The Microeconomics of Standards:
Five Essays on the Relation of Standards to Innovation and Inter-Firm Relationships

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The Microeconomics of Standards: Five Essays on the Relation of Standards to Innovation and Inter-Firm Relationships

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“Das also war des Pudels Kern.”
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Abstract

The attention of researchers on standards and standardisation has steadily been increasing. A special focus rests on standards-setting committees, the relation between standard setting and intellectual property, and the importance of private standards on (global) value chains. This dissertation adds to that literature by focussing on the micro-level factors determining a company's standardisation activities, the link of standards to the relationship between companies, and how standardisation can strategically be utilised in innovation activities. A unique contribution of this dissertation is the explicit inclusion of a company's idiosyncratic standards in a company's standardisation strategy portfolio.

Overview, Methods and Data

This dissertation is divided into three parts. The first two parts consider standardisation in the realm of open innovation. I analyse the knowledge sources of firms active in formal standardisation and consider the potential of various standardisation and patenting strategies for knowledge transfer for innovation processes. The third part specifically considers managerial and economic aspects of company standards with particular focus on knowledge transfer, inter-firm relationships and innovation.

To develop a rigorous understanding of micro-level standardisation strategies, I employ both quantitative and qualitative methods using a myriad of data in my analyses. These data are evaluated with careful attention to my research questions and the current state of the research field to derive methodologically rigorous results. Quantitative data sets were constructed from multiple sources: the Dutch Community Innovation Survey, the German Standardisation Panel and a self-constructed automotive supplier survey. All qualitative interviews were conducted with selected experts on the corresponding topics of this dissertation.

Results and Implications

The first two parts show how standardisation activities fit into the open innovation paradigm. Therein, the first paper finds that utilising suppliers' information for innovation activities reduces the probability to be active in formal standardisation. The second paper theoretically develops the costs and benefits of knowledge in- and outflows from patenting and standardisation activities for new product development. I develop management recommendations for linking standardisation and patenting strategies to the new product development process. The third part specifically considers company standards. The elementary finding is that company standards are not employed to cure insufficiencies in external or formal standards. I find that company standards are

positively linked to process innovations and that they play a role in inter-firm relationships.

Both managerial and economic implications derive from this dissertation. From an economic perspective, standardisation should be considered both in the realm of the open innovation paradigm. Actively sourcing knowledge from and participation in standardisation activities enables firms to develop products compatible with the market and reduces hold-up problems. Company standardisation should consider the diversion of these standards from market standards and the provision of information on supply chain partners. This aspect also becomes relevant in the light of global value chains, where company-specific standards increasingly play a dominating role.

Company managers should consider the strategic role of standardisation activities, whereby the bandwidth of standardisation provides the following means for firms: to achieve diffusion of information on innovations; to push own standards into the market; and to influence the relationship with and governance of supply-chain partners.

Abstract (Deutsch)

Die Aufmerksamkeit der Forschung auf Standards und Standardisierung steigt kontinuierlich. Besonderer Fokus liegt dabei auf Standardisierungskomitees, der Beziehung zwischen Standardisierung und geistigem Eigentum und der Bedeutung von privaten Standards für (globale) Wertschöpfungsketten. Diese Dissertation erweitert die Literatur um die Sicht auf mikroökonomische Determinanten für Standardisierungsaktivitäten in Unternehmen, die Verbindung von Standards zu den Beziehungen zwischen Unternehmen und der strategischen Nutzung von Standardisierung für Innovationsaktivitäten. Ein besonderer Beitrag dieser Arbeit ist die explizite Einbeziehung von firmenspezifischen Standards in das Portfolio von Standardisierungsstrategien.

Überblick, Methodik und Daten

Diese Dissertation gliedert sich in drei Teile. Die ersten beiden Teile betrachten Standardisierung im Kontext von "Open Innovation". Hierbei analysiere ich die Wissensquellen von Firmen in Standardisierungskomitees und betrachte das Potential von verschiedenen Patentierungs- und Standardisierungsstrategien für Innovationsprozesse. Der dritte Teil untersucht die wirtschaftlichen Aspekte von Firmenstandards, mit einem besonderen Fokus auf Wissenstransfer, zwischenbetrieblichen Beziehungen und Innovation.

Um ein rigoroses Verständnis von Standardisierungsstrategien auf Firmenebene zu schaffen, nutzte ich in meiner Analyse sowohl qualitative als auch quantitative Methoden mit vielfältigen Daten. Diese wurden mit Betrachtung auf die Forschungsfragen und den aktuellen Stand des Forschungsgebiets ausgewertet, um methodologisch sorgfältige Ergebnisse zu erzielen. Quantitative Datensätze wurden von unterschiedlichen Quellen zusammengestellt: aus dem niederländischen Innovationspanel, aus dem deutschen Normungspanel und aus einer selbsterstellten Lieferantenumfrage in der Automobilbranche. Alle qualitativen Interviews wurden mit ausgewählten Experten in den jeweiligen Themengebieten dieser Dissertation durchgeführt.

Ergebnisse und Implikationen

Die ersten beiden Teile zeigen, wie Standardisierungsaktivitäten in das "Open Innovation" Paradigma passen. Hierbei zeigt der erste Beitrag, dass die Nutzung von Lieferantenwissen für Innovationsaktivitäten die Standardisierungsteilnahme mindert. Der zweite Beitrag elaboriert das ein- und ausdringen von Wissen durch Patentierungs- und Standardisierungsaktivitäten entlang der Neuproduktentwicklung. Hier entwickele ich eine betriebswirtschaftliche Empfehlung,

wie Standardisierung und Patentierung in den Produktentwicklungsprozess eingebunden werden können. Im dritten Teil liegt der Fokus auf Firmenstandards. Das wesentliche Ergebnis ist, dass Firmenstandards nicht eingesetzt werden um Unzulänglichkeiten von externen oder formalen Standards zu bereinigen. Vielmehr finde ich heraus, dass Firmenstandards sich positiv zu Prozessinnovationen verhalten und diese eine Rolle in der zwischenbetrieblichen Beziehung spielen.

Aus dieser Dissertation ergeben sich vielfältige ökonomische Implikationen. Aus der volkswirtschaftlichen Perspektive sollte Standardisierung Beachtung innerhalb des "Open Innovation" Paradigma finden. Die aktive Nutzung von Wissen aus der Standardisierung sowie die Teilnahme an der Standardisierung erlaubt es Firmen, ihre Produkte marktkompatibel zu entwickeln und reduziert dabei "Hold-up" Probleme. Unternehmen sollte die Abweichung ihrer Standards vom Markstandard sowie die Bereitstellung von Informationen zu Partnern in der Belieferungskette betrachten. Diese Aspekte sind überdies wichtig in der Betrachtung von globalen Wertschöpfungsketten, in denen firmenspezifische Standards eine immer dominantere Rolle übernehmen.

Manager sollten der strategischen Rolle von Standardisierungsaktivitäten mehr Beachtung schenken. Die Bandbreite von Standardisierungsaktivitäten bietet Firmen die Möglichkeit zur Innovationsdiffusion, um eigene Standards im Mark voranzubringen und die Beziehung und Führung von Partnern entlang der Belieferungskette zu unterstützen.

Publication and Submission Record

The essay "Innovation Knowledge Sources of Firms Active in Formal Standardisation" is co-authored by Knut Blind and Henk de Vries. It was presented at the BRICK workshop 2013 in Turin, Italy, the DRUID Academy Workshop 2014 in Aarlborg, Denmark, the Innovation Research Colloquium (CIF) at TU Berlin in November 2013, and the EURAM Conference 2014 in Valencia, Spain. It has been invited for revision and resubmission at the Journal *Technovation* (submission date: 29th September 2014).

The essay "The Strategic Use of Patents and Standards for Knowledge Transfer" is co-authored by Ellen Filipovic and Luisa Lazina. It was presented at the ISPIM conference in Dublin, Ireland and at the workshop of TU Innovation Economics Winter Symposium in January 2014. An earlier version was published as "NPD knowledge transfer via standards and patents? A case study" (Filipovic, E. & Großmann, A., 2014) in *The Proceedings of XXV ISPIM Conference - Innovation for Sustainable Economy and Society*, edited by K. R. R. Huizingh, S. Conn, M. Torkkeli & I. Bitran. It is currently under review at the Journal *R&D Management* (submission date: 19th December 2014).

The essay "Supplier's Motives for Applying Their Buyer's Company Standards" under my single authorship was presented at the EURAS Conference 2013 in Brussels, Belgium, at the Competition and Innovation Summer School 2013 in Turunc, Turkey, and at TU Berlin CIF in May 2013.

The essay "Company standard Implementation, Inter-Firm Relationships and Innovativeness" is co-authored by Knut Blind. It was presented at the EURAS conference in Belgrade, Serbia, and at the CIF at TU Berlin in November 2014.

The essay "Company Standards in Supply Chains —Inter-Firm Relationships and Strategic Positioning" is co-authored by Paul von Gruben. It was presented at the HICL conference in Hamburg, Germany and the CIF at TU Berlin in November 2014. An earlier version was published as "The role of company standards in supply chains - The case of the German automotive industry"(Großman, A. & von Gruben, P., 2014) in *Innovative Methods in Logistics and Supply Chain Management Current Issues and Emerging Practices* , edited by W. Kersten, T. Blecker, & C. M. Ringle, (pp. 99-120). Berlin: Epubli GmbH.

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Work experience at the Stahl Judenburg GmbH, MVO GmbH and Daimler AG gave me the first insight into the challenges automotive suppliers and producers face when adhering to company and formal standards. I would especially like to thank Egon Behr, Thomas Laemmle, Stefan Grau and the whole RD/OES team of the Daimler AG, Christiane von Finckenstein-Wang of Volkswagen Group, Markus Franke at Schaeffler Group, the participants at the standardisation practice committees and numerous other experts - extending beyond the automotive industry - for their time and insight into the often undervalued topic of company standards. Perhaps one day standardisation will be considered more "sexy" because of your efforts.

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Anne-Marie Großmann

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INTRODUCTION

The overriding focus of this dissertation is on two instruments available to companies for strategic revelation, access and documentation of knowledge. These are formal standards as the result of standard-setting processes at standard development organisations (SDOs) and company standards as initiated, developed and implemented by individual companies. Within this dissertation, these instruments are nestled by intellectual property (IP) protection via patents. I relate the use of standards and standardisation activities and the corresponding transfer of knowledge by companies to the topics of innovation and inter-firm relationships. In order to clarify the background of these concepts, I review each in the following chapter.

Formal Standards

A standard is the consensus of various agents to carry out certain activities by agreed-upon rules (Narayanan and Chen, 2012). Formal standards are developed in SDOs that open the standardisation process to interested parties aiming to achieve consensus on the final standard. The standardisation process unites organisations in the creation of new products (Chiao et al., 2007), shaping the technological development (Dokko et al., 2012; Tassey, 2000) and thereby collectively innovating (Lopez-Berzosa and Gawer, 2014). Formal standardisation has therefore been considered an extreme form of collaboration, as it provides a platform for explicit agreement among competitors (Chiesa et al., 2002). Formal standards have the advantage that they avoid excess inertia and reduce users' search and coordination costs (Tirole, 1980). An exhaustive overview on the economics of standardisation is provided by Swann (2000).

Limited literature considers companies' motivations for involvement in the development and

application of formal standards (Blind, 2006; Blind and Mangelsdorf, 2010; Blind and Rauber, 2012). Larger firms seem more involved in formal standardisation participation and, overall, firms seek to fulfil their own aims by preventing standards from contradicting individual interests via their participation (see e.g. Blind, 2006; Blind and Rauber, 2012). The research on the microeconomic effects of formal standards, however, is quite restricted (Riillo, 2013).

Company Standards

Standardisation is further relevant on the level of the organisation (van Wessel et al., 2007). I consider and define company standards based on their scope of application by the focal firm (Blind et al., 2014): Internal company standards are idiosyncratic standards developed within the focal company and applied either within the firm or by cooperating companies. External company standards are the idiosyncratic standards of other companies (e.g. buyers or customers) that are applied and implemented within the focal firm. The topic of company standards has been identified as vastly under-researched both in the specific context of supply chains (Gereffi and Lee, 2012) and in more general applications (Riillo, 2013).
Conceptual developments and limited empirical analyses indicate that company standards are used to raise quality (Henson and Reardon, 2005) or to communicate safety and reputation (Jaffee and Masakure, 2005), thereby differentiating products on the market.

Patents

A patent is an intellectual property (IP) right granted by a state or government to an inventor for a limited amount of time, providing them with a temporary monopoly position (Trott, 2005). Patents are primarily aimed at generating value from an innovation (James et al., 2013) and therefore provide an incentive to invest into research and development (R&D) (Arrow, 1962). The latter aspect makes them important in the context of standardisation, as the proprietor of patented technologies or products included in a standard can receive licensing revenues (Lerner and Tirole, 2014). The existence of IP protection also allows companies to reveal firm-specific knowledge by reducing the threat of imitation.

Innovation

In this dissertation, I emphasise innovation as the development or improvement of products and processes. In additional to their own knowledge, firms gather knowledge from outside of the company for innovation, a term famously coined as “open innovation” by Chesbrough (2003). Dahlander and Gann (2010) therein differentiate between revealing of internal resources to the external environment and sourcing external ideas and knowledge from suppliers, customers,

competitors and scientific institutions. Each of these sources provides different complementary resources for the firm (Miotti and Sachwald, 2003) and gives access to a different breadth of knowledge (Un et al., 2010).

One central argument in the literature is the revelation of privately funded knowledge for a firm's own technology to become the dominant design (Hippel and Krogh, 2006). As standardisation is a "private-collective" mode of demand-driven innovation (Lopez-Berzosa and Gawer, 2014) and provides a neutral arena for knowledge sharing, it has even been declared a form of open innovation (Groetnes, 2009). Analysing the microeconomic relation between innovation and standardisation contributes to the long-discussed but yet unsolved paradox of innovation and standardisation (Choi et al., 2011): do standards impede or promote innovation?

Inter-firm relationship

To understand the various ways in which standardisation affects the relationship between actors within a market exchange, I consider its link to inter-firm relationships. Instances of these are cooperation, alliances or governance structures between companies. Such relationships between companies along the value chain have considerable impact on the outcome of the final product. For example, knowledge sharing between a buyer and his supplier can enhance their relationship (Cannon and Perreault Jr., 1999) and result in faster learning on behalf of the supplier (Dyer and Hatch, 2006). As organisations aim to create efficient and competitive supply networks, they increase supplier performance and capabilities by diffusing their manufacturing and production expertise in their supply bases (Modi and Mabert, 2007). I further relate this to the concept of relational embeddedness, which refers to how companies are anchored within their larger structure (Dacin et al., 1999; Johannisson et al., 2002), allowing firms to know more about each other's reliabilities and capabilities and improving mutual understanding (Ebers and Oerlemans, 2013).

The literature on strategic partnerships strongly focuses on enhancing supplier performance (Dyer and Ouchi, 1993; Nishigushi, 1992). Intensifying the relationship between the buyer and the supplier leads to more horizontal integration and a reduced number of suppliers. Buyer-supplier relationships generally lead to tighter integration and greater interdependence of the two agents (Dyer, 1996). By tightening this relationship, adherence to company-specific standards can thereby enhance vertical integration (Schuster and Maertens, 2013). As relationships are not confined to buyers and suppliers, I also consider vertical relations such as those with competitors.

0.1 Overview: The Research Focus of this Thesis

This dissertation aims to review and connect the above mentioned concepts and supplement them with empirical analysis. I answer specific research questions related to broader-picture microeconomic aspects of formal and company standards. According to each of these objectives, the corresponding relevant literature as well as previous empirical findings are reviewed to develop a sound and rigorous background for the subsequent qualitative and quantitative analyses.

In the first paper, I review literature on knowledge transfer and open innovation, ultimately arguing that participation in standardisation committees may be an important source of external knowledge. A multivariate probit regression of a large study analyses how companies active in formal standardisation significantly differ in their knowledge sourcing activities compared to non-active companies.

The second paper consequently considers knowledge transfer strategies with respect to formal standardisation participation but also company standardisation and patenting in the new product development process. An in-depth qualitative analysis via three case studies allows me to review the integration of patenting and standardisation into the new product development (NPD) process. I develop a conceptual model of how firms can strategically employ these methods to enhance their NPD processes. In the third part of my dissertation, I take a thorough look at company standards. Although company standards are prevalent across most industries, they received little attention in the field of applied microeconomics and therefore warrant a broader perspective. I include both qualitative and quantitative empirical methods.

