in the alliance portfolio does matter, it is their joint presence that generates synergies in the portfolio (Parise & Casher, 2003). As both types of partners provide access to different but complementary external resources, the focal firm can recombine and orchestrate these external resources to generate innovation that could not have been achieved with only one of their partners (Castro & Roldán, 2015; Wassmer & Dussauge, 2011). Based on this we propose the following:

> ***Proposition 1a:*** *Firms can introduce innovations by combining alliances with competitors and alliances with customers in their coopetitive portfolio.*

However, on its own, collaborating with customers in addition to competitors is not sufficient for achieving firm innovation. Specifically, we find that supplier collaboration also plays an important role, particularly in interaction with universities as partners. We observe that if a firm has a supplier in its alliance portfolio, a university can also become part of it, but does not have to. If

suppliers are not part of the portfolio, however, collaborating with universities could in fact even be harmful for innovation. This is in line with Belderbos et al. (2006), who find that collaboration with universities and collaboration with competitors are sub-additive, and combining them could actually be harmful for productivity, which can affect firm performance. Specifically, the authors highlight that knowledge generated from collaborating with universities can unintentionally spill over to competitors (Belderbos et al., 2006). Furthermore, Kang and Kang (2010) highlight that knowledge created by universities is often "*on the cutting edge of contemporary knowledge and technology*" (p. 951), which in turn might be difficult for firms to understand and interpret, as firms and universities come from very different domains (Rajalo & Vadi, 2017). Moreover, Un et al. (2010) mention that university spillovers might be so broad that they help firms improve their innovation processes but are difficult to immediately use within the industry. In line with this, Belderbos et al. (2006) highlight that university knowledge is often targeted at achieving radical innovation. However, this might interfere with coopetition, which is often rather geared at incremental innovation (Ritala & Hurmelinna-Laukkanen, 2013). This discrepancy between goals of the respective collaboration strategies might cause the combination of competitors and universities to become harmful for innovation overall (Cassiman et al., 2009). Moreover, Nieto and Santamaría (2007) point out that collaboration with suppliers is often connected with cost reduction and input quality improvement. As reasoned above, university knowledge is complex and not suited for immediate usage but first needs to be translated properly (Un et al., 2010). Following our findings, it seems that suppliers might take on the role of decoder and translate the (novel) knowledge generated by universities, making it more accessible. This is also in line with the reasoning in prior research (see e.g. Bonaccorsi & Lipparini, 1994; Cassiman et al., 2009). Taking advantage of the presence of universities in the coopetitive portfolio might be too complex as they generate more coordination costs with limited short-term benefits for the focal firm. However, suppliers seem to be able to help the focal firm in absorbing the knowledge created by universities. Based on this argumentation, we propose the following:

> ***Proposition 1b:*** *Firms can introduce innovations by combining alliances with competitors and alliances with customers in their coopetitive portfolio, while simultaneously collaborating with suppliers and universities. However, the introduction*

of innovation can be hampered by including universities in coopetitive portfolios when the presence of suppliers is not given.

4.5.1.1 Small vs. large firms

Following Chiambaretto et al. (2020) and Morris et al. (2007), firms derive different benefits from coopeting and collaborating, depending on their size. Interestingly, we find the same solutions for SMEs as for the overall sample, meaning that their coopetitive portfolios need to contain customers in order for them to achieve innovation, but can only include universities if suppliers are also present. One reason for that could be that SMEs do not necessarily have the absorptive capacity to appropriate knowledge provided by universities on their own (Howells et al., 2012; Laursen & Salter, 2004; Yang et al., 2014). Moreover, Subramanian et al. (2018) show that small firms benefit from homogeneity of knowledge, meaning that they draw on similar knowledge as their partner. The novel knowledge provided by universities might in turn be too different to absorb on their own. Therefore, SMEs seem to require suppliers to be present in their coopetitive portfolio if they want to collaborate with universities. Another explanation for the similarity in findings could be the fact that the majority (about two thirds) of firms in the overall sample are considered to be SMEs. Generally, we observe that SMEs do not make use of coopetitive portfolios consisting of all four partner types. Instead, SMEs tend to collaborate out of necessity to survive and therefore focus only on those partners that can provide them with the resources to do so (Tokman et al., 2020). Here, customers for instance can help greatly in providing insights into specific needs and wants.

For large firms, we find that the only significantly consistent solution suggests that all partner types need to be included in the firm's alliance portfolio to achieve innovation. Therefore, compared to SMEs, large firms in our sample need to collaborate with competitors, suppliers, customers and universities simultaneously to introduce innovation. Research investigating alliances formed by large firms highlights that such firms usually have more capacity and financial resources for alliance management than SMEs, meaning they are able to handle the complexities posed by multiple alliances (de Leeuw et al., 2014; Duysters et al., 2012; Faems et al., 2012). In particular, large firms are able to diversify risks, and better exploit and absorb diverse knowledge (Nooteboom et al., 2007; Schmidt, 2010). Additionally, such firms generally do not have as much of a need

to collaborate for innovation, as do SMEs, because their innovation processes and resource bases are more extensive (Baum et al., 2000; Nieto & Santamaría, 2010). Instead, large firms might use collaborative efforts to extend their network in order to increase exploration options necessary for developing new products (Yamakawa et al., 2011). More diverse alliance portfolios consisting of all four partner types can help to get this exposure and achieve innovation. Following the above reasoning, we can formulate the following proposition:

Proposition 2: *The coopetitive portfolio configurations in firms with innovation differ for SMEs and large firms. Large firms can introduce innovation by including all types of partners simultaneously in their coopetitive portfolio. By contrast, SMEs can introduce innovation by gathering customers and suppliers in their coopetitive portfolio, while the presence of universities becomes beneficial only if suppliers are also present.*

4.5.1.2 Low vs. high industry dynamism

For firms in less dynamic markets, we find that all partner types need to be included in the coopetitive portfolio to achieve innovation. Such markets typically have a relatively slow speed of product turnover, meaning that innovations are not introduced to the market at a rapid pace (Ritala, 2012). In such circumstances, firms are able to manage more complex alliance portfolios because they do not need to develop innovations quickly. By collaborating with all four partner types simultaneously they can rather extend their network and accumulate more knowledge, without the pressure of having to apply this knowledge to innovations immediately. Similar to Greve et al. (2014), we argue that having many different types of partners allows for a more diversified sourcing of new ideas and technologies. Naturally, it requires proper alliance portfolio management capacities (such as absorptive capacity) to understand and integrate those new ideas, leaving less managerial capacity to handle industry pressures (Castro & Roldán, 2015; Faems et al., 2012). In line with this, we argue that low-dynamic industries are also characterized by lower levels of uncertainties, meaning that less resources need to be spent on managing those uncertainties. Such resources can rather be invested in managing the complexities of a diverse coopetitive portfolio.