The third paper uses a quantitative case study of suppliers to a particular buyer. This allows me to analyse the particularities in suppliers' motivations to implement the company standards of their buyer and how this affects the companies economically. In a first step I employ factor analysis to reveal underlying patterns of the motives to use such standards. Secondly, I utilise a multivariate ordered logistic analysis to relate identified factors to the economic benefits that suppliers expect from applying the buyer's company standards. I find that knowledge transfer and the fulfilment of quality requirements play a favourable role.

The fourth paper advances these aspects on a larger scale, adding the dimensions of innovation and the platform aspects of company standards. A variety of companies from different sectors are analysed using a multinomial probit analysis. I therein consider the influence of companies' innovation and cooperation activities on their enforcement of internal and external company standards. The findings strengthen the perspective of my analysis on the inter-firm relationship, as different types of cooperation have significantly different correlations with the various ways to implement company standards. In the fifth paper, this aspect is further questioned by qualita-

tively analysing how companies at different stages of the supply chain deal with internal and external company standards. I reveal that power as well as network position play an important role in dealing with external company standards.

0.2 Contribution and Implication: Who learns what from this dissertation?

Although my thesis primarily addresses aspects of inter-firm relationships and innovation and their relation to standardisation activities, this microeconomic perspective also allows for broader policy implications. This is mainly achieved by the first two parts, which consider formal standardisation participation for the active sourcing and revealing of knowledge that inter alia can be important for national standardisation policies. The third part on company standards is of considerable interest for business policies, as it reveals how company standards govern inter-firm relationships, such as across supply chains. In the following, I will therefore state the main results and more specific implications from this dissertation.

Standardisation participation should be considered part of an open innovation strategy

The potential of sourcing knowledge from standardisation committees provides firms with early information on the direction of technological development, which is especially relevant for NPD processes. I show that firms sourcing knowledge from their customers increases, but sourcing knowledge from their suppliers decreases, the likelihood to be active in formal standardisation. This provides evidence that standardisation could support demand-pull innovation and is therefore should be an important consideration for innovation policy makers.

Following patenting, standardisation strategies should be linked to the individual product development processes

As patenting is established as part of a monetary open innovation strategy for companies, I link it to standardisation activities for the non-monetary revealing and sourcing of information. My analysis shows how the neglect of standardisation activities can prove considerably costly for a company's NPD. Firms with contrasting overall strategies are using these mechanisms differently. The result is a product-specific strategy for patenting and standardisation activities, both for inbound and outbound knowledge transfer, to be considered within the development process.

Company standards reflect firms-specific knowledge and can have significant influence on suppliers

Contrary to existing literature on the topic, I find that company standards are not just substituting or extending external standards (van Wessel et al., 2007). They are foremost employed to access business relations with a buyer. This motive is followed by knowledge transfer and the fulfilment of quality requirements. This result should be of interest to formal SDOs and standardisation managers. Suppliers that are applying their buyers' company standards for knowledge transfer or to fulfil quality and reputation requirements expect a higher net benefit from the application of these company standards.

Companies with process innovations are more likely to set and use company standards

Focussing on the question whether standardisation has a positive or negative relation to innovation, I find that the likelihood of having company standards increases in companies with process innovations. Although this does not show whether the standardisation itself promotes innovation, it indicates that company standards do not seem to hinder innovation.

Company standard relate to the governance of inter-firm relationships

A significant relationship exists between companies' cooperation activities and their use of company standards. Whereas cooperation activities with suppliers significantly decrease the likelihood of having company standards, the opposite holds for cooperation activities with competitors and customers. Suppliers are less likely to have internal-only company standards, but more likely to have both internal and external company standards. In the fourth paper I find that not only powerful buyers enforce their standards on suppliers, but that they are also passed from raw material producers to suppliers. This is of considerable importance to supply chain management and managers should consider these effects on the governance of inter-firm relationships.

Overall, this dissertation aims to contribute a microeconomic angle to the knowledge on standardisation activities. It foremost aims to drive the state of research in the field of company standardisation activities.

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PAPER 1

Innovation Knowledge Sources of Firms Active in Formal Standardisation

Innovation requires knowledge which may stem from within or outside a firm. This paper argues that participation in standardisation committees may be an important source of external knowledge. Participants in standardisation get the opportunity to understand and influence technological development and in doing so, meet representatives of suppliers, competitors, customers and research institutes. Our study aims to distinguish this source of information for innovation from other sources. We develop a conceptual framework and test it by combining firm-level data from the Dutch Community Innovation Survey about the sources companies use for their innovation with data from the Netherlands Standardisation Institute about firms' involvement in their committees. The substantial overlap shows that many innovative firms also participate in standardisation. It turns out that firms using knowledge from scientific organisations are more likely involved in formal standardisation. A significant finding is provided by the finding that utilising suppliers' information is less common for companies participating in standardisation. We provide an extensive discussion what knowledge can be accessed by involvement in standardisation and how this could provide an alternative mean to access knowledge from suppliers for innovation activities. Our analysis hints at the importance of participation in formal standardisation as an external knowledge source for innovation.

Keywords: Standardisation; Innovation; Knowledge Spillovers; External Knowledge Sources

1.1 Introduction

Knowledge is an important factor for innovation in organisations (Teece et al., 1997). Additional to their own knowledge, firms gather knowledge from outside the company (Chesbrough, 2003). Standardisation committees that a company participates in are potential sources of external knowledge. This standardisation process brings together firms in creating new products, shaping technological development and thereby collectively innovating in setting new standards (see e.g. Chiao et al., 2007; Dokko et al., 2012; Lopez-Berzosa and Gawer, 2014; Tassey, 2000). As Ranganathan and Rosenkopf (2014) state, "[t]hese industry-wide organisations are venues where firms debate and coordinate the technological rules that define a common path for future technological development." Thus, potential knowledge spillovers from other organisations within the standardisation process play an important role (Blind and Mangelsdorf, 2013; Chiao et al., 2007; Gupta et al., 2008).

This paper investigates what sources of external knowledge for innovation companies active in standardisation committees use compared to those not involved. This question is relevant as standardisation is recognized as providing access to external knowledge (Groetnes, 2009). We focus on formal standardisation at the national level: the national members of the 'official' international standardisation organisations, International Organisation for Standardisation (ISO) and International Electrotechnical Committee (IEC). We develop a concept based on the incentives of firms to participate in formal standardisation committees - which is not only to influence standards but also to understand the technological development within the specific industries.

Despite a substantial number of firms involved in formal standardisation institutions[1], little theoretical and empirical attention has been paid to the motivations for participation in standard-setting committees related to potential knowledge sourcing activities (Leiponen, 2008). However, evidence for the importance of knowledge spillover in the form of patent citations has been detected in informal standardisation consortia by Delcamp and Leiponen (2014). Formal standardisation institutions are built to organise the development and publication of formal standards. Participating individuals and organisations gather in technical committees to develop - in general, consensually - agreed-upon standards on a topic within their interest. Hence some participants disclose at least part of their knowledge to contribute to the development of the standard (Blind and Mangelsdorf, 2013; Leiponen, 2008).

We consider a firm's potential external sources of information to be suppliers, customers,

[1]The German standardisation institute DIN, for example, saw more than 30,000 experts active in technical committees in October 2013 (www.din.de). The British standardisation institute BSI had about 10,000 committee members in October 2013 (http://www.bsigroup.com/en-GB/about-bsi/media-centre/Facts-and-figures/).

competitors and scientific organisations. These external information sources provide different complementary resources for the firm (Miotti and Sachwald, 2003) and each gives access to a different breadth of knowledge (Un et al., 2010). We relate the exploitation of these external sources for innovation to the involvement of firms in formal standardisation. As the firms involved are interested in the development of technological trajectories (Dokko et al., 2012; Ranganathan and Rosenkopf, 2014), they are assumed to be less likely to source information for innovation from suppliers and more likely to source it from customers, competitors and scientific institutions. If standardising firms want to be successful in placing their innovations in the market, they are assumed to orient themselves towards the demand from their customers as well as monitor potentially competing technologies from their competitors. Firms in formal standardisation seem to be less interested in the innovation knowledge available from their suppliers. Buyer-supplier relationships generally lead to tighter integration and greater interdependence of the two agents (Dyer, 1996), reducing the need for a broader knowledge pool. Finally, firms in formal standardisation might generally be closer to research as they are aiming to shape the technological development via participation in standardisation committees and hence assumed more likely to use knowledge from scientific institutions.

To test the framework, we analyse data from the Dutch version of the Fourth Community Innovation survey (CIS) that is matched with data from the Netherlands Standardisation Institute (NEN). This empirical analysis partly supports our hypotheses. We discuss implications of our analysis both for innovation management and standardisation policy. Firstly, companies active in standardisation seem more open towards cooperation with and using knowledge from scientific organisations in their innovation activities. As the more fundamental second result we find that sourcing knowledge from suppliers seems to be less likely when a firm is involved in formal standardisation. This is result is surprising in the context of no significant relationship with information sourcing from customers or competitors. We therefore discuss whether suppliers provide a different scope of information for innovation compared to standardisation participation. There is also the potential that firms unable to participate in standardisation might use their suppliers as an alternative source or even that suppliers rather than buyers are participating in formal standardisation processes. As there is no evidence that firms in formal standardisation utilise knowledge from their competitors more compared to those not involved, this may reduce the fear of firms to participate in standardisation committees where competitors are present.

In the following section, the conceptual framework as the basis for the empirical analysis is presented. The emphasis of this section lies on the specific aspects of formal standardisation participation and a company's perspective on external knowledge sourcing. The third section presents the empirical analysis based on the data available from the CIS and NEN. The last section summarizes and discusses the results, highlighting the differences in external knowledge

sourcing of firms active in formal standardisation.

1.2 Conceptual Framework

The process of standardisation facilitates coordination among economic players (Farrell and Saloner, 1988; Farrell and Simcoe, 2012). The resulting standards are constructs following from reasoned, collective choice that enable agreement on solutions to recurrent problems (Tassey, 2000). More than 100,000 of such standards to date have been developed in technical committees at formal standardisation organisations. Such committees try to establish consensus on, in most cases, characteristics of or requirements for a technology or process. Standards thereby influence and shape technological development (Axelrod et al., 1995; Keil, 2002; Ranganathan and Rosenkopf, 2014; Tassey, 2000). During the standardisation process, participants reveal knowledge about the direction of this technological development. Participation in standardisation can therefore be an organisational resource which enables firms to improve and extend their own pool of resources for new products during this process (Dokko and Rosenkopf, 2010; Groetnes, 2009). This paper focusses on knowledge flows intrinsic to participation in formal standardisation committees. Therefore, formal standardisation can be seen as a process of open innovation that covers both aspects of knowledge revelation and knowledge sourcing (Dahlander and Gann, 2010).

We proceed to explain the nature of formal standardisation and the role of knowledge on the technological development relevant for the involved firms. By looking at their motivations to be active in such committees, we finally derive hypotheses relating the external knowledge sourcing activities to involvement in formal standardisation committees.

Knowledge Revelation and Sourcing in Formal Standardisation

Standardisation facilitates coordination on the early shaping of technological development. Firms involved may try to implement their own technology in the standard or aim to get requirements in the standard they can easily meet, where other companies may face difficulties in implementing them. The rules and regulations of formal standardisation allow all stakeholders to be represented: directly at the national level, or indirectly at the international level via representatives of the national committees.

The first goal of a standardisation committee is to develop a standard candidate (Keil, 2002). The technological solution in this candidate is either created within the committee or taken as a readily available solution from one of the participating organisations. This process involves substantial uncertainty ex ante: if the result of the standardisation process had been determined from the start, little incentive for participation would be given. Contribution to the technical

specification development of standards requires technical expertise, and so active participants are generally engineers or technical experts (Farrell and Saloner, 1988; Leiponen, 2008). Including owned technology in a standard or influencing the technological development set in the standard is widely accepted as the primary motivation for participation (see e.g. Chiao et al., 2007; Contreras, 2014; Farrell and Saloner, 1988; Leiponen, 2008; Tassey, 2000).

As the standardisation process provides a neutral arena for knowledge sharing, Groetnes (2009) declares it a form of open innovation. Huizingh (2011) states that standardisation is a "classic example" of public innovation, where the outcome of the innovation process is open and available to the public. The link between the openness of the innovation process and standardisation is to our understanding best described, however, by Dahlander and Gann (2010)'s in- and outbound non-pecuniary innovation strategies *revealing* and *sourcing* of knowledge. *Revealing* focusses on "revealing internal resources to the external environment," occurring when technical experts bring their organisation's knowledge into the committee to use it for the development of the standard. *Sourcing* focusses on "sourcing external ideas and knowledge from suppliers, customers, competitors, [... and research organisations]." This is inherent in the standardisation process, where participants can perceive the input from other participants who are revealing their knowledge.

According to Axelrod et al. (1995), firms dislike partaking in standardisation with rivals, as this opens up effective price or product competition in the post-adoption market for the standardised good. In practice, however, we observe participation of horizontal competitors within standardisation committees. Additionally, small and medium sized companies mostly lack the ability to push their own technology into the standard but may participate in the formal standardisation committees in order to gain knowledge, especially from larger companies.

A limited amount of studies confirm that companies are motivated by the knowledge available within standardisation committees (Blind, 2002; Blind and Mangelsdorf, 2013), and hence that standardisation provides a channel for knowledge transfer. Blind and Mangelsdorf (2013), for example, show that small and medium-sized firms and firms in the electrical engineering and machinery industries confirm the access to the knowledge of other participants as a motivation for joining standardisation committees. With regards to the participation of researchers at a scientific organisation, Zi and Blind (2015) show that higher qualified researchers are more likely to participate in standardisation. Organisations in the standardisation process therefore engage both in revealing and sourcing and hence we assume them to have a particular interest in available outside sources of information for innovation.

Effects of Knowledge Sourcing for Standardisation Participants

We approach knowledge sourcing of firms in formal standardisation from the knowledge-based view. This knowledge-based view is an extension of the resource-based view of the firm (Grant, 1991; Teece et al., 1997). Therein a company's competitive advantage is determined by the resources it holds and whether these are rare and inimitable. By learning from outside sources, firms build up their knowledge base and ultimately enhance the innovation activities of their companies (Lazaric and Marengo, 2000). Organisations can learn, share, diffuse and create knowledge through interaction with other sources (Caloghirou et al., 2004). This is especially important in today's world, where individual firms can no longer rely on their own resources to compete (Sobrero and Roberts, 2002). Learning from outside sources of information has to be understood as knowledge-building (Lazaric and Marengo, 2000). Such external sources need to be heterogeneous enough to have potentially new knowledge available, but some element of homogeneity must exist so that mutual understanding is still possible (Mowery et al., 1996).

There are potentially different learning opportunities for innovation activities, depending on the partner involved (Un et al., 2010). Caloghirou et al. (2004) show how this ability of firms to create linkages with other entities and establish channels of knowledge flows between them positively impacts the level of innovativeness of firms. The cooperating with other organisations is motivated by the varying objectives that a firm is pursuing. Fritsch and Lukas (2001) find that the type of innovation influences which external information is needed, and from whom. It is henceforth important to consider each of the available external sources of knowledge separately.

Standardisation can be seen as a "private-collective" mode of demand-driven innovation (Lopez-Berzosa and Gawer, 2014). Hereby a potential threat in sharing firm-specific knowledge is inherent (Cassiman and Veugelers, 2002; Laursen and Salter, 2013). Consequently, Hertzfeld et al. (2006) highlight the importance of intellectual property protection and patented technologies. However, if firms find it beneficial to collaborate, intellectual property might be a negotiation problem but not a "showstopper." Cassiman and Veugelers (2002) find that spillovers to vertical partners especially matter and, in these instances, the importance of strategic protection of intellectual property is very high. In the case of formal standardisation, however, patents have a special value if they are part of the collaboration and are included in the resulting standards (Farrell et al., 2007; Hytönen et al., 2012). Such patents may confer market power ex post that was much weaker ex ante (Rysman and Simcoe, 2008). It can therefore be desirable to bring knowledge into the formal standardisation process, as firms can capitalize this knowledge and license it to other participants under fair and reasonable conditions (Chiao et al., 2007). Dokko and Rosenkopf (2010) support this by finding that companies owning patents have a greater influence in standardisation committees' decisions. However, in most standards, no patented technologies are included.

Knowledge revelation and sourcing may create direct network externalities for participants in synergistic activities such as sharing intellectual property, joint development of complementary products, and agreeing to specifications for components (Farrell and Saloner, 1988). If the firms can anticipate the reactions of the different stakeholders and have foresight[2] into future markets, this also allows for a better sense of the timing for technological development. In formal standardisation, firms have the opportunities to learn about such new technologies, business processes and know-how developed by other participants (Gupta et al., 2008). Understanding the direction of the technological development is crucial for companies to steer their own research and development (R&D) and ultimately innovation efforts.

Formal Standardising Companies' Heterogeneous Sourcing Activities

We establish that standardisation participants are interested in technological development, actively by influencing and passively by observing it. In the following we develop our hypotheses on the type of organisations that standardising firms exploit as knowledge sources for innovation.

External knowledge sources can be utilised for the internal innovation activities of a firm (see e.g. Laursen and Salter, 2006; Miotti and Sachwald, 2003; Un et al., 2010). Potentially relevant sources are customers, suppliers, competitors and scientific institutions (Fritsch and Lukas, 2001; Laursen and Salter, 2013). As mentioned previously, these sources are generally also present in formal standardisation committees. The complementary resources that are available from each source determine which of these sources is utilised (Miotti and Sachwald, 2003). Important determinants for this are the breadth of knowledge available from the source, the ease of access to that information (Un et al., 2010), and the firm-specific characteristics (Fritsch and Lukas, 2001). We are interested in understanding how firms active in formal standardisation utilise external sources for their innovation activities, compared to firms that are not active in committees. We therefore review the potential of each external source to be moew beneficial for innovation for these types of firms and thereby derive hypotheses about which sources are used more by companies involved in formal standardisation.

We first consider suppliers as potential innovation sources. They provide valuable information on the input of products to be innovated, such as possible ways to improve a component of a new product or the process of production. In a study of German firms, Fritsch and Lukas (2001) find that cooperation with suppliers works for many firms as a substitute for individual innovation efforts. This effect is not shown for cooperation with other sources. If information received from a

[2]Standardisation bodies even started their own foresight activities to identify promising future fields for their activities (Goluchowicz and Blind, 2011)

supplier is already sufficient for the observation of future technological development, this can dampen the need to receive such information from collaborations in larger knowledge pools, such as standardisation.

A stronger buyer-supplier relationship increases horizontal integration and reduces the amount of suppliers, leading to the reciprocal interdependence of the two agents (Dyer, 1996). The engagement of knowledge sharing between the buyer and a supplier can improve the relationship between the buyer and the supplier (Cannon and Perreault, 1999) and results in faster learning on part of the supplier (Dyer and Hatch, 2006). Therefore, the more information for innovation activities available from suppliers, the lower the need for other sources such as standardisation committees as knowledge pools for innovation. Supplier's knowledge is encoded in products and thereby passed on to buyers (Appleyard, 2003). Therefore companies also have the potential to acquire knowledge about their competitors via common suppliers (Cassiman and Veugelers, 2002). Formal standardisation provides a broad pool of knowledge potentially including these competitors, thereby decreasing the need for such knowledge from suppliers.

Lau et al. (2010) show that utilising information from a supplier directly improves product performance, which is supported by Cousins et al. (2011) who find that a firm's supply base is a major source for ideas and innovations. If knowledge on technological development is available from suppliers, there is little incentive to acquire such knowledge elsewhere, such as from the process of standardisation. Cooperation with suppliers is however generally aimed at rationalisation or process innovations and also done by less innovative firms (Fritsch and Lukas, 2001). We thereby assume that firms involved in formal standardisation are using knowledge from their suppliers less for innovation compared to firms not involved, because they are more interested in technological development or potentially see direct knowledge sourcing from suppliers as substitutes to formal standardisation participation.

Hypothesis 1: *Companies sourcing information from their suppliers for innovation activities are less likely to be involved in standardisation.*

Secondly we turn to customers as an additional source of vertical information. Information from customers for innovation processes can provide indications where future market needs are located and steer innovation activities of the company into the right direction (Jeppesen and Molin, 2003). For example, Hippel (1998) argues that users rather than suppliers are better designers of "mass-customization" products, especially when integration and interfaces are at stake. Fritsch and Lukas (2001) find that generally more innovative firms aim at cooperation with customers. Collaborations with customers also produce knowledge that is utilised for product innovations rather than further development of already existing products. Demand is a determin-

ing component in directing the technological development towards the right economic venues (Di Stefano et al., 2012). Understanding the wants of customers is crucial for marketing new technological developments and therefore arriving at effective innovations.

As companies active in formal standardisation aim at understanding and influencing the technological development and marketing of their innovations, they want to utilise information from their customers for their innovation processes. We therefore arrive at our second hypothesis:

Hypothesis 2: *Companies sourcing knowledge from their customers for innovation activities are more likely to be involved in standardisation.*

We now turn to potential knowledge spillovers from outside the supply chain. A study by Blind and Mangelsdorf (2013) discovers that small and medium-sized enterprises relying on incoming spillovers from competitors and research organisations are more likely to participate in standardisation activities. In the following, we separately approach the potential knowledge sources of competitors and scientific organisations for firms active in formal standardisation and start with competitors. Joining collaborations where close rivals are present, such as standardisation committees, increases competitive pressure on firms (Axelrod et al., 1995). This lowers the incentive of firms to participate in such committees. However, firms interested in the technological development must consider their competitors' strategies and closely observe their actions. Although the breadth of knowledge available from competitors is small (Un et al., 2010), it is crucial to be aware of the competing technologies when trying to develop a new industry standard. We hence assume that firms who consider the information available from their competitors important for their own innovation activities will be more active in formal standardisation.

Hypothesis 3: *Companies utilising knowledge from competitors are more likely to be involved in standardisation.*

The last source of interest for a company concerns scientific organisations, such as universities. Scientific organisations provide a broad knowledge base for companies (Un et al., 2010). Firms that consider publicly available information as more important for their innovation processes are more likely to cooperate with research institutions (Cassiman and Veugelers, 2002). Also, firms that are more open in their search strategies and or with higher investments in R&D are more likely to use universities as a source for innovation (Laursen and Salter, 2006). Zi and Blind (2015) find that researchers, especially in the field of more technology-oriented or market-relevant knowledge, are participating in standardisation. As we establish standardising firms to be interested in technological development in their industry, we expect them to be more

likely to source information from scientific institutions for their innovation activities compared to firms that are not.

Hypothesis 4: *Companies utilising knowledge from scientific organisations are more likely to be involved in standardisation.*

After introducing the hypotheses resulting from the conceptual framework, we will now present the methodology to test these hypotheses and the results of our analysis.

1.3 Data and Methods

The data for our analysis stem from the Dutch version of the Fourth European Community Innovation Survey (CIS) that compiles companies' innovation activities. Although this survey was not designed to test the hypotheses we developed, it nevertheless provides an exhaustive sample of companies' innovation and standardisation activities[3]. This survey asks individual firms about their product and process innovations, the sources of information for their innovation activities, cooperation activities and expenditures on R&D. The survey was conducted in 2007 and relates to innovation activities undertaken in the three-year period from 2004 to 2006. The CISs are executed within multiple European countries and were used in recent articles as a basis for innovation research (see e.g. Derbyshire, 2014; Mention, 2011). As this is an independently collected and well regarded survey, we believe it to be a sound database for our investigation . The sample comprises over 3,450 companies that provided all necessary information.

To relate the knowledge acquisition activities of firms for innovation to the participation in standardisation, this dataset is matched by information of individual companies' involvement in the national formal standards development organisation: The Netherlands Standardisation Institute (NEN). NEN provided a list of all 1,400 companies actively involved in standardisation at NEN at the end of 2008. These committees prepare the Dutch input for standardisation at the international level (ISO or IEC) and/or for European standardisation (the European Committee for Standardisation CEN or the European Commiteee for Electrotechnical Standardisation CENELEC). This input includes comments, votes, draft texts for standards, and sending delegates to international or European standardisation committees. Some of the committees also develop national standards and in exceptional cases they focus on national standards only. The 7,000 committee members together have 17,000 memberships (some of them participate in multiple commitees) and represent different stakeholders including 1,400 companies, in majority SMEs. More than 480 of these companies provided full information in the CIS; therefore 14% of the surveyed companies were actively participating in standardisation at NEN. Tables 1.2 and 1.3 (see

[3]Because these surveys are used extensively in the literature, we will not introduce the procedure of the data collection here. The interested reader might consult Mention (2011) andDerbyshire (2014) for further information.

section 1.7) provide a summary of the constructed variables, and their means and distributions, respectively. We will provide a brief introduction to the variables along with the specification of the model.

This cross-sectional dataset allows us to investigate the characteristics of firms that are involved in formal standardisation. The focus lies on the activities of firms towards their knowledge pool and therefore on the usage of external sources of information for innovation. The binary variable NEN indicates whether the firm has been participating in standardisation.

The explanatory variables of interest are the external information sources a company utilised for innovation activities (is_i). This is measured on a scale from low importance to high importance for the time period of 2004 to 2006. On average, information sourcing from suppliers (is_{su}) is rated highest, followed by sourcing from customers (is_{cu}) and competitors (is_{co}). Information used from scientific (is_{sc}) institutions is least important for the companies in the sample. We assume these variables to relate to the likelihood of participation in NEN in the way specified by our hypotheses.

We further include a series of control variables important for the likelihood to participate in standardisation. To distinguish the general knowledge sourcing from external sources from cooperation with external sources, we also include information on cooperation activities as well as the utilisation of spillovers of such cooperation activities as formal external linkages. This distinction can be relevant as shown by Freitas et al. (2011) in a cross-country comparison of the CIS surveys in Sweden, Norway, the Netherlands and the UK. The authors find a complementarity of information sourcing and cooperation activities. The cooperation with external organisations is measured with a binary variable indicating whether the firm has cooperated with the potential partner on innovation in the period between 2004 and 2006. The variables are cooperation with suppliers (co_{su}), cooperation with customers (co_{cu}), cooperation with competitors (co_{co}) and cooperation with scientific institutions (co_{sc}). Of the companies in the sample, 37% cooperate with suppliers, followed by customers and scientific organisations; 15% of the firms in the sample cooperate with their competitors. To relate the cooperation with external sources and the use of information for innovation activities, we also include an interaction term of the two variables (x_i). This allows us to see where information from cooperation is used for innovation activities and helps to discriminate the effects of information sourcing from external knowledge sources in general and from specific cooperation activities.

We consider the relative spending on R&D for innovation to be important for participation. The variable rd reports the firm's expenditure on R&D activities for innovation divided by total turnover in the year 2006. Average R&D spending in the sample is 3.2%. A higher level of R&D

indicates a firm's higher level of absorptive capacity Cohen and Levinthal (1990), i.e. the ability of a firm to recognize external information for its innovative capabilities.

As mentioned, the existence of patents can be a valuable resource in a standard. The existence of intellectual property rights is also important for the revelation of knowledge in collaborations Cassiman and Veugelers (2002). The variable pat therefore measures the importance of patent protection for intellectual property on a three level scale from low to high importance.

Further, the size of a company is relevant as it determines the resources available for standardisation. Firms need to invest time for their participation in technical committees, cover travel expenses, and pay membership fees. The variable $size$ measures the logarithm of the number of employees in the year 2006. Companies in our sample have at least 10 employees or more. The export activities of a company are further suggested to have a positive relation with the likelihood of participation in standardisation. Participation in national standardisation is usually the precondition for involvement in international standardisation and, moreover, national standards may be transferred to the international level as input for an international standard (e.g. ISO). Being able to influence and comply with international standards and to be well informed about these standards can reduce transaction costs in cross-border trade. The export activity exp is measured on a three-level scale from national over European to international activities. Finally, we include sector-specific dummies (ind_i). We discriminate between manufacturing and services industries. Manufacturing industries are divided into low-tech (lt), medium-low-tech (mlt) and medium-high-tech (mht). Service industries are separated in knowledge-intensive service (kis), less knowledge-intensive services ($lkis$) and infrastructure related services ($infra$).

The model used to test the hypothesis relates the probability that a firm is participating in standardisation for information sourcing from external sources for innovation activities. Two types of cross sectional probit models measure the effects of the independent variables on a company's likelihood of participating in NEN. In the first type of models, we focus only on the general information sourcing from external sources for innovation. Apart from testing all information sources together, we also test for each source individually. The second type of models also includes the utilisation of knowledge from specific cooperation activities related to innovation as a robustness check. This checks whether the information available from specific cooperation alters the relevance of the utilisation of the knowledge sources available. Again, we also test each source individually.

(1.1)

$$Probability\,(\,NEN = 1\,) = \beta_0 + \beta_1 is_{su} + \beta_2 is_{cu} + \beta_3 is_{co} + \beta_4 is_{sc} + \beta_5 rd + \beta_6 pat + \beta_7 size + \beta_i ind_i + \varepsilon$$

(1.2)

$$Probability\ (\ NEN = 1) = \beta_0 + \beta_1 is_{su} + \beta_2 is_{cu} + \beta_3 is_{co} + \beta_4 is_{sc} + \beta_5 co_{su} + \beta_6 co_{cu} + \beta_7 co_{co} + \beta_8 co_{sc} + \beta_9 x_{su} + \beta_{10} x_{cu} + \beta_{11} x_{co} + \beta_{12} x_{sc} + \beta_{13} rd + \beta_{14} pat + \beta_{15} size + \beta_i ind_i + \varepsilon$$

In order to examine the proposed relationships with the involvement in national standardisation, we estimated two simple Probit regression models.

1.4 Results

Table 1.1 provides the result of this analysis. The model has been estimated with sector dummies, which are not included in the regression output for brevity. The coefficients of the regression as well as the standard errors in parentheses are reported[4].

The models test our hypotheses concerning the external knowledge sourcing activities of firms for innovation. According to McFadden's Pseudo R-squared, all models constitute an excellent fit (McFadden, 1979); we additionally conducted robustness checks for this analysis. The first hypothesis assumes that companies sourcing knowledge from their suppliers are less likely to be involved in standardisation. We find that the coefficient of information sourcing from suppliers is highly significant and negative in all relevant models. The data therefore support hypothesis one. From our additional control variables it further seems that this knowledge is not provided from cooperative relationships with suppliers, as the coefficients of the interaction term are not significant in both models. The second, third and fourth hypotheses assume that firms that source information from customers, competitors and scientific organisations, respectively, are more likely to be involved in standardisation. The results from the regression analysis reveal a significant relationship of information sourcing from scientific institutions only in both types of models, lending support to hypothesis d four. In this case the significant relationship with information sourcing in the second model is driven by the knowledge available from cooperation with scientific organisations. The second and third hypotheses, however, are not supported by our data. There exist no significant relationships with the information sourcing from customers or competitors in either of the models.

With regards to our control variables we find highly significant positive relationships with research expenditure, patent activity, size and export activity in our model. Our considerations regarding the innovative resources and ability available are thereby supported. The protection of intellectual property also relates positively with the involvement in standardisation activities. A

[4]As robustness checks we also used alternative coding methods for our explanatory variables (e.g. as binary variables). The resulting significance of the effect remains unchanged, however.

Table 1.1: Results of the Probit Estimation Models

Model[†]	1	1a	1b	1c	1d	2	2a	2b	2c	2d
Explanatory Variables										
is_{su}	-0.355	-0.323				-0.413	-0.429			
	(0.065)***	(0.063)***				(0.085)***	(0.082)***			
is_{cu}	0.097		0.099			0.095		0.077		
	-0.07		-0.064			-0.082		-0.075		
is_{co}	0.065			0.069		0.086			0.066	
	-0.067			-0.06		-0.076			-0.068	
is_{sc}	0.283				0.275	-0.149				-0.143
	(0.104)***				(0.102)***	-0.247				-0.241
Control Variables										
co_{su}						-0.071	0.104			
						-0.122	-0.112			
co_{cu}						-0.062		0.246		
						-0.16		(0.143)*		
co_{co}						0.332			0.461	
						(0.125)***			(0.111)***	
co_{sc}						0.26				0.318
						(0.085)***				(0.068)***
x_{su}						0.129	0.154			
						-0.137	-0.134			
x_{cu}						-0.027		-0.09		
						-0.167		-0.15		
x_{co}						-0.131			-0.13	
						-0.152			-0.146	
x_{sc}						0.372				0.369
						-0.276				(0.271)
RD	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***	(0.001)***
Pat	0.311	0.343	0.328	0.331	0.312	0.252	0.314	0.3	0.292	0.256
	(0.073)***	(0.072)***	(0.072)***	(0.072)***	(0.072)***	(0.074)**	(0.073)***	(0.073)***	(0.072)***	(0.073)***
$Size$	0.399	0.406	0.396	0.395	0.393	0.372	0.395	0.387	0.376	0.371
	(0.023)***	(0.023)***	(0.022)***	(0.022)***	(0.022)***	(0.023)***	(0.023)***	(0.023)***	(0.023)***	(0.023)***
Exp	0.287	0.299	0.306	0.31	0.31	0.271	0.284	0.294	0.31	0.283
	(0.067)***	(0.665)***	(0.066)***	(0.066)***	(0.066)***	(0.068)***	(0.067)***	(0.066)***	(0.066)***	(0.066)***
$Industry\ Dummies$	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	3456	3456	3456	3456	3456	3456	3456	3456	3456	3456
Pseudo R^2	0.22	0.21	0.20	0.20	0.20	0.23	0.21	0.20	0.21	0.21

[†] The table reports the coefficients of the Probit regressions on the variable NEN. Standard errors are in parentheses. Asterisk ***,**,* denote statistically significant coefficients at the 1%, 5% and 10% level of significance.

further significant positive relationship is revealed both by cooperation with customers as well as cooperation with competitors. Consequently, companies that cooperate with their customers or competitors in our sample are more likely involved in formal standardisation.
The data from the Netherlands survey support two of the four hypotheses we postulated. There exist significant relationships with two external knowledge sources for innovation and the participation in formal standardisation. The type of innovation knowledge that has a significant relation with the Dutch firms‚Äô involvement in standardisation, however, differs. Whereas innovation knowledge coming from within cooperative relationships with scientific organisations has a significant positive relation with the likelihood to be involved, innovation knowledge from outside of cooperative relationships with suppliers has a significant negative relation with standardisation participation. We will now turn to discuss the implications of the data analysis for both research and innovation management policy.