By contrast, when industry dynamism is high, firms need to collaborate with competitors and customers to achieve innovation. Including suppliers or universities in the coopetitive portfolio does not alter the effect of combined

competitor and customer collaboration for firm innovation. This can be explained by the definition of industry dynamism. In particular, industry dynamism refers not only to the speed at which changes occur in the industry but subsequently also to the fact that the technologies used in the industry change often (Belderbos, Carree, Diederen, et al., 2004; Ritala, 2012). As such, a high industry dynamism requires the ability to react quickly and thus to limit the transaction costs associated to many different types of partners in the coopetitive portfolio (Greve et al., 2014; Nemeh, 2018). Put differently, when firms need to be able to introduce new products quickly, having too many partner types in a coopetitive portfolio seems to slow down their innovation process, so that the simplest (yet efficient) configuration will be chosen: competitors and customers. Here, customers are the efficient choice, as they help greatly in reducing uncertainties that could hinder the successful introduction of new products. The results further suggest that the presence or absence of universities and suppliers is irrelevant for the solution to lead to the outcome. Moreover, Tether (2002), as well as Belderbos, Carree, Diederen, et al. (2004) argue that collaboration with customers is key to developing new-to-the-market innovations. Being able to develop such radical innovations naturally enables firms to keep up with the rapid pace of change in their industry. Following the above line of argumentation, we propose the following:

Proposition 3: *The coopetitive portfolio configurations in firms with innovation differ depending on the level of industry dynamism. In industries with low dynamism, firms can introduce innovations by including suppliers, customers and universities in their coopetitive portfolio. By contrast, firms in industries with high dynamism can introduce innovation by combining alliances with competitors and alliances with customers in their coopetitive portfolio, while the presence of universities and suppliers is not relevant.*

4.5.2 Theoretical contributions

Our study on coopetitive portfolio configurations contributes to the literature on coopetition and innovation in multiple ways. This research sheds new light on the existing literature regarding the impact of coopetition on innovation by underlining the importance of reasoning at the coopetitive portfolio level. While prior contributions have investigated the innovative impact of coopetition at the dyadic or agreement level (Gast et al., 2018), our research confirms the importance of analyzing this impact at the coopetitive

portfolio level (Chiambaretto & Fernandez, 2018; Park et al., 2014). Indeed, our findings reveal that coopetition alone does not yield superior firm innovation performance and that it always has to be combined, at least, with customers in the coopetitive portfolio. In other words, contrary to previous research, we show that coopetition alone is not necessarily beneficial for firms, but that firms achieve innovation by including additional partner types in their coopetitive portfolios.

Furthermore, to explain the specific role of the benefits and risks in such coopetitive portfolios, we draw on the theoretical notions underlying the resource-based view (RBV) and the transaction cost economics (TCE). We reason that firms engage in collaboration with multiple types of firms simultaneously because this allows them access to a broad variety of resources. Here, competitors are identified as especially relevant collaboration partners due to the resource compatibility, allowing for the creation of synergies. Yet, we also acknowledge the risks related to spillover of information within such alliance portfolios. Coopetition on its own is likely to encourage opportunism, as collaboration partners remain competitors (Cygler et al., 2018; Raza-Ullah et al., 2014; Tidström, 2014), and those risks are likely to transfer to the portfolio level (Chiambaretto & Fernandez, 2018). The added complexities caused by the need to manage multiple alliances simultaneously might even strengthen these risks (de Leeuw et al., 2014). We therefore contribute to current coopetition and alliance portfolio literature by emphasizing that the theoretical notions of RBV and TCE are particularly relevant on the portfolio level. The benefits of resource exchange can potentially increase at a portfolio level where firms engage in a variety of alliances and gain access to even more resources. However, the additional managerial complexity of alliance portfolios can also foster the risks inherent to such resource exchange. This is especially threatening when considering coopetitive portfolios, where (some) partners are also competitors that tend to behave opportunistically.

Moreover, this chapter answers the call of recent research to identify better how different partner types interact with one another in coopetitive portfolios (Chiambaretto & Fernandez, 2018). Using crisp-set QCA, we underline the diversity of causal paths leading to firm innovation (Speldekamp et al., 2020). We demonstrate that there are multiple coopetitive portfolio configurations present in firms that introduce innovation. We further show that the presence

of some partner types in the coopetitive portfolio does not automatically yield innovation. For instance, we reveal that the presence of universities is beneficial only if suppliers are also part of the coopetitive portfolio. This is an important contribution to the coopetition literature, as the effects of the individual collaborations are often not considered as a whole. Relying on crisp-set QCA, we illustrate that it is crucial to investigate the interplay of the different partner types and allow for multiple configurations to lead to the outcome, as has previously been touched upon by e.g. Belderbos et al. (2006). In addition to that, by employing QCA, we further contribute to the existing body of strategic management literature in emphasizing the relevance of continuously drawing on rather novel or unconventional methodology. In doing so, we follow calls from Koppman and Leahey (2019) who point out that "*breaking from tradition is necessary for the advancement of scientific knowledge*" (p. 1).

Besides, this research enriches the debate concerning the importance of contingency variables to assess the impact of coopetition on innovation. We highlight that there is no "one size fits all" coopetitive portfolio configuration that would work for any type of firm or industry. In line with recent research that has shown that coopetition benefits and risks differ according to firm size (Chiambaretto, Bengtsson, et al., 2020; Granata et al., 2018), we reveal in both the main and the supplementary analyses that the coopetitive portfolio configurations that generate innovation are not the same for SMEs and large firms. Coopetitive portfolios can enable firms to create synergies through resource exchange, but at the same time the added complexity of various simultaneous alliances can also foster the risks. Based on our findings, this seems to be especially prevalent for SMEs, which generally are known to have less absorptive capacity and managerial capabilities to handle the tensions of alliances (Dickson et al., 2006). Therefore, they might simply not be able to reap the benefits of a (complex) coopetitive alliance portfolio. Additionally, we find that large firms tend to rely on a full coopetitive portfolio containing all partner types when introducing innovation. We reason that they benefit more from the diversity, as they are able to manage the tensions. Similarly, Weerawardena et al. (2006) point out that industry dynamism could have an impact on firms' innovation output. We find that firms in low dynamism tend to make use of more diverse coopetitive portfolios (consisting of all four partner types), while those in high-dynamic industries only combine competitors and customers in

their portfolio. This reflects that firms in less dynamic industries are able to handle an increased complexity in their coopetitive portfolio, while those in high-dynamic markets focus on the essentials. By specifically collaborating with customers, firms in such environments can hedge against market risks and keep up with the rapid changes (Belderbos, Carree, Diederen, et al., 2004; Tether, 2002). With our findings we therefore stress the importance of adopting a more nuanced view of coopetition with a stronger emphasis on the context in which coopetition strategies are implemented.

This is also highlighted in our supplementary analyses, whose suggested solutions do not always match those of the main analysis. Specifically, by investigating samples that account for firms' collaboration activities over time, we partially find different solutions. Initially, we observe a smaller variety of suggested solutions, but a higher complexity of portfolio configurations. Here, we particularly rely on the notion of alliance experience to explain the differences in findings between the main and the supplementary analyses. In doing so, we reinforce prior research findings indicating that as firms gain more experience, they are able to manage a broader diversity of partner types in their portfolios (Duysters et al., 2012). The differences in solutions between main and supplementary analyses are particularly prevalent when considering a firm's size. The suggested portfolio configurations differ both for SMEs as well as large companies, as opposed to the main analysis. This indicates once more the relevance of and need for a nuanced consideration of firm- and industry-specific factors in coopetition studies. Especially with regards to firm size, there seems to be room for more investigation.

4.5.3 Managerial implications

Our analysis sheds light on beneficial coopetitive portfolio configurations to develop firm innovation and allows us to draw several implications for practitioners. First, our research suggests to top managers or innovation managers to combine alliances with competitors and customers when they want to develop new products. Information acquired from customers can be a very valuable addition to the knowledge and resources provided by competitors. On the one hand, competitors know market risks and uncertainties well and can help deal with those from a producer perspective. On the other hand, customers can facilitate the identification of actual needs and wants, thereby diminishing

uncertainties and increasing chances of actual product adoption. In order to get access to customer insights, firms can engage in lead-user analysis or design thinking for instance, where users actively help firms in product development through feedback loops (Franke et al., 2006; Meinel & Leifer, 2011; Schreier & Prügl, 2008).

Second, our study warns practitioners about the double-edged presence of suppliers and universities in the coopetitive portfolio. For instance, the presence of an alliance with universities in the coopetitive portfolio turns out to be harmful for firm innovation if the presence of an alliance with suppliers is not given. Practitioners need to be aware of the interdependencies between the partner types in their coopetitive portfolio and handle the consequences of including certain partners with others being present/absent. In particular, suppliers seem necessary to "translate" knowledge generated by universities into valuable input for innovation.