1.5 Discussions, Conclusions and Limitations

The aim of this analysis was to identify whether and how firms active in formal standardisation use knowledge from external sources for innovation activities differently compared to firms not involved. We assumed that firms interested in influencing and understanding the technological development use formal standardisation for this purpose. We found that firms utilising suppliers' information for innovation activities are significantly less likely involved in standardisation. Firms that utilise scientific institutions, however, are more likely involved in standardisation. We further uncovered that the negative influence of innovation knowledge absorbed in the former case stems from a non-cooperative relationship with suppliers. In the latter case, however, the innovation knowledge sourced from scientific organisations is provided by cooperative activities. Finally, there is no evidence that firms involved in formal standardisation committees use competitors' or customers' information differently. Instead we find significant positive influences of cooperation activities with these potential knowledge sources. We therefore highlight fundamental differences in standardising companies knowledge sourcing activities.

We now discuss the implications and limitations of our analysis. The fact that firms active in standardisation use information for innovation less from their suppliers is the most noticeable result of this paper. Firms that utilise their supplier's information for innovation which is not obtained from cooperative activities seem to have less need to be active in formal standardisation. This fundamental result leads us to postulate that suppliers provide an alternative source for innovation activities to the knowledge pool generally available to firms active in standardisation. A possible explanation is that some firms either experience barriers to participation in standardisation, for example because of the resources needed for active involvement, or that they do not

want to influence the technological development via standardisation committees. If those firms want to access complementary resources, they turn to the source more easily accessible: their suppliers. Firms not participating in standardisation could hence be more inclined to use their suppliers as sources for innovation if information from other sources is not sufficient. However, as our data show, it does not seem necessary that the spillover comes from cooperation. This result contrasts the assumed complementarity of the two sources by Freitas et al. (2011). Or, conversely, companies participating in standardisation may feel less need to seek information from suppliers. An alternative explanation would also be that more companies that act as suppliers are involved in the standardisation processes which simply have fewer own suppliers to source their knowledge from. As we cannot test these possible explanations with our data, they represent an opportunity for future research. A company wanting to rely on suppliers as a source for its innovation would have the user role in that standardisation committee in relation to its suppliers. Traditionally it is difficult to involve users in standardisation (Jakobs et al., 2006) and if they participate it is challenging to relate this participation to their innovation (Jakobs, 2006).

Although not at the focus of our analysis, we further find that cooperation activities with customers and competitors have a significant positive relation with the probability to be involved in formal standardisation. This contrasts Axelrod et al. (1995) who postulated that a firm's utility to join a standard-setting alliance decreases with the presence of close rivals in the alliance. However, if we consider the influence of a particular cooperative alliance in a standardisation committee, joint participation of cooperating partners may increase this influence and can therefore be beneficial for firms.

Furthermore, we find that firms active in standardisation are more open towards knowledge derived from cooperative relationships with scientific institutions to support their innovation activities. For managers this highlights the potential relevance of technical committees as a source of information for innovation. Firms active in formal standardisation source knowledge from research organisations, seemingly to understand and, additionally from previous findings, to influence technological development. Furthermore, sourcing of information from suppliers seems to have a negative influence on the likelihood of being involved in standardisation. Hence innovation managers should consider what knowledge sources they want to access for specific innovation types. Finally, as we find no evidence that firms involved in standardisation utilise spillovers from their competitors, this may reduce the fear that knowledge revealed in the technical committee benefits rivals.

The study has several limitations. First of all we do not discriminate between knowledge available from the standardisation process and other available knowledge, although we control for knowledge available through directed cooperation activities. The availability of cross-sectional

data does not enable us to consider the impact of the longitudinal evolution of knowledge sourcing with respect to the involvement in standardisation. Furthermore, our data are constrained to a single national standardisation institute, which may not be representative for the involvement in other kinds of formal standardisation organisations. In relation to the small size of the country, NEN has a high involvement of companies which are generally export oriented. A further limitation is that the data do not allow us to investigate the network relationships of the surveyed firms, as we do not know who has cooperated with whom. For this reason, we were obligated to use a simple multivariate regression method.

Additional studies could complement the issue by looking at the specific knowledge generation resulting from the formal standardisation processes. The introduction of panel data could shed light on possible causal relations. A qualitative investigation into the reasons why firms might source innovation knowledge different once they are active in formal standardisation could uncover why the information from suppliers seems to be an alternative to standardisation participation. We see this as a relevant future opportunity for the research on standardisation. This large-scale study therefore provides the first step in establishing the importance of formal standardisation as a knowledge pool for innovation activities.

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1.7 Appendix

Table 1.2: Construction of Variables

Model Variable	Indicator
Dependent Variable	
NEN	*Dummy variable:* 1 if a company actively participated in standardisation in the year 2008,0 otherwise
Independent Variables	
$is_{su}, is_{cu}, is_{co}, is_{sc}$	*Dummy variable:* 1 if a company used spillovers from suppliers (is_{su}), customers (is_{cu}), competitors (is_{co}) or scientific organisations (is_{sc}), 0 otherwise
$co_{su}, co_{cu}, co_{co}, co_{sc}$	*Dummy variable:* 1 if company cooperated with suppliers (co_{su}), customers (co_{cu}), competitors (co_{co}) or scientific organizations (co_{sc}) in innovation activities between 2004 and 2006, 0 otherwise
$x_{su}, x_{cu}, x_{co}, x_{sc}$	*Dummy variable:* Interaction term between cooperation activities and importance of incoming knowledge spillovers from suppliers (x_{su}), customers (x_{cu}), competitors (x_{co}) or scientific organizations (co_{sc})
Rd	*Continuous variable:* Expenditure on own R&D divided by total turnover in 2006
$Size$	*Continuous variable:* Logarithm of employment 2006
Exp	*Dummy variable:* 1 if company had international export activities, 0 otherwise
Pat	*Dummy variable:* 1 if the company had patent activities, 0 otherwise
Lt	*Dummy variable:*Low-technology manufacturing industries: NACE 15, 17, 21, 22, 23.
Mlt	*Dummy variable:*Medium-low-technology manufacturing industries: NACE 25, 27, 28.
Mht	*Dummy variable:*Medium-high-technology manufacturing industries: NACE 29, 30, 34.
Kis	*Dummy variable:*Knowledge-intensive services industries: NACE 65, 72, 73, 74.1, 74.2, 74.4, 90, 93.
$Lkis$	*Dummy variable:*Less-knowledge-intensive services industries: NACE 51, 52, 55, 60.
$infra$ (basis)	*Dummy variable:*Infrastructure related services: NACE 40, 45.

Table 1.3: Descriptive Statistics of Variables

Model Variable	Observations	Mean	Standard Deviation
NEN	3456	0.14	0.35
is_{su}	3456	0.68	0.47
is_{cu}	3456	0.61	0.49
is_{co}	3456	0.44	0.50
is_{sc}	3456	0.07	0.25
co_{su}	3456	0.37	0.48
co_{cu}	3456	0.25	0.43
co_{co}	3456	0.15	0.36
co_{sc}	3456	0.26	0.44
x_{su}	3456	0.29	0.45
x_{cu}	3456	0.21	0.41
x_{co}	3456	0.09	0.29
x_{sc}	3456	0.05	0.21
Rd	3456	3.47	34.48
Pat	3456	0.18	0.38
$Size$	3456	4.48	1.42
Exp	3456	0.37	0.48
Lt	3456	0.15	0.36
mlt	3456	0.09	0.28
Mht	3456	0.16	0.37
Kis	3456	0.25	0.43
$Lkis$	3456	0.24	0.43
$Infra$	3456	0.11	0.25

Table 1.4: Correlation Matrix of Independent Variables

	rd	$size$	exp	pat	lt	mlt	mht	kis	$lkis$	is_{sc}	is_{co}	is_{cu}	is_{su}	x_{su}	x_{cu}	x_{co}	x_{sc}	co_{su}	co_{cu}	co_{co}	co_{sc}
rd	1.00																				
$size$	-0.03	1.00																			
exp	0.03	0.14***	1.00																		
pat	0.04*	0.19***	0.26***	1.00																	
lt	-0.03	0.05**	0.04*	0.04**	1.00																
mlt	-0.02	-0.05***	0.10***	0.08***	-0.13***	1.00															
mht	-0.01	0.00	0.32***	0.20***	-0.19***	-0.14***	1.00														
kis	0.02	-0.03	-0.19***	-0.15***	-0.25***	-0.18***	-0.26***	1.00													
$lkis$	-0.01	-0.01	-0.10***	-0.12***	-0.24***	-0.17***	-0.25***	-0.33***	1.00												
is_{sc}	0.05***	0.12***	0.05***	0.14***	-0.01	-0.02	0.04*	-0.03*	-0.02	1.00											
is_{co}	0.03	0.10***	0.08***	0.08***	0.02	-0.04*	0.07***	-0.05**	0.01	0.16***	1.00										
is_{cu}	0.01	0.09***	0.15***	0.12***	0.04*	0.01	0.13***	-0.03	-0.06***	0.11***	0.39***	1.00									
is_{su}	-0.02	0.05**	0.00	0.03	0.07***	0.03	0.03	-0.08***	-0.03	0.06***	0.16***	0.12***	1.00								
x_{su}	0.01	0.18***	0.10***	0.15***	0.04*	0.02	0.09***	-0.07***	-0.06***	0.11***	0.08***	0.11***	0.44***	1.00							
x_{cu}	0.04*	0.19***	0.16***	0.20**	-0.01	0.02	0.14***	0.00	-0.10***	0.13***	0.14***	0.41***	0.08***	0.44***	1.00						
x_{co}	0.02	0.16***	0.05***	0.10***	-0.01	-0.02	0.04*	0.01	-0.04**	0.17***	0.36***	0.12***	0.06***	0.28***	0.35***	1.00					
x_{sc}	0.06***	0.17***	0.07***	0.16***	0.02	-0.03*	0.04*	-0.04**	-0.04*	0.81***	0.11***	0.09***	0.04*	0.18***	0.19***	0.22***	1.00				
co_{su}	0.05**	0.20***	0.14***	0.19***	0.03	0.00	0.09***	-0.06***	-0.07***	0.12***	0.08***	0.11***	0.19***	0.84***	0.51***	0.32***	0.21***	1.00			
co_{cu}	0.06***	0.20***	0.16***	0.22***	-0.01	0.02	0.15***	-0.02	-0.11***	0.15***	0.11***	0.27***	0.06***	0.48***	0.89***	0.36***	0.23***	0.58***	1.00		
co_{co}	0.06***	0.19***	0.03*	0.14***	-0.03*	-0.02	0.00	0.02	-0.04**	0.16***	0.13***	0.07***	0.03	0.34***	0.38***	0.74***	0.23***	0.41***	0.47***	1.00	
co_{sc}	0.05***	0.27***	0.18***	0.24***	0.00	0.00	0.11***	-0.03	-0.09***	0.26***	0.10***	0.14***	0.05***	0.44***	0.47***	0.33***	0.37***	0.53***	0.53***	0.46***	1.00

The table reports the coefficients of the explanatory variables. Asterisk ***,**,* denote statistically significant coefficients at the 0.1%, 1% and 5% level of significance.

PAPER 2

The Strategic Use of Patents and Standards for NPD Knowledge Transfer

In this paper we develop a theoretical understanding of patenting and standardisation strategies and analyse their practical implementation for in- and outbound knowledge transfer in new product development (NPD) processes. Our case study consists of two original equipment manufacturers (OEM) and one supplier active in the global automotive industry. We consult extensive external and company documents as well as interviews with thirteen company experts. Although our theoretical considerations suggest that standardisation, patenting and their interrelation can be of considerable importance for knowledge transfer in NPD and innovation processes, this is hardly implemented in practise. The resources devoted to patenting by far outweigh those for the standardisation process. The OEMs have no dedicated strategy for standardisation activities; only patenting strategies are considered in the NPD processes. The surveyed supplier, however, uses standardisation strategically. We further consider how a standardisation strategy should relate to the patenting strategy in terms of generating the most beneficial outcome for knowledge transfer. We recommend an integrated standardisation strategy that is analogously to the patenting strategy and tied to the NPD process.

Keywords: Company Standardisation; Standards; Patents; NPD; Technology Innovation Management

2.1 Introduction

The literature on "open innovation" considers an organisation's in- and outflows of knowledge for innovation. Competitive advantage is derived from opening up to external Research and Development (R&D) efforts as well as considering external paths to market (Chesbrough and Crowther, 2006; Dahlander and Gann, 2010). The topic has been divided into the inbound processes of sourcing and acquiring of knowledge and the outbound processes of revealing and selling information (Dahlander and Gann, 2010). Thereby, revealing and sourcing constitute non-pecuniary interactions and consist of indirect benefits, whereas selling and acquiring knowledge entail monetary exchanges (Dahlander and Gann, 2010). Patents enable acquiring and selling of knowledge whereas standardisation activities allow for strategic sourcing and revealing of knowledge for innovation (Lerner and Tirole, 2014). In this paper, we aim to establish standardisation besides existing intellectual property strategies (IP strategies, i.e. patenting and licensing;see e.g. Arora and Gambardella, 2010) as knowledge transfer activities to support innovation (open) and new product development (NPD).

One central argument in open innovation is the revelation of privately funded knowledge for a firm's own technology to become the dominant design (Hippel and Krogh, 2006). Such revelations are at the heart of the standard-setting process which provides information on existing and emerging technologies (Lerner and Tirole, 2014; Nambisan, 2013) in order to impose a common standard in the market (Chiesa et al., 2002). EU institutions[1] as well as R&D stakeholders increasingly recognise the role of standardisation as a bridge between research activities and the market. Patenting, instead, has long been established as a central force for innovation management (Trott, 2005) as it allows for the acquisition and licensing of patented technologies and therefore the marketing of external and internal R&D efforts, respectively.

From our theoretical considerations we establish that standards, the standard setting process, patents, and patent applications provide a repository of explicit technological knowledge both internal and external to the company (see e.g. Choi et al., 2011; James et al., 2013; Leiponen, 2008; Lerner and Tirole, 2014; Tassey, 2000; Trott, 2005). A strategic approach to these elements is important for NPD and innovations as companies must watch their environments closely to be aware of inventions and emerging technologies (Trott, 2005). Multiple studies have also supported the positive impact of sourcing knowledge from external sources on innovativeness (see e.g. Ili et al., 2010; Rohrbeck et al., 2009). We address standardisation as an important, yet underrated economic alignment mechanism when technological development is concerned (Bekkers et al., 2012). Where patents are mostly understood as supporting the development of a technology, standards are associated with technological diffusion (Iversen et al., 2004). Although Blind and

[1] According to the Communication from the European Commission "A Stronger European Industry for Growth and Economic Recovery"; 10.10.2012.

Thumm (2004) find that companies do not pursue standards and patents simultaneously, we propose that these strategies are linked. Patenting considerations should precede the company's consideration of revealing own R&D results in the standardisation process. This is also relevant for the potential ex-post licensing of patents "essential" to a standard (Lerner and Tirole, 2014). Such a dedicated strategy should enhance the NPD process and add to the recurrent debate on the relation between standards and patents (Bekkers et al., 2012).