Finally, we advise practitioners that there is no magic recipe to develop innovation. Practitioners in SMEs and in large firms should ally with different (sets of) partners to achieve innovations. While we recommend SMEs to collaborate with at least customers, large firms should partner with all types of firms in their coopetitive portfolio to generate innovation. Practitioners should also pay significant attention to the dynamism of their industry and adapt the configurations of their coopetitive portfolio accordingly. When the industry is highly dynamic, firms should ally with customers in addition to competitors. By contrast, in low dynamic industries, firms should rather collaborate with all four partner types. We thus invite practitioners to carefully assess the peculiarities of their situation (size and industry dynamism) before crafting their ideal coopetitive portfolio.

4.5.4 Limitations and future research

Despite our contributions to the coopetition literature, this study suffers from several limitations. Specifically, the results might be affected by the composition of our sample. In particular, two thirds of the firms in the sample are SMEs. This can affect our findings as smaller firms might benefit from different coopetitive portfolio configurations than large firms. Similarly, two thirds of firms in the sample operate in industries with high dynamism. This again could impact the results. Firms in less dynamic industries might actually

benefit more from collaborating, as they are able to manage the complexities of diverse portfolios. We suggest that future research considers a larger sample to gain further insights and to test whether the effects pertain.

Besides specific sample composition issues, there are also limitations attached to the use of data collected through the CIS. In particular, the dataset might suffer from self-selection bias, as firms are not obliged to respond. Furthermore, firms can choose which questions they respond to. Therefore, we might not have information on all questions for all firms. Moreover, the questionnaire is not specifically designed to suit the research project at hand. Therefore, we are limited to the information requested in the survey. For instance, for firms that are collaborating for innovation, we do not have any information about the partners' characteristics like firm size or age. Having access to this information could improve the conclusions that can be drawn from the analyses. Future research may consider including a more informative dataset, which is specifically targeted to the investigation. It would be interesting to study whether firms collaborate with partners of the same size, and whether partners are domestic or international. Such factors can affect the managerial complexity of alliances, e.g. because of cultural issues. Moreover, it would be interesting to find out whether firms engage in repeated alliances with certain partners, as this could have an impact on the trust and routines inherent to the collaboration and therefore also on the alliance management (see e.g. Belderbos et al., 2012, 2015; Gulati, 1995).

4.6 Conclusion

In this chapter, we investigate the role of coopetitive portfolio configurations for firms pursuing innovation. By doing so, we aim to underline the complementarity and substitutability of competitors and other partners such as customers, suppliers and universities within a coopetitive portfolio for innovation. Using a crisp-set QCA approach, we find that often there are multiple coopetitive portfolio configurations present in firms with innovation, where customers are a necessary part of a firm's coopetitive portfolio, while universities can harm innovation if not included in the right manner. Overall, we are able to provide insights into the interplay of competitors and other types of partners in coopetitive portfolios. Specifically, we show that often there are multiple ways for a firm to achieve innovation, and that it is essential to combine

competitors with other partner types in coopetitive portfolios. Nevertheless, we call for future research to further investigate coopetitive portfolio configurations (beyond the simple presence or absence of various partner types) and their impact on firm innovation performance.

Appendix

Table A4.1: Logit regression

	Product innovation
x1100	-0.066
	(0.291)
x1010	1.147*
	(0.570)
x1001	-0.020
	(0.356)
x1110	0.677*
	(0.329)
x1101	0.458
	(0.358)
x1011	0.582
	(0.497)
x1111	1.023***
	(0.271)
Intercept	0.993***
	(0.214)
Log Likelihood	*-422.846*

Note: † $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; The meaning of the different measures can be found in table A4.2

Table A4.2: Overview of different coopetitive portfolio configuration measures

Measure	**Meaning**
x1000	Partners: Competitors
x1100	Partners: Competitors & suppliers
x1010	Partners: Competitors & customers
x1001	Partners: Competitors & universities
x1110	Partners: Competitors, suppliers & customers
x1101	Partners: Competitors, suppliers & universities
x1011	Partners: Competitors, customers & universities
x1111	Partners: Competitors, suppliers, customers & universities

Chapter 5
General discussion & conclusion

5.1 Introduction

This final chapter summarizes and synthesizes the main findings of this dissertation. Additionally, I detail the implications of the findings, as well as suggest potential avenues for future research. Each of the chapters addresses one or more research question(s) outlined in Chapter 1. Chapter 2 and Chapter 3 focus on the specifics of coopetition itself. In particular, these chapters assess how the use of intellectual property (IP) protection affects a firm's propensity to engage in coopetition, as well as how it alters the relationship between coopetition, knowledge spillovers and product innovation. Chapter 4 considers the effect that the presence of other types of partners can have in combination with coopetition.

5.2 Summary of main findings

Chapter 2 investigates the relation between firms' reliance on formal and informal appropriation mechanisms and the propensity to engage in coopetition. I argue that firms who have appropriation mechanisms in place are more likely to engage in coopetition because they expect to be able to capture most of the jointly created value for themselves. The chapter also studies how this relationship is affected by industry dynamism and competition intensity, as prior research has shown that contextual factors will affect firms' strategic decision making (see e.g. Ritala, 2012). Here, the distinction between formal and informal IP mechanisms is very important, because the signals they send may vary in different industry circumstances. In particular, formal mechanisms are more applicable to protect explicit knowledge, while informal mechanisms signal that a firm possesses valuable tacit knowledge that cannot be effectively protected by formal IP tools. As tacit knowledge is frequently linked to higher innovativeness, this implies that firms using informal IP mechanisms can be seen as more innovative. Firms relying on formal mechanisms can be considered as less innovative, meaning that they are more dependent on collaboration to develop innovations. This is especially the case in dynamic industries where firms need

to keep up with a fast pace of innovation. Dynamic industries are characterized by a high speed of technological change, i.e., a fast pace of introduction of new product innovations. Consequently, in such environments, firms relying on formal appropriation instruments are more likely to collaborate with others in order to be able to keep up with the high speed of innovating. Firms using informal mechanisms in turn do not need to collaborate to sustain a competitive advantage because they are more innovative on their own to begin with. Therefore, a positive (negative) moderation effect of dynamism on the relationship between formal (informal) IP and coopetition is expected. In a similar vein, a high competition intensity in an industry tends to tie up many resources that are required to cope with the increased competitive pressures. Consequently, firms lack those resources when engaging in coopetition and aiming to manage the risks of opportunism and unintended knowledge spillovers inherent to competitor collaboration. If firms have formal IP mechanisms in place, they do not have to worry about their knowledge being exploited as it is legally protected. Informal mechanisms, however, do not provide any type of legal protection, which in turn could hinder firms from coopeting. Therefore, Chapter 2 hypothesizes that competition intensity positively (negatively) moderates the relationship between formal (informal) IP mechanisms and coopetition.

The findings are mostly in line with the expectations. In particular, the results support the hypothesis that formal appropriation increases a firm's propensity to engage in coopetition, while there is no statistically significant effect for informal appropriation on coopetition likelihood. Moreover, firms relying on formal mechanisms are indeed more likely to engage in coopetition in dynamic industries, while those making use of informal mechanisms are less likely to coopete. Similarly, the results illustrate that informal appropriation is also harmful for coopetition engagement in competitive markets. However, there is not enough evidence to support the hypothesis that formal appropriation is beneficial in industries with high competition intensity.

Chapter 3 sheds further light on the role of IP protection in coopetition. In particular, it studies how the use of informal IP protection mechanisms affects the impact that engaging in coopetition has on knowledge spillovers and a firm's product innovation performance. Based on prior research on the benefits of collaborating with rivals, it can be expected that coopeting firms create value

together that enables them to enhance their innovation performance. Moreover, in line with the knowledge-based view (KBV), one of the reasons for firms to engage in coopetition is the prospect of gaining access to relevant knowledge. Accordingly, it is expected that coopeting increases the value of incoming knowledge spillovers from competitors, as both partners intend to share knowledge. However, this can be negatively affected if a firm relies on informal IP mechanisms, due to the very nature of such mechanisms. For instance, secrets prevent knowledge sharing. Due to reciprocity, if one partner does not share any information, neither will the other. Furthermore, the use of informal IP mechanisms also signals a certain amount of distrust, which further harms collaboration. Therefore, informal IP mechanisms are expected to negatively moderate the relationship between coopetition and incoming knowledge spillovers.

The analysis provides support for the above expectations, once again emphasizing the special role of informal IP protection in coopetition. Specifically, the results show that instead of enabling firms to benefit more from coopeting by providing security, relying on informal mechanisms can actually hamper the benefits they can derive. Yet, in order to find out more about how much of the relationship between coopetition and product innovation can be explained by knowledge spillovers, a mediation analysis is performed. This analysis shows that incoming knowledge spillovers partially mediate the connection between coopetition and innovation. This path is moderated by informal IP mechanisms. The direct effect between coopetition and product innovation is not moderated once knowledge spillovers are accounted for. This emphasizes that there are other mechanisms inherent to coopetition for innovation which are not related to IP and therefore do not require IP protection. Those could be cost and risk sharing, for instance.

Chapter 4 studies how coopetitive portfolios relate to the introduction of product innovation. It argues that the characteristic tensions of coopetition can also intensify the complexities and tensions inherent to alliance portfolios. Specifically, the reasoning follows prior research that points out competitor collaboration can be complementary with some types of partners, while it can be subadditive with others. Accordingly, the chapter emphasizes that the configuration of alliance portfolios that contain competitors – i.e., coopetitive portfolios – matters for a firm's innovation performance. Contrary to many prior

contributions, Chapter 4 acknowledges that there can be more than one portfolio configuration leading to product innovation. Yet, to date, little is known about the partner types firms should combine with competitors to achieve product innovation. Therefore, this chapter takes a rather exploratory approach investigating the partner types included in the coopetitive portfolios of firms with product innovation and derives propositions to be further assessed in future research.

The findings indicate that coopetitive portfolios of innovating firms include customers. Nevertheless, the presence of customers is not enough but requires additional conditions. Specifically, the analysis shows that the presence of universities in coopetitive portfolios can be harmful for innovation. Yet, when firms collaborate with competitors, customers, as well as suppliers, the presence or absence of universities will not affect innovation performance. However, these findings might not be applicable for all firms in all industries. Therefore, a distinction is made between small and large firms, as well as low and high industry dynamism. While the analysis provides the same solutions for small firms as for the overall sample, large firms benefit from including all partner types in their coopetitive portfolios. Contrary to small firms, large firms possess the capabilities to better handle the complexities of more diverse portfolios. Moreover, due to their better developed own resource base, large firms might only be able to derive benefits from a broader set of resources than small firms. When considering industry dynamism, firms operating in less dynamic markets rely on full coopetitive portfolios – i.e., those containing all four partner types – while those in high dynamic industries benefit from collaborating with competitors and customers specifically. Handling the risks and uncertainties related to increasing levels of industry dynamism requires managerial capacities. Therefore, firms operating in markets characterized by high dynamism choose to rely only on the core partner type: customers. In line with prior research, collaboration with customers enables firms to deal with the uncertainties inherent to dynamic industries. Firms in less dynamic markets, however, are better able to manage the complexities of diverse portfolios and draw from a variety of knowledge sources without the need to constantly and quickly introduce new products.

5.2.1 Synthesis

Chapter 2 and Chapter 3 of this thesis study the role of IP mechanisms in the context of coopetition. The empirical models and methods employed in the chapters differ, however. Specifically, they draw on different samples, and consider coopetition as well as IP mechanisms in different positions, where the focus is only on informal mechanisms in Chapter 3. Table 5.1 displays an overview of the differences between the chapters.

Moreover, Chapter 3 and Chapter 4 both investigate the effect of coopeting on product innovation. While Chapter 3 focuses exclusively on collaboration with competitors, Chapter 4 also takes into account the complementarities and subadditive effects between different types of partners. The specifics regarding the methodology employed in Chapter 4 are also illustrated in Table 5.1. In spite of the clear differences between the two chapters, the findings are complementary and shed further light on how coopetition affects firms' innovation performance.

Table 5.1: Overview of empirical approaches in Chapters 2, 3, and 4

	Chapter 2	**Chapter 3**	**Chapter 4**
Sample characteristics	2,207 firms (2,337 observations)	11,189 firms (13,248 observations)	921 firms
Data period	2000 & 2012 (1998 & 2010)	2000, 2004, 2010	2010-2016
Data source	Dutch CIS	MIP (German CIS)	Dutch CIS
Role of coopetition	Outcome	Antecedent	Antecedent
Main variables	Formal & informal IP; dynamic & competitive industries	Informal IP; incoming knowledge spillovers & product innovation	Suppliers, customers & universities; firm size & industry dynamism; product innovation
Methodology	GSEM	Ordered probit, fractional response logit, mediation	Crisp-set QCA

The findings in Chapter 2 indicate that formal IP mechanisms increase firms' propensity to coopete, also in dynamic and competitive industries. This can be explained by the lower degree of innovativeness of firms relying on such mechanisms, but also by the fact that formal mechanisms provide legal protection. This allows firms to coopete without fearing unintentional knowledge spillovers, meaning they can share knowledge in a controlled manner. Relying on the KBV, Chapter 3 emphasizes that such knowledge sharing is essential for the success of a coopetitive relationship. While the role of formal IP is not investigated as a moderator in this chapter, it is included as a control variable to account for a firm's reliance on formal IP mechanisms. The results indicate that such tools themselves increase the value of incoming knowledge spillovers from competitors. This hints at the fact that firms with formal IP are open to disclosing knowledge, which also encourages their rival partners to share more valuable insights as well.

With respect to informal IP mechanisms, however, the findings suggest that the role of these might be special. The results in Chapter 2 point out that relying on such instruments does not drive a firm into coopeting. This suggests that firms with informal IP mechanisms do not want to share any knowledge and therefore do not seek to collaborate with competitors. In line with this, in Chapter 3 I find that the reliance on informal IP harms information exchange with competitors, as the focal firm displays both a distrust and an unwillingness to share resources like knowledge. This in turn prevents successful collaboration because it will keep the partner firm from committing resources, too. Therefore, it is possible to derive an important conclusion from Chapters 2 and 3, namely: despite the benefits expected from protection and appropriation of IP using informal mechanisms, relying on such tools can actually be harmful, especially when aiming to achieve product innovation.

The findings of Chapter 3 indicate that coopetition generally is beneficial for innovation. Contextual factors can impact this relationship. This becomes apparent in Chapter 4, where it is argued that competitors seldom are the only type of partner a firm collaborates with. In fact, the results show that coopetition needs to be combined with certain partner types to induce product innovation. Moreover, the findings highlight that there are differences between firms of different size, as well as between industries characterized by different levels of dynamism. Specifically, customers are complementary to competitors in a

coopetitive portfolio, which can be explained by the fact that collaboration with customers enables firms to mitigate risks and uncertainties related to the development and introduction of new products. This is a good addition to the knowledge and resources accessed through coopetition, which are often directed to a specific product and industry. Nevertheless, suppliers and universities also need to be considered as potential partners.

Overall, the main takeaways from this dissertation are that IP protection is not always beneficial for a firm seeking to enhance its innovation performance and does not necessarily encourage firms to engage in coopetition in the first place. The results reveal that the type of protection, as well as the industry context a firm operates in matter. Moreover, coopetition should not be assessed independently from a firm's other types of collaboration because not all partners are compatible. Here, once again, both firm- as well as industry-specific characteristics matter.

5.3 Contributions and implications

This dissertation examines the role of IP appropriation and protection in coopetitive relationships, as well as how coopetitive portfolios need to be configured to achieve product innovation. The subsequent sections provide more detailed insights into the contributions to literature and the implications for practitioners.