Based on our theoretical development, we analyse and compare the strategies for patenting and standardisation participation along the NPD processes of three players in the global automotive industry: two original equipment manufacturers (OEMs A and B) and one supplier (SUP). We consider this an interesting research environment as Ili et al. (2010) call on the automotive industry to increasingly look outside their boundaries to achieve the necessary increases in productivity required by increasing competitive pressure. This case study is composed of business reports, internal documents and interview data from the OEMs and supplier. The analysis shows how resources devoted to the patenting process by far outweigh those for external and internal standardisation activities. At the OEMs, standardisation processes are neither formally included in the NPD process, nor does the company follow a strategy for incorporating knowledge from standards or standardisation processes. This neglect can be of potential harm to the firm, especially where developments in other industry sectors become relevant for the firm (Ili et al., 2010), such as the increasing occurrence of interconnected products from different industries (Van de Kaa, G. et al., 2009). An example is the current "smart cars" initiative of the European Union[2], which makes existing and developing ICT standards crucial for the automotive industry. We find that only the supplier, who generally emphasizes open innovation, has a dedicated standardisation strategy for new products in place. We develop recommendations for NPD management and suggest the implementation of a strategy for standardisation that is linked to the one for patenting.

In the following we provide a brief introduction into patenting and standardisation, after which we theoretically consider their utility for NPD knowledge transfer. We proceed by introducing the methods and data of our case study. Thereafter follows the analysis of the case; we conclude with recommendations for innovation management. Thus the aim of this paper is to answer the following questions:

1. What is the theoretical basis for standardisation and patenting strategies for knowledge transfer?

[2]See Communication from the European Commission "On the Intelligent Car Imitative: Raising Awareness of ICT for Smarter, Safer and Cleaner Vehicles"; 15.02.2006.

2. What knowledge relevant for product development is codified in standards and patents and revealed in the standardisation process and patent applications?

3. Is there a link between standardisation and patenting strategies and how should these be integrated in the NPD process?

2.2 Theoretical Considerations

An Introduction to Patents and Standards

A patent is an intellectual property right granted by the state to its inventor for a limited amount of time, providing them with a temporary monopoly position (Trott, 2005). Patents primarily generate value from an innovation James et al. (2013) and provide an incentive to invest into R&D (Arrow, 1962). However, they also provide a strategic tool for their owners (Grindley and Teece, 1997; Trombini and Zirpoli, 2013). By building large patent portfolios, a patent holder can reinforce its bargaining power in the innovation process. Patents can for example be used for strategic blockades of competitors or as "bargaining chips" in external negotiations (see e.g. Bekkers et al., 2012; Ernst, 2003; Noel and Schankerman, 2013).

In the application of a patent, the details of an invention will be disclosed. As patents codify recent technological developments (Gauch and Blind, 2014), the patent database provides a valuable source of new technological knowledge to companies (Trott, 2005). Some firms patent to stimulate the knowledge transfer from their innovations or to influence the direction of innovative activity (James et al., 2013; Trott, 2005). Supporting patent knowledge in top-level management can become a key organisational method to enhance performance and appropriate returns from innovations (see e.g. Ernst, 2003; Trombini and Zirpoli, 2013).

Patents bear a close resemblance to standards in that their function of disseminating information and thereby influencing the direction of innovative activity (James et al., 2013; Tassey, 2000). A standard is the consensus of various agents to do certain activities according to agreed-upon rules (Narayanan and Chen, 2012). Standardisation activities can be divided into company and external standardisation (de Vries, 2006). The former are the results of internal standardisation activities by various actors within the firm or in close relation with a supplier, primarily for the economic benefit of that company. Some share of company standards is usually provided to suppliers and cooperation partners (Großmann and Gruben, 2014). External standardisation is the development of standards resulting from meetings in technical expert committees. These committees are arranged either formally by standard development organisations (SDOs), such as the International Organisation for Standardisation (ISO), or informally in consortia, such as

specific interest groups (e.g. the working group composed of the OEMs in the German automotive industry).

One of the key functions of company standardisation is the retrieval of information from external and internal sources in order to minimise costs and efforts. Company standards thereby document the current state of products, technologies and processes central to the firm that are not available from external sources for recurring application (de Vries, 2006). These are distributed not only within the boundaries of the company but also to outside sources, such as suppliers or cooperation partners (Großmann and Gruben, 2014), transferring codified idiosyncratic knowledge of the company.

SDOs unite stakeholders for the standardisation of objects which can be seen as an extreme form of collaboration, as this provides a platform for explicit agreement among competitors (Chiesa et al., 2002). Whereas formal standardisation organisations aim at consent and provide transparency for the general public, consortia are built to fulfil the interest of a closed group of participants. Standards can be created by combining current technologies, adding innovative technologies into existing processes and, creating, offering, and applying innovative add-on technologies (Jiang et al., 2012). The process of standardisation therefore unites firms in the development of technology (Tassey, 2000).

Formal standards form a recognised basis for the compatibility of individual products ex ante[3] with those available in the market and therefore for later diffusion in the market (Iversen et al., 2004; Tassey, 2000). The ex post contribution of individual NPD knowledge into standards benefits the diffusion of a company's own products and technologies into the market (Chiesa et al., 2002; Tassey, 2000). Standardisation facilitates the sharing of knowledge and coordination of R&D efforts (Delcamp and Leiponen, 2013). There exists a potential for knowledge spillover from other firms during the standardisation process (Blind, 2006; Chiao et al., 2007; Gupta et al., 2008; Nambisan, 2013) as throughout the standardisation process numerous industry participants are in concurrent interaction (Dokko et al., 2010). The role of standardisation in innovation can be associated with a selection process to reduce the variety of arising technologies (Iversen et al., 2004).

After this introduction to patents, patent applications, standards, and the standardisation process, we consider how these issues can develop and codify knowledge relevant for the NPD process.

[3]Conforming to a standard can ensure compatibility with products already in the market.

Patents and Standards for Knowledge Transfer

Both patents and standards provide knowledge on the various states of a technology (see e.g. Choi et al., 2011; James et al., 2013; Leiponen, 2008; Tassey, 2000; Trott, 2005). Whereas the formal standard documents provide established and approved knowledge on the state of the art of technology, patents are, to some degree, setting the state of the art (Grindley and Teece, 1997; Noel and Schankerman, 2013). Codifying technology both enhances its use and innovation (Iversen et al., 2004).

When considering knowledge within a company, we refer to both explicit and tacit knowledge (Nonaka, 1994). Explicit knowledge can be articulated, transferred and archived. Tacit knowledge, in contrast, implicitly requires know-how and cannot easily be measured (Argote and Ingram, 2000). The interaction of these two types of knowledge is termed knowledge conversion (Nonaka, 1994). The flow from tacit to explicit is referred to as externalisation whereas the conversion from explicit to tacit knowledge is called internalisation. Knowledge within an organisation therefore resides in multiple repositories, such as roles and organisational structures or the organisation's standard operating procedures and practices (Argote and Ingram, 2000). We propose that standardisation, patenting, and available external standards and patents can (and should) be used for externalisation and internalisation of knowledge. Examples are when users apply explicit knowledge from existing standards and patents or convert their own tacit knowledge into explicit knowledge by filing patent applications or participating in standard setting.

Throughout the standardisation process, implicit knowledge can be accessed by other participants (Blind, 2006). Firms left out of the standardisation race may have to spend a lot of resources to bridge the knowledge gap with the winner (Chiesa et al., 2002); the standardisation process itself reveals knowledge that is later codified in a standard. Company standards can manage the information flow from one stage of the value chain to the next (Sturgeon et al., 2008), for example by providing knowledge on customer requirements. Noel and Schankerman (2013) indicate that a greater fragmentation of patent ownership in a market has a positive effect on both the R&D and patenting activities by the firm, and that R&D spillovers lead to increases in patenting activities and market value.

In managing innovations, it is important to be aware of inventions and emerging technologies (Trott, 2005). A strategic analysis of patents for the acquisition of knowledge is therefore of value for technology management (Adams, 2012; Ernst, 2003). Patents can provide information on the state of the art, technological development, the IP protection of competitors and potential suppliers as well as R&D cooperation partners and actual suppliers as external knowledge sources. Understanding the information that is codified in patents enables the setting of a licensing strategy and opens the potential for further innovation. Therefore the management of patents

can be a central interface for the diffusion of knowledge into R&D and NPD processes (Jiang et al., 2012; Tiefel, 2007).

A comprehensive knowledge on the state of technology is also required by product liability laws. Companies need to be aware of relevant available and developing patents and standards. We will now consider their relevance for NPD processes.

Knowledge Transfer for NPD

The NPD process is a complex process requiring constant control and interaction based on the exchange of data and information (Calabrese, 1997). Converting knowledge from tacit to explicit can be one of the critical steps of knowledge management (Ameri and Dutta, 2005) for NPD processes. During the development of products, it is important that either new knowledge is added to the knowledge base or that the existing knowledge base can be accessed (Ameri and Dutta, 2005). The likelihood of finding a technology or the necessary information for an innovation is increased by looking outside the boundaries of the firm and search beyond the specific application needed, as external sources will have information on aspects of the solution that is needed (Hippel and Krogh, 2006). Such inward technology transfer is coined "inbound open innovation" (Chesbrough and Crowther, 2006) and can be either non-monetary via sourcing or bought by acquiring (Dahlander and Gann, 2010). Transferring a company's own technologies outwards is termed "outbound open innovation" and can be divided into the non-pecuniary revealing and the selling of knowledge (Dahlander and Gann, 2010). Selling, for example, covers the licensing of protected intellectual property (i.e. patents) or technologies to outside companies. Outbound open innovation can provide the firm with the strategic opportunity of establishing their own technologies as industry standards (Hippel and Krogh, 2006). Revealing of an innovation can be the best practical option for an innovator, for example when they want to increase a network or for a technology to become the dominant design or an open standard (Hippel and Krogh, 2006).

Both sourcing and acquiring of external knowledge during the innovation process as well as free revelation strategies are shown to have positive effects on firm performance (Chesbrough and Crowther, 2006; Hippel and Krogh, 2006). As the standardisation process is a neutral playground for knowledge sharing, Groetnes (2009) classified it as open innovation. Utilizing standardisation participation for the innovation process relates to Dahlander and Gann (2010) non-pecuniary open innovation strategies of revealing and sourcing. Where studies such as Ili et al. (2010) use patents as sources for outbound open innovation and governmental regulations as inward sources for innovation, we would like to establish knowledge transfer via standards and standardisation participation as a relevant additional strategy for knowledge transfer. This is particularly important as standardisation takes place nowadays in formal standardisation

FIGURE 2.1. Exemplary NPD Process with decision points, based on Cooper and Kleinschmidt (1991)

organisations ex-ante, i.e. before the technology is readily available Chiesa et al. (2002).

Strategic Integration of Standards and Patents into the NPD Process

Figure 2.1 presents an example NPD process with its consecutive stages, as visualised by the arrows, and the corresponding decision points as represented by the circles (Cooper and Kleinschmidt, 1991). In the early stages of the NPD process, i.e. the idea and preliminary investigation phases, the screening of recent patent applications and proposed standard setting processes within a technological field can provide ideas about the most recent developments, not only within that specific field but also for potential acquisition of external technologies as substitutes for developing new ones. The revelation of knowledge from the participants of the standardisation process enables knowledge sourcing for the development of a company's own products as well as providing information on developing new industry standards. For example, Rohrbeck et al. (2009) show how consortia projects are part of the research phase and strategic alliances part of the development and commercialisation phases of the innovation process at Deutsche Telekom, contributing to its open innovation ecosystem at specific NPD stages. From the outbound perspective, patents can generate additional revenue because they facilitate the licensing of developed technologies in the later stages of the NPD process. Existing standards provide knowledge on the state of a specific technological field; these should be observed in the initial NPD stages, especially when a new product aims to enter "new territories". The standardisation process provides options to reveal knowledge and technologies to the market and establish them as dominant designs. If a product or technology has passed the testing and validation phase of the NPD process, however, it is better equipped to be implemented into the standard. Developing a company standard, on the other hand, can provide a staging area, where technologies that have the potential to become an industry standard later on can be diffused first internally, and then with suppliers and cooperation partners.

Though as the inclusion of own IP in a standard is an important consideration, patenting and standardisation strategies should not be seen as independent (Bekkers et al., 2012; Lerner

and Tirole, 2014). Once a technology is out in the market, it can no longer be protected by a patent. Therefore, strategies concerning patenting and standardisation activities should carefully consider during which phase of the NPD to utilize in- and outbound knowledge. Revealing owned knowledge in the standardisation process should only follow the assurance whether key intellectual property already is or should be protected. Hence an outbound strategy should always have the revelation of knowledge via patents precede the revelation of internal knowledge in the standardisation process.

2.3 Data and Methods

As the mechanism of knowledge transfer via standardisation and patents for NPD has yet to be investigated, an extensive case study provides the most valuable insight for our analysis (Yin, 2014). During this case study, we paid close attention to the measures of good case study research regarding validity and reliability (Beverland and Lindgreen, 2010; Gibbert et al., 2008). We consider the automotive industry as an appropriate environment for this case study because of recent increases in competition due to the consolidation of companies, the required product portfolio of the producers, and in the quality demanded from customers (Trombini and Zirpoli, 2013). The required reduction of complexity is tackled with modularity strategies and the implementation of model-spanning carry-over parts (Trombini and Zirpoli, 2013). The integration of external technology as well as intensive collaboration with other industry sectors is becoming a crucial factor needed to increase innovativeness (Ili et al., 2010). A further motivation to provide management recommendations in this field is the recent increase in vehicle recalls in the market, which can be traced back to deficient NPD processes and insufficient management of innovations (Hab and Wagner, 2013).

The case study is composed of an in-depth analysis via documents and interviews of two of the largest, internationally operating OEMs (OEM A and OEM B) and, for corroboration, one supplier (SUP). All three companies have their headquarters in Germany and dedicated departments for standardisation and IP (such as patents, licenses and trademarks), respectively. OEM A is a producer of premium cars and trucks sold globally under different brands with headquarters in Germany. The main strategies of OEM A are to produce the best products in their field of competition and to find new, customer-oriented mobility solutions that fully exploit the increasing digitalization. OEM B produces automobiles and motorcycles under a variety of brands with a broad product portfolio from economic compact to premium cars. The main strategies of OEM B are to use intelligent innovations and technologies to be the leading automotive company both economically and ecologically. We chose these OEMs as they both aim to develop new, high quality products but differ in their product portfolios. To cross-check our results from these two OEMs, we additionally surveyed a large, internationally operating supplier of clutches, rolling and ball

bearings. The SUP declares innovative strength as one central element of their philosophy, and they proclaim to use a wide variety of instruments and methods of open innovation.

We collected data from various sources. Documents were provided by the companies as well as independent third parties. First we considered standardisation documents written by the OEMs and their employee's participation in patenting and standardisation activities. We chose to consider employees as they provide fundamental repositories of the knowledge available within the respective companies. Bibliographic data on all available company standards were provided by the OEMs themselves. We classified company standards as those with the declaration "company standard" or "delivery specification". The data on committee membership of OEM employees were provided by the German Institute for Standardisation (DIN). This data set contains the documented participation of the company and its employees in formal standardisation committees between 2008 and 2013. This data was cross-checked with the internal documentation of both companies. The data on the patenting activities from 2008-2013 were provided by the patent departments of OEM A and B. Again the validity of this data was confirmed with patent research using the Thomson Reuters Innovation tool. Finally, internal documents such as process charts and guidelines on the NPD process were used to understand how patents and standards are integrated. Furthermore, external documents and public materials, such as business reports and newspaper articles, were analysed.

We conducted semi-structured expert interviews with different representatives of the OEMs as well as an additional supplier (SUP), who employs a different approach in regard to our investigated strategies. Appendix items 2.0 and 2.1 provide an overview of the interview construct and notation of the company representatives interviewed. These experts have process or product responsibilities and they were chosen based on their knowledge on patents, standards or the NPD process. These shorter narrative interviews were used to complement findings from the analysis of documentation as well as to gain a better understanding of the dynamics of knowledge flows. In total we interviewed 13 experts: eight at OEM A; three at OEM B; and two at SUP. The cases of OEMs A and B and the supplier help us to understand how patenting and standardisation can be and are used for the transfer of knowledge and how this is integrated into the product development process. We proceed by a within- and cross-case analysis as proposed by Yin (2014).