5.3.1 Contributions to literature

This doctoral thesis contributes to existing coopetition literature in various ways. First, it follows calls from knowledge management and collaboration literature to explore the role of both formal and informal appropriation mechanisms. I establish that IP mechanisms in general are especially relevant within coopetitive relationships, as they enable firms to manage the risks inherent to collaboration with rivals. In doing so, this dissertation studies the link between the previously rather disconnected topics of IP protection and coopetition. In particular, the findings stress the importance of distinguishing between the two types of mechanisms. While prior research often differentiates between one or two specific mechanisms (e.g. patents and secrecy) in an attempt to show the differences in effectiveness, this does not provide a complete picture. By instead considering the overarching concepts of formal and informal

mechanisms that pick up a broader set of protection instruments, the results in this thesis offer more generalizable insights.

Second, especially the informal mechanisms are traditionally difficult to observe and measure, which resulted in a lack of research considering informal mechanisms up until this point. In order to provide insights into the role of informal IP mechanisms, Chapter 3 and parts of the analysis in Chapter 2 pay special attention to such instruments. This is the second major contribution of this thesis. In contrast to the general understanding that IP mechanisms aim to enable firms to safely engage in coopetition and derive benefits from doing so, the findings suggest that relying on informal IP mechanisms can in fact be harmful for a firms' innovation performance, and generally, their propensity to engage in coopetition. This further underlines the importance of distinguishing between formal and informal IP mechanisms, and the need for more research to focus especially on the latter.

Third, this thesis reconciles some of the ambiguity in findings regarding the relationship between coopetition and innovation. In particular, I continuously emphasize that the effect of coopetition in product innovation is not straightforward, but rather needs to be considered in light of firm- and industry-specific characteristics. Chapter 3 highlights that the use of informal IP mechanisms can negatively impact the relationship between coopetition and innovation, while Chapter 4 illustrates that the presence of other types of collaboration can influence whether coopetition enables firms to introduce product innovation. Here, especially small and large firms are compared, as well as firms operating in less and more dynamic industries. The analysis shows that those factors impact the coopetitive portfolio configurations from which firms can benefit. Chapter 2 also uses industry dynamism and additionally the market's competition intensity to illustrate that in certain conditions, firms relying on IP mechanisms are more likely to engage in coopetition than in others. In doing so, this thesis provides further insights into why coopetition is beneficial for a firm in some cases, but not in others, and is therefore able to mitigate some of the ambiguity in previous findings.

Fourth, this dissertation investigates how different configurations of coopetitive portfolios relate to product innovation. In doing so, it follows calls from recent coopetition literature to study coopetition at the portfolio level, where tensions and risks are also present and potentially even increased. As the

current state of research in that area is scarce, the research in Chapter 4 contributes to the general understanding of how coopetitive portfolios affect firms' innovation performance. By showing that the presence or absence of specific partners matters for a firm's ability to introduce product innovation, the chapter supports the discoveries by Belderbos et al. (2006), who highlight the complementarity between competitors and customers, but the harmfulness of combining competitors and universities. The study is of exploratory nature and provides an initial look into the specific role of competitors in alliance portfolios, and how those affect product innovation. Therefore, it establishes a basis for future research to further investigate the concept of coopetitive portfolios.

Fifth, this doctoral thesis draws on various theoretical notions such as the resource-based view (RBV), knowledge-based view (KBV) and transaction cost economics (TCE) to elaborate on the tensions between value creation and value appropriation in coopetition. The RBV, on the one hand, describes that firms are incentivized to engage in collaboration because this allows to get access to a broader set of resources. The KBV is an extension of the RBV, which specifically focuses on knowledge as the most important resource to be accessed. The TCE, on the other hand, illustrates the risks of opportunistic partner behavior, which are especially prevalent in coopetition. Drawing on and combining those different theoretical notions enables me to shed more light on the mechanisms behind coopetition, and why there remains ambiguity in findings regarding the outcomes of coopeting. Therefore, this dissertation contributes to the existing body of coopetition literature by emphasizing the relevance of the different theoretical notions to explain the tensions inherent to competitor collaboration.

Lastly, this thesis contributes to coopetition and management literature from a methodological point of view. Chapter 3 contains a mediation analysis using a non-linear model. Well-established approaches as suggested by Baron and Kenny (1986) are not able to specifically account for non-linearity. Therefore, the chapter employs a rather novel technique proposed by Imai et al. (2010), which allows for such non-linearity. In addition to that, the methodology employed in Chapter 4 has also not frequently been used in coopetition literature up until now. The qualitative comparative analysis (QCA) approach accounts for equifinality by allowing for multiple causal paths to lead to the same outcome, which is called for by existing methodological research (see e.g. Woodside,

2013). By means of this dissertation, I emphasize the relevance of such novel methods in coopetition and management studies.

5.3.2 Practical implications

As highlighted in Chapter 1, firms such as the Bayer AG or Philips rely on partnerships with other firms in order to improve their innovation performance. The findings of this dissertation provide relevant insights for strategic decision makers with regards to the specifics of those partnerships, especially focusing on the paradoxical notion of collaboration with competitors.

In particular, I show that the use of IP mechanisms is neither necessarily straightforward nor always beneficial. This emphasizes the need for firms to be aware of the tools they have in place and choose to rely on. While I outline the benefits of both formal and informal IP, the findings suggest that it can actually be harmful for firms to use informal mechanisms. In fact, relying on such instruments might negatively affect a firm's innovation performance. Nevertheless, I note that many firms tend to use more informal than formal IP instruments. The results are of great importance to such firms, as they raise awareness of the negative consequences this can have for their collaboration behavior and the benefits that they can derive from coopeting. Yet, it is important to acknowledge that not all firms might be willing or able to rely on mechanisms such as patents, due to the costs and information disclosure requirements. If such firms make use of informal IP instruments instead, they need to critically assess the mechanisms and consequences for coopetition initiatives and their outcomes. If those are not (only) related to the exchange of knowledge, coopeting can remain a viable strategy to enhance innovation.

Besides such firm internal characteristics, the chapters also point out that the industry context a firm is operating in is relevant to its strategic decision making. Specifically, the findings highlight that industry dynamism and the degree of competitive intensity play a role in a firm's decision to engage in coopetition and also how firms can benefit from doing so. Firms operating in industries characterized by high competition intensity coopete in order to sustain their competitive position. Nevertheless, high levels of competitiveness might tie up a firm's managerial resources, which can affect their capability to handle the risks of coopeting. If firms find themselves in such industries, they need to carefully weigh off the benefits and costs of coopeting, especially taking into account their

other strategic choices and tools such as IP protection mechanisms. In fact, this dissertation highlights that the effectiveness of such mechanisms can differ depending on the industry competitiveness.

Regarding industry dynamism, firms in dynamic industries need to be able to keep up with a rapid pace of new product innovation and thus technological change, which has been identified as one of the incentives behind collaborating in general, and coopeting in particular. Nevertheless, firms need to be aware of complementarities between competitors and other partner types, especially in light of the complexities of dynamic industries. Firms that find themselves in such dynamic markets therefore can take into account the findings of this dissertation when making choices in terms of IP mechanisms and collaboration partners. This thesis stresses the necessity for firms to assess in what kind of environment they operate and how that – in combination with firm-specific characteristics – affects their strategic decisions and the outcomes of those choices.

5.4 Limitations and future research

Despite this dissertation's contributions to understanding more about knowledge management in coopetition, further research is needed to advance the current body of literature and to shed additional light on the specifics of the role intellectual property plays when firms collaborate with their rivals. This thesis especially highlights the need to distinguish between formal and informal IP mechanisms. Particularly, the impact of informal appropriation needs to be investigated in more detail. The findings show that more protection is not necessarily better, especially when firms rely on instruments like secrecy. Such tools can even harm the success of coopetition. Yet, thus far, research investigating these mechanisms in coopetition is rather scarce. Therefore, I suggest for future research to further explore this avenue, specifically taking into account additional factors such as different firm characteristics like size. This would also enable practitioners to make more informed decisions, better tailored to their firm's specific circumstances.

Chapter 3 argues that reciprocity with regards to knowledge sharing is important for interfirm collaboration to be successful. It points out that firms relying on informal IP (partially) refrain from sharing information, which in turn likely also keeps partners from committing knowledge resources to the

relationship. Naturally, this also applies vice versa, meaning that if the partner does not share, neither will the focal firm. However, the data used in the analyses does not allow to control for any partner-specific characteristics. In fact, only the type of partner is known, but not their IP protection strategy, for instance. Therefore, I call for future research to study IP mechanisms in light of the partner's IP protection strategy. Here, case studies and in-depth interviews could provide clearer insights into the specific processes and dynamics inherent to collaboration between rivals. This could also address another limitation; in particular, prior research shows that repeat alliances and persistence in collaborations can lead to the establishment of routines and the development of alliance experience (Belderbos et al., 2012, 2015), which in turn could increase trust (Gulati, 1995) and consequently diminish the need for IP mechanisms, for instance. Nevertheless, the lack of information about the collaboration partner also causes me to be unable to identify whether firms engage in coopetition with the same exact partner over time.

Having access to focal firm- and partner-specific information would also allow for future research to study coopetition occurring between rivals from different countries. Tensions might be increased through distance between partners – e.g. culturally or geographically. Such distance in turn can hamper collaboration success, for instance because of communication issues and a difference in perception of trust and knowledge sharing boundaries (Schmiele & Sofka, 2007). Moreover, the effectiveness of IP protection mechanisms might vary in different countries. This is likely caused by different laws and regulations with regards to formal and informal IP, which might affect the generalizability of the results in this thesis to contexts that differ from those of the firms used in the analyses. The supplementary analysis in Chapter 2 attempts to hint at this. However, it is restricted with regards to information as to which countries partners come from, and relies on relatively few observations of firms coopeting with rivals from countries with a rather weak IP protection regime such as India[68]. Therefore, a natural next step would be to conduct more research accounting for the geographical differences between partners, using a bigger sample with a clearer distinction between countries.

[68] In India, formal IP protection mechanisms such as patents tend to be less effective because of rather weak IP legislation (Oxley, 1999).

Furthermore, this dissertation also stresses the importance to consider coopetition at the portfolio level. While Belderbos et al. (2006) point out that there tend to be complementarities and subadditive effects between specific partner types, this has widely been disregarded by prior research. Chapter 4 picks up on that with the set-theoretic approach highlighting that indeed certain configurations of coopetitive portfolios can be found in innovating firms more consistently than others. More research should venture into this field, as the risks and tensions of coopetition transfer to the portfolio level. Yet, the effect of coopetitive portfolios for firm performance remains unclear. The propositions formulated in Chapter 4 can be assessed in future research. Moreover, the chapter investigates only two contingency factors – firm size and industry dynamism – while other aspects like IP protection strategy and partner location can impact the success of coopetition and other types of collaboration as well. Therefore, a logical step would be for future research to study coopetition in alliance portfolios in a variety of contextual factors and firm-specific characteristics. Such contributions would allow coopetition scholars to gain further insights into the specifics of competitor collaboration. In addition to that, they would enable practitioners to make better decisions.

With regards to the data used in this thesis, the analyses tend to be limited by the questions that are included in the Community Innovation Survey (CIS). Since the CIS aims to provide information about a broad variety of aspects from many different types of firms, the data is not specifically tailored to the research in Chapters 2, 3 and 4. Researchers could counteract this problem by collecting data themselves, and possibly gaining a more in-depth view into e.g. collaboration partners, IP strategies and other circumstances. Moreover, I am not able to make any inferences with regards to causality in this thesis. Therefore, I refer to associations rather than causal relationships in Chapter 2, for instance. In Chapter 3, I attempt to include a lagged dependent variable to account for unobserved heterogeneity in innovation abilities. However, due to a lack of coherence in firms' presence in the dataset, this exercise leads to a large loss of observations. This issue could partially be addressed by better-tailored data, which allows for the inclusion of a temporal dimension. This would also be beneficial for Chapter 4, as it would allow me to observe the coopetitive portfolios over time.

Impact Paragraph

The scientific & societal impact

Introduction

Fisher (1992) uses the title "*Preaching Love Thy Competitor*" in his New York Times article to describe Novell CEO Ray Noorda's business philosophy. Noorda recognized the added value of collaborating rather than purely competing with other industry players, and coined the term coopetition – simultaneous collaboration and competition – in the early 1990s (Bengtsson & Kock, 2000; Fisher, 1992). In fact, coopetition is often used as a strategy to improve firm performance (Belderbos, Carree, & Lokshin, 2004; Ritala, 2012). Companies collaborate with rivals to share costs and risks, and to exchange resources that can enhance innovation processes (Estrada et al., 2016; Raza-Ullah & Kostis, 2020; Tether, 2002). This results in benefits for society, e.g. through the faster introduction of new products.[69]

Nevertheless, engaging in coopetition can also harm a firm's performance, since coopetition partners remain competitors attempting to outperform each other (Lhuillery & Pfister, 2009; Nieto & Santamaría, 2007). Existing research indicates that coopetition therefore entails a paradox between joint value creation and individual value capture (Gnyawali & Park, 2011; Gnyawali & Ryan Charleton, 2018). Some researchers particularly highlight the delicate role of intellectual property (IP) in coopetitive relationships (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2016, 2018; Holgersson, 2018). Coopetition partners are likely to behave opportunistically, seeking to exploit each other's resources such as knowledge (Cygler et al., 2018; Fernandez, Le Roy, et al., 2018; Ritala & Hurmelinna-Laukkanen, 2013; Tidström, 2014; Zaheer et al., 1998). Firms can use formal or informal IP mechanisms[70] to shield their

[69] An example for this is the joint vaccine development by Pfizer and BioNTech (Bildstein & Zanardi, 2021; Pfizer Inc., 2020).

[70] Formal mechanisms are patents, design rights, copyrights and trademarks, while informal mechanisms are comprised of secrecy, complexity and short lead-times (Hall et al., 2014).

knowledge and appropriate the value created in the partnership (Estrada et al., 2016).

While it is important to understand the specifics of coopetition itself, the tensions of coopeting are also likely to affect a firm's other alliances (Chiambaretto & Fernandez, 2018; Cui & O'Connor, 2012; Subramanian & Soh, 2017). Nevertheless, little is known about the specifics of including competitors in alliance portfolios[71], and how this in turn might affect innovation performance. While Park et al. (2014) find an inverted-U-shaped effect of coopetitive portfolios on innovation performance, it is particularly Belderbos et al. (2006) who highlight that there tend to be complementary but also subadditive effects between certain partner types in combination with competitors. Yet, to date, only few studies have specifically investigated how combining different partners with coopetition affects performance (Belderbos et al., 2006; Park et al., 2014; Wu, 2014).

Overall, the first main objective of this dissertation is to investigate the role of formal and informal IP appropriation mechanisms in coopetitive partnerships. The second main aim of this thesis is to explore the role of coopetition in alliance portfolios with regards to a firm's innovation performance. The remainder of the impact paragraph elaborates on the findings of this dissertation and outlines why and to whom they are relevant.

Findings

Chapter 2 investigates whether relying on formal and informal appropriation mechanisms increases a firm's likelihood to engage in coopetition, and specifically, whether this differs in dynamic or competitive industries. The results suggest that formal mechanisms increase a firm's propensity to coopete, also in dynamic markets. Using informal mechanisms, however, decreases a firm's likelihood to collaborate with competitors in dynamic and in competitive industries. I argue that firms that rely on formal mechanisms signal a lower level of innovativeness and therefore need to collaborate. In contrast to that, firms using informal mechanisms seek to protect tacit knowledge, which is linked to a higher degree of innovativeness. Such firms do not need to coopete in dynamic

[71] As defined earlier, this particular type of alliance portfolio can also be referred to as coopetitive portfolio.

or competitive industries because they are able to outperform rivals on their own.