2.4 Empirical Analysis

The Case of OEM A

OEM A's communication states that it is "setting standards" in multiple technological fields for the future. An internal guideline states that "[OEM A has] the obligation to follow the state and

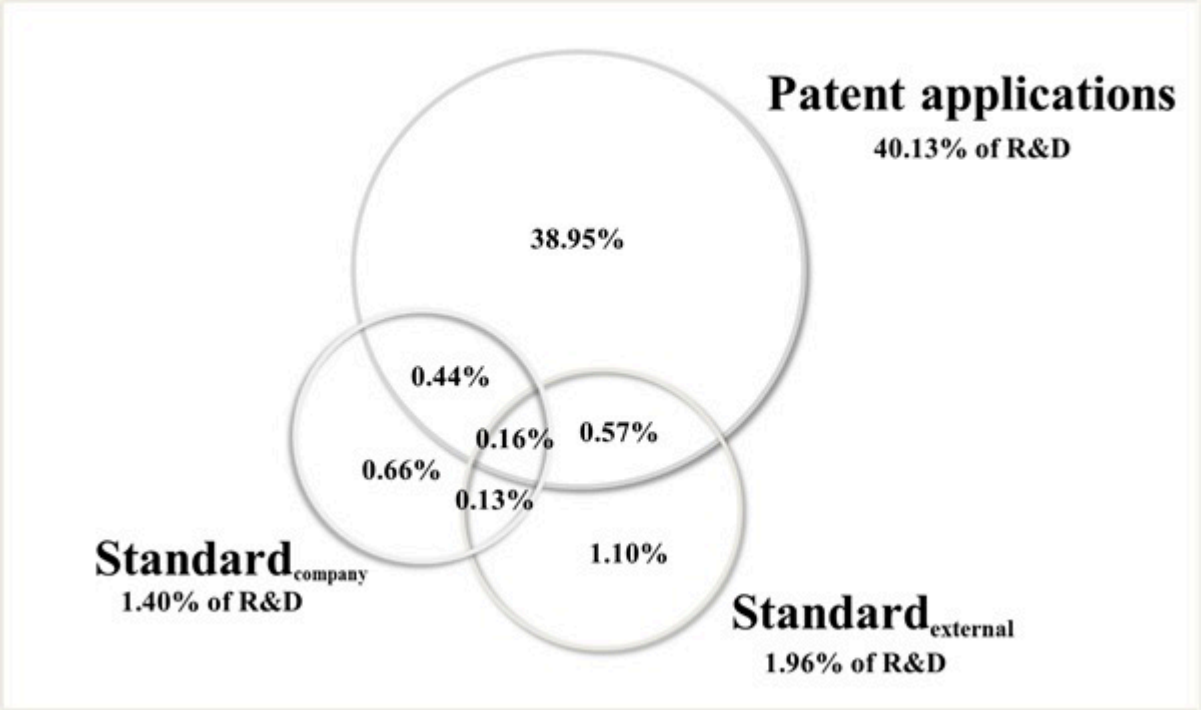

FIGURE 2.2. Division of employees at **OEM A** active in patenting and standardisation (2008-2013) compared to total R&D personnel (sum of R&D personnel: 100%)

development of science and technology", where they aim to provide "[all] necessary internal [...] and external information possibilities" to their employees. According to this guideline, existing standards play an important role. The standardisation department estimates that more than 10,000 external standards (e.g. DIN and ISO standards) and nearly 1,000 company standards are applied in each vehicle of OEM A. Nearly all of the company standards (approximately 95%) developed by OEM A are also provided to external partners, such as their suppliers. These company standards not only include quality requirements, but also aspects of security and new technologies and products. With regards to the patenting activities, the business report states that OEM A actively uses patents to secure a leadership role in technology and innovation. The patent portfolio in 2013 spanned around 22,000 patents and patent applications. These provide not only room for the company to manoeuvre, but also secure the exclusivity of their innovations. In 2013, OEM A was one of the top three patent applicants of all German companies. Additionally, the company is capitalising on patents and licenses provided to other organisations.

Figure 2.2 provides an overview of employees active in patenting and standardisation activities between 2008 and 2013. Eleven times more employees are applying for patents than actively contributing to internal or external standardisation activities. Around one percent of the employees applying for patents are also active in company standardisation, where the share is a

little higher for formal standardisation. From the perspective of activities in formal standardisation, however, about 37% of the employees active in technical standardisation committees and nearly 43% of the developers of company standards have also filed a patent application. When we consider the average patent applications per person, an average of 5.76 applications have been filed by employees also active in external standardisation compared to employees that are only applying for patents, which average of 4.47 applications. Employees active in the development of both external and internal standards average 12.91 created company standards; this is nearly three times as many as those employees that are only active in internal standardisation, which average 4.42 company standards per person.

Experts at OEM A revealed that the dealing with patents is formally integrated in and tied to the NPD process, starting in the idea phase. A general patent strategy is available for the company as a whole as well as for specific technologies and products. The detailed investigation phase represents the beginning of specific patent searches. The process of arriving at an IP strategy supports an extensive analysis of strategic knowledge available from patents with regards to emerging technologies, competitors and potential suppliers by the IP department. The exchange between the IP and technical departments is thereby given. However, an IP process manager remarked that a discrepancy exists regarding the relevant topics for NPD considered in the IP department compared to those considered in other departments, especially the R&D department. An engineer stated that he does not follow any particular process in tracking issues in patents.

Standardisation activities, on the other hand, are not formally linked to the NPD process. As a manager of the innovation management process remarks, “no process is available that provides the product managers with the results of searchers of [the knowledge within] external standards and an analysis of the standardisation situation”. The authors of the specifications for components and products are responsible for looking for potentially important standards that must be recognised. A specialist of the change management process at OEM A states that “the responsible component specialists usually only review the standards already exist in previous specifications”. One project manager explained an instance where the evolution of a new standard for a technology impacted almost all products that are in the strategy, developmental, launch or production stages. Due to the lack of participation in the development of this external standard, OEM A needed severe efforts to implement the new market standard ex-post. One change management specialist and IT-process designer stated that “from the perspective of the engineers, standards are annoying prerequisites”.

Whereas patents are recognised both as providing valuable information for new products and for protecting and securing innovations for leadership, standardisation does not strategically support the NPD process at OEM A. Dealing with existing and developing external standards

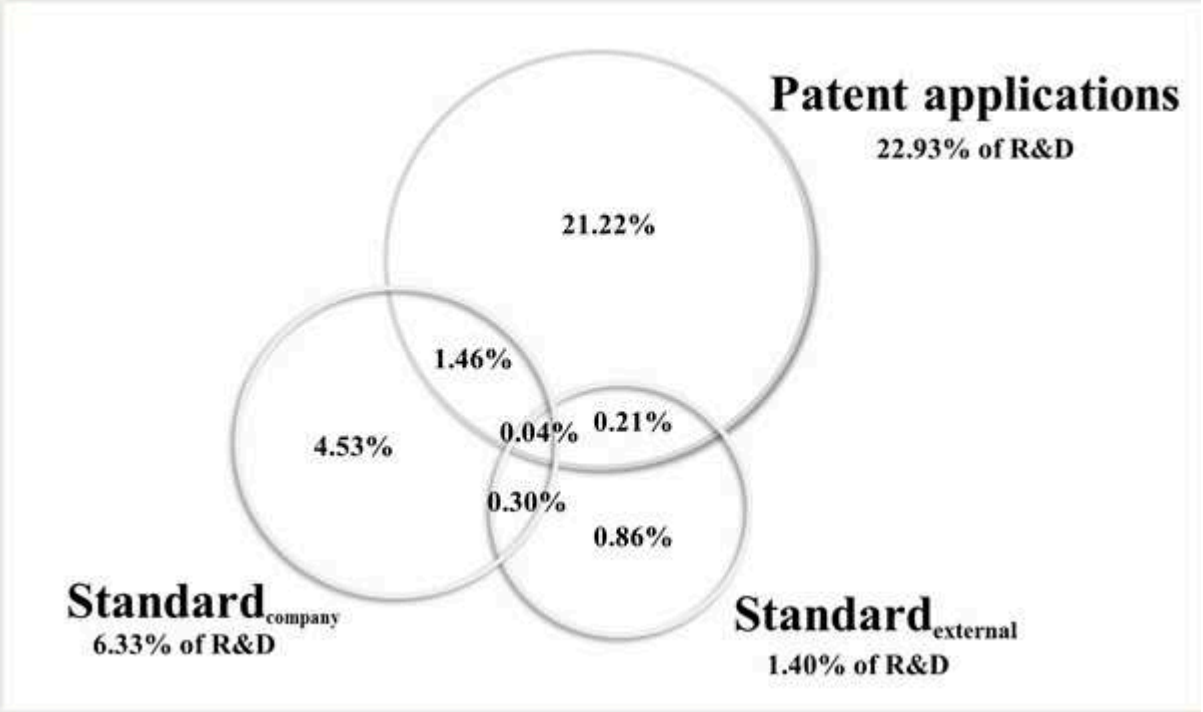

FIGURE 2.3. Division of employees at **OEM B** active in patenting and standardisation (2008-2013) compared to total R&D personnel (sum of R&D personnel: 100%)

is left to the individual developer at the company. Whereas a dedicated and detailed patenting strategy exists, nothing comparable with regards to standardisation is in place. Additionally, no links between patenting strategies and individual standardisation participation are established.

The Case of OEM B

OEM B develops individual products for their customers based on a modularity concept relying on standardised products and construction processes. The traditional focus of OEM B is company, not external standardisation. No formalized standardisation strategy exists for the company. OEM B holds about five times more company standards than OEM A, but provides only half of these to other companies, such as suppliers or development partners. The other half is development testing requirements for diffusion within the company only. Company standards are translated in up to 35 languages. In 2013, OEM B had less than half of the patent applications of OEM A though was still within the highest ten patent applicants in Germany. According to its business report, external standards are important to OEM B for fulfilling the applicable standards with regards to emissions, health and safety.

Figure 2.3 shows the activities of OEM B's employees in standardisation and patenting. About three times more employees filed for patents compared to active participation in company and formal external standardisation. About 18% of employees active in formal standardisation have also applied for patents, and around 24% of the employees writing company standards have applied for a patent during the time period. When considering the average number of patent applications per person, employees active in external standardisation have on average 5.57, where employees not participating in standardisation average 4.15 applications per person. Similarly, employees develop more company standards when they are also active in patent application (8.93) or in external standardisation (14.74). In comparison, employees that are only active in company standardisation average 7.82 company standards per person.

OEM B's patent strategy is to secure their individual technologies via patents. In the development of new technologies and products, an individual IP strategy is derived. Additionally, external patents are screened based on the relevant topics for new technologies. This procedure is formally integrated and linked to the various stages of the NPD process. OEM B recognises that recent developments require the use of technologies from the ICT area for cars. Therefore the bridge between standardisation and patenting topics becomes increasingly relevant. As vehicles are moving into an area where the interaction of technological units is relevant, compatible interfaces and standardised technologies must be implemented. In the development of these standards, patents can be an important strategic tool. The IP manager at OEM B described how ICT-area technical committees prepare patent applications before committee meetings so that standard-relevant technology can be secured. Alterations or consensuses are then reported directly by the committee, so that companies are able to file their patent applications with the appropriate content before the protocol of a standardisation meeting is published.

No strategy or process exists at OEM B that covers the use of information from standards and standardisation. Due to the variety of brands at OEM B, the first objective is to find potential alignments across the product portfolio according to a company standard, which is especially important due to their modularity strategy. A standardisation adviser said, "Some developers follow their own strategies with respect to company standards; for example that these internal standards should later be part of an external standard". In subjects such as e-mobility, however, existing external standards are preferred to company standards. In general, only older and more experienced employees participate in external committees, a practice which developed historically. Though when security aspects are at stake, the standardisation manager of OEM B stated that, "a coordinated and precedent-setting development of new products and technologies is important". The company representatives themselves are responsible for transferring and implementing the obtained knowledge from the committee meetings within the company. The standardisation manager of OEM B "hopes" that this is in fact done. Though as a standardisation

specialist highlighted, in the case of geometric product specifications, developments discussed in the standardisation committees were directly integrated into the NPD. This indicates that, at least in some cases, employees at OEM B do in fact transfer and integrate knowledge gained from standardisation committee meetings as required.

At OEM B, the observance of external patents is integrated into the NPD process, as are existing company standards, where the focus lies on supporting the component modularity based on the company's platform strategy. External standards seem to play a lesser role. The managers of both the standardisation and the IP departments, however, see a future for better integration and collaboration of the two activities.

Comparison of the OEMs

The strategies and utilization of standardisation and patenting differ between the two OEMs. Where OEM A heavily emphasises quality leadership and paving new technologies via patent applications, OEM B focusses on modularity for a broad product portfolio for which it pushes company standardisation. This can also be seen by comparing figures 1 and 2. Both companies seem to deal with external standards comparably; neither of the OEMs has a designated standardisation strategy, especially with respect to NPD. However, representatives of both companies are recognising the importance of developments within standardisation committees, as the neglect of these activities is associated with higher costs to the company. This becomes evident with emerging technologies such as "eCall", where developments in the ICT sector become important for automotive companies. Both OEM A and B recognise that standardisation activities in this field need to be integrated into the development of new products at a fast rate, but currently take a reactive rather than a proactive strategy.

Both OEMs report a dedicated patenting strategy that is linked to the NPD process, but have not strategically thought about utilising the full potential from their standardisation activities. The links between the two mechanisms could become relevant, especially because a significant amount of the employees of both companies that participate in standardisation activities also apply for patents.

The Case of SUP

To corroborate the results from the OEMs, we additionally interviewed the heads of the standardisation and IP departments at a leading supplier in the same industry. This supplier was within the top three German patent applicants in 2013. At this company, open innovation is part of their corporate innovation management strategy. Also, SUP has both a dedicated patenting

and standardisation strategy.

SUP's patenting strategy is coupled with the NPD process. In the very early stages of the NPD process, an exhaustive analysis for the freedom to operate is done to ensure that no existing protection instruments are in place. According to the head of the IP department, "our [patent search database] is used for systematically screening topics on a strategic level, for example to see the developments at competitors". This can be done via an internal patent database accessible to developers. The patent strategy is aimed at reducing risk and to observe the technological development. Throughout the NPD process, the screening of external patents becomes more finely granulated to see what aspects of the new product should be covered by a patent. He further notes that "along the NPD process, the search process for external patents works like a funnel". With respect to their own patent applications, SUP generally tries to obtain the necessary protection as early as possible.

SUP has a detailed standardisation strategy that is approved by the executive board. According to the head of the standardisation department, "The implementation of our standardisation strategy is very costly". The NPD process at SUP requires the screening of existing company standards. Additionally, information on the technical committees of external standards and planned standardisation activities within the broad technological field of operation are centrally collected within the standardisation department and distributed with the developers. The developers themselves can then decide whether they want to attend the meetings on the topic. In these meeting, the general strategy of SUP is to influence the outcome of final standards. The standardisation manager therefore notes that the technical alignment at national or international level matters more to standardisation committees than antitrust concerns of price agreements. Some internal technologies, however, can only be brought into standardisation after SUP has sufficiently mastered them and therefore only later in the NPD process. There have been instances where SUP products and technologies have been directly brought into a formal standard after completion of the internal development phase of the NPD. Another example is when a company standard is internally developed and utilized, and then later brought into standardisation committees once the technology has "ripened".

Although patents are not part of company standards at SUP, the manager of the standardisation department would find a diffusion of patented technologies via company standards useful. The patent department, however, does not endorse this as they do not want it to be publicly available.

2.5 Discussion and Recommendations

The Potential for Standardisation and Patenting in NPD

Although neither of the OEMs we surveyed has a dedicated standardisation strategy, it seems that they implicitly focus their standardisation activities to some extent. Where OEM A proclaims to "set standards" and be leading in their field of expertise, it seems to focus on the protection and later possibilities of marketing new products and technologies via patents. OEM B, on the other hand, who focusses on a modular strategy for their products across different brands, has a comparably stronger focus on company standardisation than OEM A though seems to focus less on patenting. Additionally, we find that the unique quality proclaimed by OEM A seems to be secured by patents, whereas a price-reducing modular strategy as shown by OEM B relies more on company standards. Both companies are active in external standardisation, but do not have a strategy to exploit the sourcing and revealing inherent to the standardisation process for their own NPD (Chiao et al., 2007; Chiesa et al., 2002; Lerner and Tirole, 2014; Nambisan, 2013).

The surveyed supplier, SUP, however, uses both a patenting and a standardisation strategy for NPD. SUP tries to actively set standards in their favour by analysing their potential influence in the standardisation process, and the selective revealing of their own knowledge in the standardisation process. This is in line with the incentives for open innovation we discovered in the theoretical section of this paper (Hippel and Krogh, 2006). Additionally, they consider the potential of company standards to enable the diffusion of internally developed technologies and a way of "learning" from these so that they later have the potential to become an industry standard. By integrating both patenting and standardisation strategies into the NPD process, a firm considers early on whether a technology should be protected and potentially licensed, diffused internally or within the boundaries of trade relations via company standards, or brought into an industry standard. These strategies also seem to be interrelated as the concern of intellectual property is also present in the standardisation process via essential patents (compare e.g. Bekkers et al., 2012; Iversen et al., 2004; Lerner and Tirole, 2014). On the other hand, external developments in standardisation and patent applications that have the potential to become relevant for the internal development of new products should be observed from the very early stages of NPD.

Recommendations

As a company's product liability guidelines demand the consideration of existing standards, a designated strategy could formalise how relevant information from standardisation can flow into (and out of) NPD. We propose such a strategy to include strategic standardisation participation, where internal technologies and products can contribute towards the industry standard. We recommend this strategy be tied to central decision points of the NPD process and follow the

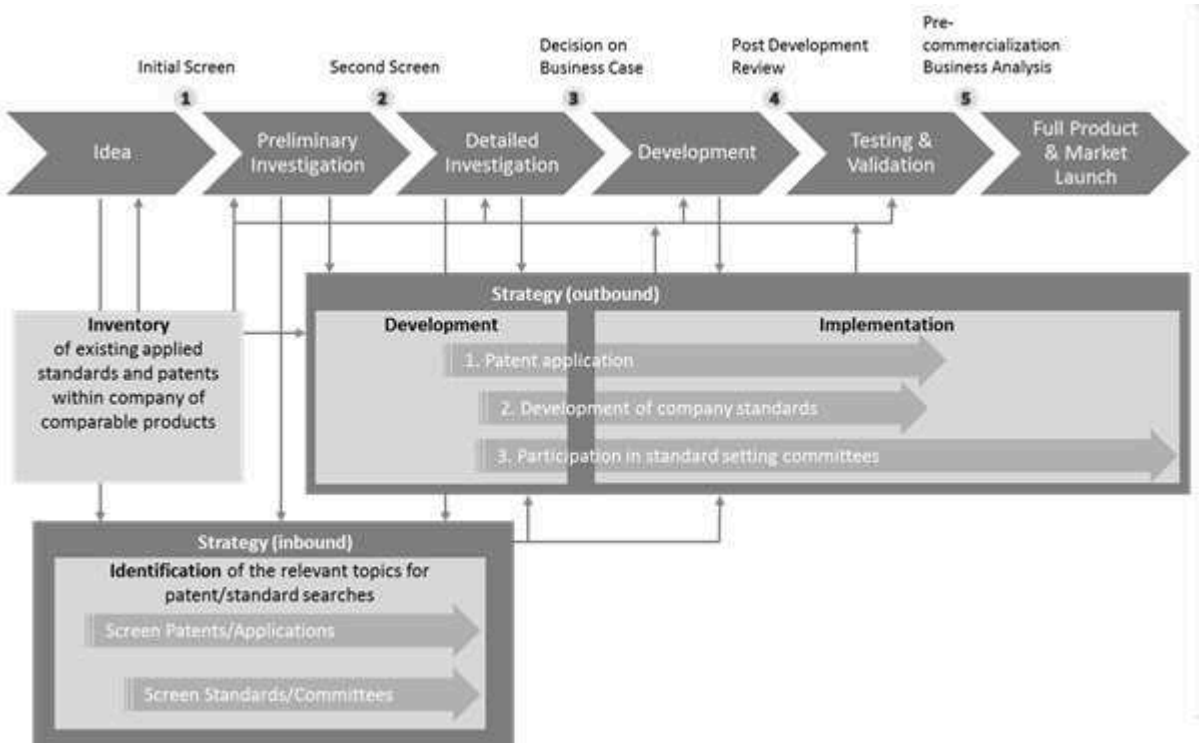

FIGURE 2.4. Process for Standardisation and Patenting Strategies along the NPD Process

patenting strategy of the firm, as visualised in Figure 2.4.

Linking patenting and standardisation strategies to the NPD process can reduce risks that arise from disregarding the current state of technology. To support innovation management, comprehensive monitoring should already be integrated with the *idea* generation stage. This can be achieved via an inventory of existing standards and patents and the identification of relevant topics for patent and standard searches. We find that developers at the OEMs consider the standards that have been fulfilled by previous version of a product of their own accord. Hence, a dedicated process of documenting existing patents and standards should reduce search costs, improve information sharing between developing engineers, and help avoid neglecting important existing standards. This inventory should be kept up to date with applicable patents and standards to enhance all stages of the NPD process. Adding to the existing standards and patents inventory can be done by searching for external patents and standards according to the topics identified in the *idea*, *preliminary investigation* and *detailed investigation* phases of the NPD process.

Once the product development process has passed the *idea* stage and a product's relevant

standards or patents have been analysed, a strategy for the outbound selling and revealing of knowledge should be developed. Such a strategy must be continuously revised and adjusted as the product passes through the various developmental stages until the actual stage of *development* is completed. Within this strategy, standardisation should be considered only after the potential patenting strategy for the specific product has been elaborated on.

Further, we recommend that the developments (i.e. patent applictions, standardisation participation, and or resulting standards) resulting from said outbound strategy be added to the inventory stock. This inventory stock should continuously feed into the NPD process, until the *testing and validation* stages have been completed. In the final NPD stage, the *full product & market launch*, all relevant standards and patents should have been considered for marketing the newly developed product. Revealing and enforcing owned knowledge in a formal standard, however, might take more time than the actual product takes to launch in the market, which can position the company at an advantage as the first mover.

Our recommended strategies can ensure that companies react to both externally conditioned demand for technological change and internally required alterations. For the derivation of an efficient standardisation strategy the exchange with the responsible innovation managers, developers and product managers can be helpful. Hence a systemic standardisation strategy should also imply a harmonisation with the patent strategy for each innovation.

Of course there are costs involved with the implementation of a strategy for standardisation activities, especially for global activities. We suppose that the benefits, however, in reducing component variety as well as the risk of neglecting rising developments in standards, will by far outweigh the costs of an integrated standardisation strategy.

2.6 Conclusion and Implications

The theoretical investigation of this paper showed how standardisation observation and participation is implied in the standardisation and management literature by the potential to enhance innovation management in a similar way as patenting strategies. Our case study reveals how the infrastructure and resources devoted to standardisation activities differs from that of patenting activities in the two OEMs we investigated. Both patenting and standardisation strategies have considerable potential for knowledge management as well as in- and outbound knowledge transfer. We find that OEM A, which focusses on quality and setting standards, is considerably stronger in the application of patents than OEM B, who employs a modular strategy across a variety of brands and devotes more resources to company standardisation.

We propose that standardisation activities and the continuous tracking of standards information should be tied to the NPD process in a similar manner as the patenting strategy process, as this is done at the surveyed supplier. We recommend that the companies develop a strategic view on standardisation that is in keeping with both their overall and IP strategies. Thereby company and formal standardisation activities should follow a product-specific patenting strategy. On the other hand, the external knowledge available from patents, patent applications, standards and the standardisation process should be continuously monitored. This recommendation is aimed at R&D as well as innovation managers: not only patenting but also standardisation strategies can provide a valid transfer mechanism of knowledge to realize strategic opportunities within NPD.

Although we have analysed the case only in the automotive industry, the essence of this matter is also relevant to other industries. Both standards and patents play a vital role for the ICT industry, for example, where standardisation is essential for network compatibility (Delcamp and Leiponen, 2013). This case study can therefore motivate the integration of patenting and standardisation strategies for a wider range of companies in their innovation management.

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2.8 Appendix

2.0 Interview Guideline

1. Short introduction if the interviewer and an overview of the research project
2. The role of the interviewee in the Company
   a. Company Name
   b. Name of the interviewee
   c. Position
   d. Responsibilities
   e. Patent- or standardisation expert?
3. Standards and Patents as instruments for knowledge transfer:
   a. What is your view on the role of external and company standards as well as
   patents for innovation processes and the development of new products within your company?
   And how do developers (employees of R&D department) view this?
   b. Are existing (external) patents and standards considered in the development of new
   products?
   c. How do you view the role of external and company standards and patents for the development of new
   products? How do developers view this?
4. Are patens, external and company standards formally included into the NPD process?
   a. If so, how?
   b. If not, why not?
   c. Is your company following a specific strategy?
5. Has your company ever experienced problems regarding the ignorance of specific patents and standards for NPD?

Overview of the Interviewees

Table 2.1: Overview of the Interviewees

Company	***Interviewee***
OEM A	Manager NPD-Process Quality Management Auditor /Archiving Specialist Component Specialist, Engineer Project Manager /Process Manager Special Taskforce Patentee/Process Manager Interface IP Process & NPD Process Document Quality Manager for Requirements Specification Patentee/ Process Manager Interface IP Process & NPD Process Change Management Specialist & IT-Process Designer
OEM B	Head of the Standardisation Department Standardisation Advisor Head of the IP Department
SUP	Head of the Standardisation Department Head of the IP Department

PAPER 3

Supplier's Motives for Applying Their Buyer's Company Standards

Company standards are of increasing importance for firms in competitive environments with strongly integrated supply chains. This paper is the first to introduce and empirically investigate the qualitative aspects of company standards for the buyer-supplier relationship. We use survey data of 133 suppliers to a large original equipment manufacturer (OEM) in the automotive industry. First, 22 potential motives for suppliers to apply buyer-specific company standards are introduced. A factor analysis of these motives identifies four main patterns: to gain access to the buyer; knowledge transfer; enabling the fulfilment of required quality requirements; and as a complement to external formal standards. We consider the influence of these factors on the expected net benefit that suppliers derive from the application of their buyer's company standards. We find that when suppliers apply their buyer's company standards for knowledge transfer or to fulfil required quality and reputation expectations, they derive a higher expected net benefit from the application of these company standards. Also, larger suppliers seem to be significantly better equipped to derive a higher net benefit from the application of the OEMs company standards. This paper provides evidence that company standards have considerable effects on the buyer-supplier relationship.

Keywords: Company Standards; Buyer-Supplier Relationship; Supplier Management

3.1 Introduction

Researchers and managers alike have recently focused on a growing stock of company specific standards, as these can have a significant impact on supply chains (Gereffi and Lee, 2012). Because the largest proportions of all existing standards are such company standards (de Vries, 2006), they should be of considerable interest to a firm and the economy. The oil and gas industry, for example, has seen a recent rapid increase in the number of internal specifications classified as company standards (OGP, 2011). The amount of idiosyncratic standards of large supermarket chains in the agro-food industry has recently increased in a similarly rapid manner (Henson and Reardon, 2005).

Company standards are linked to contractual governance and relate to the quality and security of a product; these standards are therefore important for upstream supply chain management (Marucheck et al., 2011). With increasing globalization, outsourcing, and off-shoring, non-conformance to standards can lead to unfavourable consequences for firms (Steven et al., 2014). It is therefore interesting for operations and supply chain managers to better understand suppliers' incentives to employ buyer-specific standards. Hence, this paper aims to identify and empirically investigate the motives of suppliers to apply the company standards of their buyers. We intend to reveal the effects of these application motives on the net benefit that suppliers expect from the application of these company standards.

So far, most research on the motives for participation in standardisation activities has focussed on standardisation in formal standards development organisations (SDOs), such as the International Organisation for Standardisation (ISO) (Blind and Mangelsdorf, 2010; Blind and Rauber, 2012). This paper thereby extends the literature by introducing the supplier-specific motivations for implementing company standards set by their buyers. In light of the previous focus of the literature, we contrast the motives for applying company standards with the motivation for formal standardisation participation. As those participants develop a public or club good, we consider the extent to which formal standards and company standards are competing ends.

We empirical investigate data collected from 133 global suppliers to a large original equipment manufacturer (OEM) in the automotive industry. First, we derive a parsimonious set of four determining motives via a factor analysis of 22 motives to use company standards. The most important motive concerns access to business relations with the buyer, enabled via the fulfilment of their buyer's standards. Transfer of knowledge, efficiency from the buyer, and the security aspect are ranked second. The third motive concerns fulfilment of supplier quality and reputation, which seems of only little importance to buyers. The insufficiency of external (e.g. formal) standards as the lowest ranked motive shows that company standards may not be seen as an alternative to existing formal standards.

In the second step, we explore how our four identified factors could explain the net benefit that suppliers expect from the application of the OEM's company standards. Our findings suggest that suppliers expect a higher net benefit if they use the company standards for knowledge transfer, efficiency and security gain, or for fulfilling required quality and reputation expectations, where we control for the size and the position of the respondent. Finally, larger companies seem to be able to derive a higher expected net benefit from applying company standards of their buyer.

The present analysis has implications for the governance of both supplier relations and standardisation managers. Buyers should consider the potentially favourable aspect that transferring knowledge via company standard has on their suppliers within this type of contractual governance. The results also highlight how larger suppliers seem to be better equipped to derive benefits from the application of external company standards. Finally, the aspect of quality assurance in a global context could be favourably tackled by a buyer's provision of company standards aimed at diffusing knowledge to suppliers (which is also supported by Steven et al., 2014).

The paper is organised in the following manner: In the next section, we extensively define company standards and provide a thorough review of the background literature. We then review company standards, the buyer-supplier relationship and the motives for formal standardisation participation. In the third section, we introduce and analyse empirical data of the suppliers' motives for applying the OEM's company standards and identify determining patterns via an exploratory factor analysis. The fourth section develops and tests propositions concerning the influences of these factors on the net benefit of their application. We construct a multivariate model that we test with ordered logit estimation. In the final section, we summarise the results and highlight the implications for researchers and practitioners.

3.2 Conceptual Background

In this section, we review the scant literature on company standards and combine this with the stream of buyer-supplier relationship literature. We start by introducing the concept of company standards and its respective literature. This is linked with the research on inter-firm relationships where two aspects stand out: securing the quality of products delivered by suppliers and the diffusion of knowledge to the supplier for an effective buyer-supplier relationship. We further introduce motives for formal standardisation participation. This review allows us to develop the list of motives for our explorative empirical investigation.

An Introduction to Company Standards

According to Narayanan and Chen (2012), a standard is the consensus of different agents to perform certain key activities according to agreed-upon rules. Company standards fulfil this idea within the boundaries and for the benefits of a specific company. They are not drafted within formal standard development organisations (SDOs), but are instead developed internally or in close cooperation with a specific supplier. The specific knowledge of experts is employed to tailor standards to the goals and requirements of the company at hand. Similar to formal standards, the consensus of all stakeholders within the company is a main requirement. The content of company standards is however fully determined by the issuing company. Company standards are *private goods*; they cannot simply be applied by other market participants. This is in contrast to formal or consortia standards, which are considered *public* or *club goods* (Blind, 2004). Further terms for company standards that have been used in the literature are "internal standards" or "private voluntary standards" (Henson and Reardon, 2005; OGP, 2011).

As de Vries (2006) noted are company standards not drafted by small and medium sized companies but rather by large enterprises, for example, automobile manufacturers or oil and gas producing companies. A survey on company standards of the oil and gas industry found that global producers implemented on average 816 internal standards (OGP, 2011), where larger companies had more of these standards compared to smaller companies. The growth rate of this number (OGP, 2011) reinforces the importance of our analysis.

Company standards therefore document specific requirements of a company; they can be subsequently passed on to its suppliers for the components or products bought upstream from suppliers. Therefore company standards may serve as a tool to transfer knowledge between the different stages of production along the value chain.

The ISO (2010) identified three main areas where company-specific standards have been used increasingly: in information and communication technology, in the agro-food industry, and in context with social and environmental aspects. Findings from these contributions will be incorporated in our analysis.

The Effects of a Buyer's Company Standards

We identify three main aspects of company standards in the literature: differentiation as strategic instrument; communication of safety; and reputation and cost reduction. Each of these aspects influences the relationship between buyers and suppliers to a different extent. Generally, the increasing reliance on company standards is supposed to have opposing effects on suppliers: new opportunities can be brought up by selling to specific new buyers but suppliers can also be

pushed out of the trade relationship if they are no longer able to fulfil the buyer-specific standards (Reardon and Farina, 2002).