Chapter 3 focuses on the role of informal IP mechanisms with regards to knowledge spillovers in coopetition, and the effect of coopetition on product innovation performance. While the findings suggest that competitor collaboration is beneficial for both product innovation and incoming knowledge spillovers, they also illustrate that using informal IP protection weakens those relationships. This can be explained by informal IP mechanisms preventing firms from sharing knowledge. This in turn also keeps the partner from committing any knowledge to the relationship (Nielsen & Nielsen, 2009), which diminishes the benefits of coopeting. Additionally, the findings show that some of the positive effect of coopetition on product innovation is explained by incoming knowledge spillovers. Interestingly, the direct effect of coopetition on product innovation is not moderated by informal IP protection once the mechanism of knowledge spillovers is disentangled. This suggests that there are other underlying mechanisms relevant to coopetition for innovation that are unrelated to a firm's IP.

Chapter 4 underlines the importance of also considering a firm's other collaboration partners. It assesses different configurations of coopetitive portfolios and shows that various combinations of partners can result in product innovation. Additionally, it emphasizes the relevance of distinguishing between small and large firms, as well as low and high levels of industry dynamism. The findings reveal that the presence of customers in coopetitive portfolios is beneficial for product innovation, regardless of firm size or dynamism. Moreover, including universities is only advantageous if suppliers are also part of the portfolio. However, large firms benefit from complex coopetitive portfolio configurations more than small firms, which can probably be explained by small firms' lack of managerial capabilities. Additionally, firms in more dynamic markets benefit from portfolios that contain only competitors and customers, while less dynamic industries allow for more complex partner combinations. This can be explained by the fact that handling the risks and uncertainties related to increasing levels of industry dynamism ties up managerial capabilities, while firms in less dynamic markets are able to handle more diverse portfolios.

Scientific impact

Despite the steady increase in coopetition literature throughout the past 25 years, the importance of coopetition for firm performance remains unclear (Fernandez, Chiambaretto, et al., 2018). With this dissertation, I seek to broaden the understanding of the benefits and risks related to coopetition. Especially the relevance of knowledge in coopetition is often emphasized (Estrada, 2018; Estrada et al., 2016; Fernandez & Chiambaretto, 2018). Yet, a limited amount of coopetition research has studied the role of knowledge management in this context up until now (Estrada et al., 2016). Therefore, this dissertation investigates formal and informal IP appropriation mechanisms in more detail. In doing so, it responds to calls from coopetition scholars who invite more research to look into value capture and knowledge management in coopetitive relationships (see e.g. Estrada et al., 2016). By specifically zooming in on informal instruments, this thesis further extends coopetition research, as those mechanisms are difficult to observe and assess (Estrada et al., 2016; Hall et al., 2014; Laursen & Salter, 2014). The findings highlight the relevance of distinguishing between different types of IP mechanisms. Moreover, the different chapters underline the necessity for research to consider different industry circumstances, as the effectiveness of a firm's strategic choices like relying on IP mechanisms or engaging in coopetition may vary depending on the operating environment. Furthermore, this thesis points out that the tensions and complexities related to knowledge and resource management in coopetition are also likely to affect a firm's other collaborative agreements and vice versa. By evaluating which different coopetitive portfolio configurations enable firms to introduce product innovation, Chapter 4 follows up on coopetition scholars' calls for more research in this area (see e.g. Chiambaretto & Fernandez, 2018). It underlines that multiple configurations of coopetitive portfolios can result in innovation. In doing so, a baseline of propositions is provided that can be used in future research to gain a better understanding of the coopetition in alliance portfolios. The insights are relevant for coopetition research as they stress the need to focus on firm-internal and -external factors, which may counter the ambiguity of prior results.

The tensions between benefits and risks underline the importance of drawing on various theoretical notions. While the resource-based view (RBV) points at ways for joint value creation in coopetition, transaction cost economics

(TCE) emphasize the riskiness of opening up to competing firms. The relevance of knowledge in coopetition is advanced by the knowledge-based view (KBV). In relying on these different theoretical notions, this dissertation provides further insights into value creation, as well as the value appropriation aspects of coopetition. In addition to that, this thesis also emphasizes the relevance of employing methods that are rather novel to coopetition and strategic management literature. In particular, Chapter 3 deviates from traditional mediation analysis tools such as suggested by Baron and Kenny (1986). Instead, the chapter emphasizes the usefulness of the methodology proposed by Imai et al. (2010), which can account for non-linear models. Furthermore, Chapter 4 acknowledges that multiple causal paths (here: coopetitive portfolio configurations) can lead to the same outcome (here: product innovation). As well-established regression-based approaches are not able to account for such equifinality, the chapter follows up on calls from existing methodological research to rely on tools that are able to do so (see e.g. Woodside, 2013). Overall, this dissertation highlights the relevance of continuously developing and improving existing empirical approaches and standards.

Societal impact

This doctoral thesis provides insights that are relevant to managers, policy makers and society at large. The findings indicate that it is important to be aware of firms' internal and external circumstances when engaging in competitor collaboration. Contrary to the belief that collaboration between rivals results in collusion (Rusko, 2011; Walley, 2007), I show that engaging in coopetition can be a viable strategy for firms to jointly increase their innovation performance. In contrast to the negative effects of collusion between firms such as price-fixing (Rusko, 2011; Strutton et al., 2001; Walley, 2007), enhanced innovation performance can benefit society, e.g. through faster introduction of new products to the market (Gnyawali & Park, 2009; Ritala & Hurmelinna-Laukkanen, 2009). This means that for instance pharmaceutical drugs can be developed quicker and thus also be put to use sooner. This is also illustrated by the Bayer AG (2020) or by the joint vaccine development of Pfizer and BioNTech (Bildstein & Zanardi, 2021; Pfizer Inc., 2020). Subsequently, such coopetition then allows for faster treatment of illnesses and diseases. Related to that, the exchange of resources and knowledge can also enable partners to

develop new products that neither of them could have created on their own (Chiambaretto & Fernandez, 2018; Gnyawali & Park, 2009; Mitchell et al., 2002).

In light of those examples, the findings of this dissertation suggest that policy makers should encourage collaboration between competing firms, if the partners' aim is to improve their innovation performance and therefore to benefit society.[72] Furthermore, a safe and regulated coopetition environment that builds trust and disincentivizes opportunistic behavior might decrease (part of) the need for IP protection mechanisms. This could result in more knowledge sharing, inducing innovation. Ultimately, policy makers need to make a clear distinction between coopetition for the benefit of society and collusion. Moreover, this thesis also provides some important take-aways for managers. In particular, I emphasize that it is necessary for managers to be aware of the industry context their firm is operating in, and which strategic tools and decisions they rely on. The findings underline that the effectiveness of formal and informal IP appropriation mechanisms and coopetition, as well as the beneficial combination of partner types can differ depending on industry circumstances and firm-specific characteristics. This needs to be kept in mind by decision-makers when choosing to engage in coopetition to improve innovation performance.

[72] For a broader, more in-depth assessment of the role of policy makers for coopetition, please refer to Mariani (2018).

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Nederlandse Samenvatting

Deze dissertatie onderzoekt het concept van coopetitie – gelijktijdige samenwerking en concurrentie tussen bedrijven. In coopetitie gaat een belangrijke paradox schuil: partners creëren gezamenlijk waarde, maar streven ernaar om zich individueel zoveel mogelijk van deze waarde toe te eigenen met als doel elkaar als concurrent te overtreffen. Waarde wordt met name gecreëerd door strategisch belangrijke middelen – zoals kennis – in te brengen in het samenwerkingsverband en door kosten en risico's gerelateerd aan de productie- en bedrijfsomgeving te delen. Vervolgens kunnen ondernemingen formele en informele toe-eigeningsmechanismen gebruiken om (grote) aandelen van deze waarde voor zichzelf veilig te stellen en te beschermen tegen uitbuiting door de coopetitiepartner. Formele mechanismen bieden tijdelijk beperkte juridische bescherming van intellectueel eigendom (IE) door middel van octrooien, handelsmerken, auteursrechten en modelrechten. Ondernemingen die een beroep doen op informele mechanismen maken gebruik van geheimhouding, complexe processen of doorlooptijdvoordelen om hun IE te beschermen. Deze mechanismen maken het voor anderen moeilijk of onmogelijk om de kennis van een andere onderneming te beoordelen en te exploiteren.

Hoofdstuk 2 bestudeert de relatie tussen coopetitie en het gebruik van toe-eigeningsmechanismen, met een focus op omgevingsdynamiek en concurrentie-intensiteit binnen de industrie. Het doel van dit hoofdstuk is om te onderzoeken of bedrijven die gebruik maken van formele of informele mechanismen meer of minder geneigd zijn om aan coopetitie te doen, vergeleken met bedrijven die geen gebruik maken van zulke instrumenten. Ik beargumenteer dat de toe-eigeningsmechanismen fungeren als een signaal voor het innovatievermogen van een onderneming. Terwijl formele mechanismen een lager innovatieniveau aanduiden, wijzen informele mechanismen juist op een hoger niveau. Op basis van de *resource-based view* en in lijn met de bovenstaande verwachtingen kom ik tot de bevinding dat bedrijven die zich op formele mechanismen beroepen meer behoefte hebben aan samenwerking om hun innovatiekracht te verhogen. Dit betekent dat dergelijke bedrijven meer geneigd zijn om met concurrenten samen

te werken. Tevens geldt dit voor bedrijven die in een dynamische industrie werkzaam zijn en het hoge innovatietempo moeten bijhouden. Bovendien zijn ondernemingen die informele mechanismen gebruiken inderdaad minder geneigd tot coopetitie in dynamische en concurrerende industrieën.

In hoofdstuk 3 staat centraal hoe coopetitie kennis-spillovers en innovatieprestaties beïnvloedt, en wordt specifiek gekeken naar de rol van informele IE-beschermingsmechanismen in die context. In dit hoofdstuk baseer ik mij op de *knowledge-based view*, die kennis beschouwt als de belangrijkste strategische hulpbron van bedrijven. Ik veronderstel dat het gebruik van informele mechanismen voor IE-bescherming wijst op wantrouwen binnen de samenwerking, aangezien dergelijke mechanismen gericht zijn op het voorkomen van kennis-spillovers en dus op het verminderen van kennisdeling. Dit kan het succes van de samenwerking belemmeren. In lijn met deze verwachtingen, vind ik dat coopetitie inkomende kennis-spillovers verhoogt, maar dat deze relatie negatief wordt gemodereerd door het gebruik van informele IE-beschermingsmechanismen. Daarbij verhoogt coopetitie ook de innovatieprestaties van een onderneming, maar deze relatie wordt gedeeltelijk gemedieerd door kennis-spillovers (ongeveer 50%).

Hoofdstuk 4 benadrukt dat concurrenten vaak niet de enige soorten partners van een onderneming zijn, maar dat ondernemingen veelal gebruik maken van alliantieportfolio's om hun innovatie te versterken. Alliantieportefeuilles die concurrenten bevatten worden ook wel "coopetitieve portefeuilles" genoemd. Zij verschillen van traditionele alliantieportfolio's in die zin dat zij hogere risico's bevatten als gevolg van de coopetitieve spanningen die overslaan op het portefeuilleniveau. Dit kan invloed hebben op de voordelen die een onderneming kan halen uit het aangaan van een verscheidenheid aan samenwerkingsverbanden. Hoofdstuk 4 levert een bijdrage aan de schaarse literatuur over coopetitieve portefeuilles door te onderzoeken hoe verschillende portefeuilleconfiguraties de geneigdheid van bedrijven om te innoveren vergroten. Als aanvullende analyse, houd ik rekening met de grootte van de onderneming en de dynamiek van de industrie; factoren die van invloed zijn op de behoefte van ondernemingen aan samenwerking en dus op hun partnerkeuze. Met behulp van een systematische kwalitatieve vergelijkende analyse kom ik tot de conclusie dat er niet slechts één optimale oplossing is, maar dat er verschillende manieren zijn waarop bedrijven hun innovatieprestaties kunnen

verbeteren. Vooral klanten spelen een essentiële rol in de coopetitieve portefeuilles van bedrijven, terwijl de aanwezigheid van universiteiten nadelig kan zijn. Op basis van deze inzichten formuleer ik een aantal stellingen.

Hoofdstuk 5 bespreekt de bevindingen en geeft een synthese van de drie belangrijkste hoofdstukken. Dit proefschrift beoogt een waardevolle bijdrage te leveren aan de coopetitie literatuur, en aan het veld van strategisch management in het algemeen. Het levert nieuwe inzichten in de schaarse hoeveelheid coopetitie-onderzoek dat de rol van IE-bescherming bestudeert. Ik benadruk hierin vooral de rol van informele IE-mechanismen, die traditioneel moeilijk te observeren en te meten zijn. Bovendien beargumenteer ik dat coopetitie vaak geen geïsoleerde vorm van samenwerking is. De in hoofdstuk 4 geformuleerde stellingen kunnen in toekomstig onderzoek in meer detail worden getoetst. Verder onderstreept deze dissertatie dat de relatie tussen samenwerkende concurrenten en innovatie niet noodzakelijkerwijs rechtlijnig is, maar dat zowel bedrijfs- als sectorspecifieke aspecten in aanmerking moeten worden genomen in coopetitie-studies. Deze inzichten zijn ook relevant voor mensen uit de praktijk, die de bevindingen van dit proefschrift kunnen gebruiken om hun strategische besluitvorming te verbeteren. Deze dissertatie heeft namelijk als doel bewustwording te creëren dat samenwerking met rivalen gunstig kan zijn, mits op de juiste manier gemanaged.

Curriculum Vitae

Nina Karthaus was born on 23rd of March 1993 in Wermelskirchen, Germany. From 2003 until 2012, she attended the Städtisches Leibniz Gymnasium in Remscheid, where she obtained her Abitur. During that time, she also spent one year at Northwest High School in Cedar Hills, Missouri in the USA. In September 2012, Nina moved to the Netherlands to pursue her Bachelor studies in International Business at the School of Business and Economics (SBE) of Maastricht University. During her undergraduate studies, she spent an exchange semester at the University of Adelaide in South Australia. After receiving her B.Sc. degree in August 2015, Nina followed a two-year Research Master in Business Research, where she specialized in Strategy & Organization. She successfully obtained her M.Sc. degree in August 2017.

During her Master studies, Nina was part of the SBE's Student Council and Program Committee, and a teaching assistant for the Department of Marketing & Supply Chain Management. In September 2016, she joined the Department of Organization, Strategy and Entrepreneurship as a research assistant, where she continued working as a Ph.D. candidate under the supervision of Prof. Dr. Wilko Letterie and Dr. Boris Lokshin in October 2017. During her Ph.D. trajectory, Nina taught the Master course Entrepreneurship & Innovation, and supervised various Bachelor and Master theses. She also worked at the Coopetition Lab of the University of Montpellier both in 2020 and 2021 as (visiting) researcher. Currently, she is continuing her academic career as tenure-track Assistant Professor in Strategic Management at the Vrije Universiteit Amsterdam.

Nina presented her work at various seminars and renowned international conferences, such as the European Academy of Management Conference (EURAM), the Academy of Management Conference, the ZEW/MaCCI Conference on the Economics of Innovation and Patenting, the Ph.D.

Colloquium of the R&D Management Conference, and the Competition and Innovation Summer School. Moreover, she has served as a reviewer for R&D Management, and received an outstanding reviewer reward at the EURAM conference. Nina is currently also the Community Officer of the research community around Coopetition, Ecosystems, Networks and Alliances (CENA), aiming to provide a platform for researchers around the globe to discuss and share interesting work and ideas.