The aspect of *differentiation* is identified as one of the main incentives for issuing company-specific standards (Farina et al., 2005; Jaffee and Masakure, 2005; Mainville et al., 2005; Reardon and Farina, 2002). A differentiated product allows firms to sell at higher prices compared to competitors. A horizontal differentiation through increased product quality can also increase the quantity demanded. Private standards allow the definition of a unique quality. Schlippenbach and Teichmann (2012) identify a strategic aspect of private standards related to this: if suppliers are expected to adhere to higher quality standards, wholesalers can strengthen their bargaining power with respect to these suppliers in the intermediate goods market for food. As the suppliers need to fulfil the standards set by their buyer, they become more interchangeable and hence lose their bargaining position. In the upstream supply management, buyers can therefore use their power to require differentiated quality of their products from their suppliers. Such differentiation thereby has the potential to improve the market position of a company and affects the buyer-supplier relationship.

A second aspect raised in the literature is the *communication of safety and reputation*. The trust of consumers can improve via company-specific standards compared to lower de facto or formal standards in the market (Jaffee and Masakure, 2005; Reardon and Farina, 2002). The cost advantage of providing buyer-specific standards is due to the reduction in transaction costs (Henson and Reardon, 2005; Reardon and Farina, 2002) where they can act as an instrument of coordination along the value chain.

Introducing Company Standards in the Inter-Firm Relationship

As the impact of company standards on the relationship between buyers and the supplier has become evident, we review aspects of the literature on inter-firm relationships relevant for company standards before delving into quality requirements and knowledge transfer inherent to these relationships.

A strong focus of the literature on strategic partnerships is *on enhancing supplier performance* (Dyer and Ouchi, 1993; Nishigushi, 1992) and on developing supplier integration capabilities for sustainable competitive advantage (Vanpoucke et al., 2014). Intensifying the relationship between the buyer and the supplier leads to more horizontal integration and a reduced number of suppliers. Sharing information with suppliers is essential for a successful partnership (Krause et al., 2007). We therefore expect the requirement to fulfil a buyer's company standards to increase the closeness of the supplier to the buyer.

The automotive industry provides a prominent example of the importance of buyer-supplier relationships (Krause et al., 2007). This is due to the reciprocal interdependence of the two agents (Dyer, 1996). Japanese car manufacturers, for example, achieve high integrity because suppliers are required to make customised parts (Clark, 1989; Corsten et al., 2011). They involve suppliers stronger in the process of production which accounts for a significant fraction for their advantage in lead time cost. As a consequence, Japanese automobile manufacturers achieve a higher level of quality than other carmakers. This results, for example, from specific quality standards that these companies set for their suppliers.

Ensuring Supplier Quality

Quality assurance along the value chain of consumer goods is imperative for the economic success of a company (Gereffi and Lee, 2012; Schlippenbach and Teichmann, 2012). As supply chains are becoming increasingly global, regulations and standards are ever more important for solutions regarding safety and security (Marucheck et al., 2011). Lack of control of supply-chain relationships can result in inconsistency in quality controls and standards, especially in a global context (Steven et al., 2014). Failure to deliver a certain quality can have large repercussions on company costs as well as on consumer trust in the end-product. Although a reduction in quality can occur at any step along the chain, consumers usually connect product errors with the seller of the end-product and not the underlying suppliers (Schlippenbach and Teichmann, 2012).

Security-related industries, such as the agro-food or automotive industry, must especially emphasise quality. For example, in February 2013 the automobile producer Chrysler announced a recall of nearly 370,000 pickups and SUVs because of an axe-locking problem in Canada and the US. This recall, precipitated by a supplier issue, was costly to the company. These potential costs make company standards which require high quality especially valuable for the makers of automobiles and other durable goods (Kindleberger, 1983). Setting and maintaining these quality standards above those of the market can enhance consumer satisfaction. With a consistent standard of company-quality, the end consumer can switch between the different goods of one company and ensure the same quality without search.

Company standards can reduced the problem of *information asymmetries* between buyers and suppliers as identified by Akerlof (1970). One of these asymmetries is adverse selection. This happens if the buyer of a product, for example a used car, cannot test its quality and provides the seller with an incentive to behave opportunistically. The fulfilment of an accepted standard of quality can serve as a signal to overcome this problem. Leland (1979) considers this an argument

for common minimum quality standards[1]. It is not only formal standards but also company standards which can improve information asymmetries: the buyer decides what quality to require from suppliers by providing standards tailored to the company's interest. Failure to provide this quality results in a breach of contract and high costs on part of the supplier. Therefore company standards can offer a "self-selection" mechanism in the inter-firm relationship, where only suppliers fulfilling the required company standards want to enter the exchange with the buyer.

A further problem associated with information asymmetries can be the lack of *testing*. If required qualities cannot be tested sufficiently, the incentives for the seller to fulfil the required quality are reduced. This is the problem of moral hazard (Akerlof, 1970), a special case of the principal-agent problem. Here the principal delegates some of his tasks to an agent and has to ensure that the agent performs all the duties to set specifications (Schlippenbach and Teichmann, 2012). Buyers and suppliers in their relationship can be seen as the principal and agent, respectively, with the potential for moral hazard. The requirements to adhere to a buyer's company standards may strengthen the relationship. Specifying the necessary quality explicitly may therefore decrease the likelihood of moral hazard.

Sharing of Knowledge

Dyer and Hatch (2006) find that more knowledge sharing results in *faster learning* on part of suppliers. Knowledge transfer is also an important aspect of quality management (Molina et al., 2007). Accordingly, the right amount of knowledge reduces suppliers' defects considerably more than competitors' not engaged in this knowledge sharing. Company standards can provide the means of transferring knowledge from the buyer to the supplier, providing potential for this learning effect.

The exchange of information can similarly improve the relationship between buyers and sellers (Cannon and Perreault Jr., 1999; Cheung et al., 2010). In sharing the buyer's knowledge with the supplier, product quality can be improved and new product development can be facilitated. Through information sharing, the respective understanding of the results of mutual behaviours of buyers and suppliers is improved (Kelley and Thibaut, 1978). The open mutual sharing of information can also deepen the commitment in a relationship (Anderson and Weitz, 1992). As company standards allow the transfer of knowledge between the buyer and the supplier of a product, they can also benefit the agents upstream in the value chain.

[1] Leland (1979) refers to the general notion of standards and not to company standards.

Formal Standardisation Motives

Before we discuss motives for implementing a buyer's company standards, an overview of the literature on objectives for participating in formal standardisation and implementing formal standards provides a valuable perspective. The general motives and barriers to participate were investigated by Blind and Rauber (2012). The main reasons highlighted creation of qualitatively good and fitting formal standards, and the prevention of standards that contradict individual interest. Blind and Mangelsdorf (2010) investigate the firms' strategic objectives to participate in formal standardisation in two sectors. They found that firms want to implement industry friendly regulations and enforce their own content in the formal standards. The investigated companies further aim to prevent formal standards from conflicting with their own interests. The study moreover showed that firms do not want to solve company specific technical problems in formal standardisation. Lastly, Wakke and Blind (2012) investigate motivations for implementing service standards. The main intention for using such formal standards is the assurance of quality as well as increasing legal certainty. This literature unilaterally highlights that formal standardisation participation is concerned with the objective to promote individual interests. Company standards however are exclusively concerned with the specific interest of the issuing company, therefore suppliers are assumed to have little impact on their content (as long as the standards are not developed in cooperation).

3.3 Empirical Investigation of a Supplier's Motives to Apply Buyer-Specific Standards

Introducing the Data

To assess the impact of the application of a buyer's company standards on a supplier, we surveyed suppliers to a large, globally active automobile original equipment manufacturer (OEM). The data consists of a sample of 133 suppliers that answered a questionnaire on company standards in autumn 2012. These suppliers were identified as key users of the OEM's company standards via their downloading behaviour from the buyer's document provision system. An invitation for participation in the survey was sent to the 500 companies with the highest number of downloads. The response rate was 26.6%. The answers of the suppliers were supplemented by national and international firm characteristics data. The sample consists of 80% manufacturing, 12% service and 8% wholesale trade companies. Twenty-nine percent of the answers in the sample came from managers and the remaining 71% from clerks.

The survey was supported by the OEM defined hereafter as "the buyer". It was constructed after consultation of the literature and interviews with both technical and standardisation experts

at the buyer. The buyer is a major multinational corporation with headquarters in Germany, producing mainly premium cars. The inputs in the production within the buyer's company are sourced globally with a variety of suppliers.

Unfortunately, the item response varies considerably, and hence our analysis differs in the number of observations across the investigated motives. To prevent the loss of large amounts of information, all data has been retained for the analysis. The robustness of our results was however cross-checked with a restricted full-response sample. It should further be noted that despite the broad range of suppliers questioned, the answers concern the company standards of the investigated buyer only. This could provide a potential bias. If the investigated OEM had particularly high quality requirements, for example, this would be mirrored in our results. A potential extension of this research is therefore a replication of the analysis among other clusters of buyers and suppliers.

Motives for Using Company Standards

The questionnaire listed 22 motives for applying the buyer's company standards. These motives were identified from the analysed literature and further developed and enhanced in intensive collaboration with product representatives and standardisation experts of the OEM. Additional to company-standard-specific motives, motives concerning the relation to external standards were included. The results of the suppliers' ranking of each motive are presented in table 3.1. The most important motive is the contractual agreement to apply company standards followed by the legal security that fulfilling these company standards provides. Generally, motives related to quality are ranked highly, whereas motives considering company standards as an alternative to external standards are of lower importance. Also the objectives related to knowledge transfer are important. The lowest average ranking was given to the application of company standards to products not directed by the buyer.

Exploratory Factor Analysis

To reduce the number of motives we conducted an exploratory factor analysis. Prior to the analysis, the adequateness of a factor analysis for the available data was checked. According to Dziuban and Shirkey (1974), there are two appropriate tests for this: Barlett's test of sphericity and the Kaiser-Meyer-Olkin measure of sampling adequacy. With the first criterion, we can reject the null hypothesis that the underlying correlation matrix is an identity matrix at the 0.1% significance level. There therefore exists enough co-variation in the data to condense these to a smaller number of underlying constructs. The Kaiser-Meyer-Olkin measure of sampling adequacy

is 0.821, which corresponds to an appropriate correlation matrix[2] . We therefore conclude that the patterns of correlation we identified are very robust.

Table 3.1: Importance of the motives for applying the OEM's company standards

Application Motive	Rank	Mean†	SD	Obs.
Application is contractually agreed upon	1	1.33	0.68	121
(Legal) Security	2	0.96	0.83	97
Learning effects	3	0.93	0.87	108
Using Company's state of the art	4	0.92	0.80	101
Improving quality of end-product	5	0.92	0.82	99
Efficiency gain from repeated application	6	0.91	0.87	102
Access to business relation with Company	7	0.89	0.89	122
Improving delivered quality of suppliers	8	0.79	0.84	98
Favouring company-preferred technologies	9	0.73	0.75	104
Improving technical compatibility of components	10	0.72	0.80	96
Improving reputation as suppliers	11	0.68	0.83	95
Efficiency gain through network effects	12	0.67	0.80	96
Transferring company-specific know-how	13	0.66	0.81	100
Reducing product variety	14	0.51	0.98	98
Existing contradictions in external standards	15	0.40	0.93	97
Improving reputation within own company	16	0.38	1.02	94
Application costs of external standards higher	17	0.36	0.82	109
Insufficient quality requirements of external standards	18	0.29	0.83	96
External standards used for superordinate topics	19	0.25	0.88	97
Topic not available in external standards	20	0.23	0.86	98
Application due to managerial order	21	0.15	0.99	96
Comprehensibility of external standards insufficient	22	-0.06	1.02	108

† The mean is the average on a scale of -2 (=completely disagree with this motive) to 2 (=completely agree with this motive); CS=Company Standard; SD = Standard Deviation; Obs. = Number of observations.

In the initial analysis we obtained eigenvalues of the condensed factors of the data. As four factors had an eigenvalue larger than one, they were retained for rotation and further analysis by Kaiser's criterion. The scree-plot criterion also reconfirmed the retention of four factors (Lance and Vandenberg, 2009). Together these factors explain 84% of the total variance, as displayed in table A.1 in the appendix. As the independence of the factors cannot be guaranteed, an oblique rotation technique was used to improve the fit of the motives.
As can be seen from table 3.1, two motives load highly (more than 0.42) on more than one factor. This confirms the assumption of the interrelation of the motives. According to Vaus (2002), this item is to be included in the factor where it has the highest loading when creating factor-based scores. We will now outline and interpret the identified factors.

[2]Hutcheson and Dofroniou (1999) state that values between 0.8 and 0.9 are very good for factor analysis.

Factor 1: 'Knowledge transfer, efficiency and security.'

The first factor loads highly on motives connected to company-specific knowledge diffusion and efficiency, favouring company-preferred technologies, learning effects, favouring buyer-preferred technologies, transferring buyer-specific know-how, reducing product variety, efficiency gain through repeated application, efficiency gain through network effects, and improving the technical compatibility of products. Also, the security (legal) and the use of the standard-issuing buyer's state of the art are associated with this factor. Hence this factor is most strongly connected with the transfer of company-specific knowledge and efficiency gains for the supplier. The security aspect of company standards complements the efficiency and knowledge transfer aspects, as minimizing the risk for the technicians can be a key goal in achieving cost efficiency within a company. The internal reliability for this factor, measured by a Cronbach's alpha of 0.81, is good (Field, 2009).

Factor 2 'Fulfil required quality and reputation.'

Motives relating to the quality requirements for the supplier, items of improving the delivered quality of the supplier, and improving the quality of the end-product have high loadings with the second factor have. Also the reputation as a supplier and the reputation of the respondent within their own company, and the application due to managerial order are assigned to this factor. The connection between the two aspects seems adequate, as a continuous delivery of high quality from a supplier can improve the reputation with the buyer. A Cronbach's alpha of 0.9 indicates a very good reliability of this factor.

Factor 3: 'Complementing external standards.'

The third factor has high factor loadings with motives regarding the insufficiency of external standards making way for company standards. The items are: application costs of external standards are comparably higher; comprehensibility of external standards is insufficient; insufficient quality requirements of external standards; topics are not available in external standards; existing contradictions in external standards: and external standards are used for superordinate topics only. This factor is therefore clearly related to the motive of applying company standards as complements to external standards, due to their insufficiency in application. The internal reliability of this factor is also very good with an alpha of 0.9.

Factor 4: 'Access to buyer.'

The motives of access to business relations with the buyer, and the contractual agreement of the application of company standards have high loadings on the fourth factor. These motives consider how company standards can be used to gain access to business relations with the buyer. Although the reliability of this factor is questionable with an alpha of just 0.6, this can be due to the low number of items involved in the factor (Field, 2009) and can still provide a sufficient measurement of the underlying construct.

The four factors that have been extracted in the exploratory factor analysis mirror the theoretical considerations of the previous chapter. The importance of inter-firm relationship is highlighted in the dimension of knowledge transfer of the first factor, the reputation of the supplier and quality of the second factor and the general access to the relationship with the fourth factor. The literature review already highlighted that the aspects of knowledge transfer and the fulfilment of the required quality by suppliers should be especially separated, as they have different effects for the relationships between buyers and suppliers.

Table 3.2: Ranking of motive factors for applying company standards

Application Motive[†]	Rank	Mean	SD
Factor 4 'Access to the buyer'	1	1.11	0.67
Factor 1 'Knowledge transfer, efficiency and security'	2	0.74	0.65
Factor 2 'Fulfil required quality & reputation'	3	0.69	0.81
Factor 3 'Complementing external standards'	4	0.41	0.60

[†] The mean is the average on a scale of -2 (=completely disagree with this motive) to 2 (=completely agree with this motive); CS=Company Standard; SD = Standard Deviation.

In Table 3.2 the average importance of the motives constructed from the factor analysis are presented. The most important factor is access to the buyer, followed by the knowledge transfer, efficiency and security. Also important is the fulfilment of supplier quality and reputation. The average importance for the motives regarding external standards, alternative to external standards and insufficiency of external standards, are significantly lower.

3.4 The Net Benefit of Buyer's Standards on the Supplier

Propositions

To assess the different company standard application motives, the analysis is finalised by proposing the economic impact of the derived patterns of company standard usage for the supplier. This can be seen as a "robustness check" of the previous findings. Due to the exploratory nature of this analysis where we previously identified the underlying factors, we suggest propositions

regarding the impact of company standards on the expected net benefit of the suppliers. We therefore consider propositions regarding the impact of each of the motivational patterns for applying the buyer's company standards on the expected net benefit to the supplier.

Knowledge transfer, efficiency and security

The theoretical development emphasised that sharing of knowledge enables faster learning (Dyer and Hatch, 2006) and an improved relationship between the buyers and sellers (Cannon and Perreault Jr., 1999). Also, the efficiency associated with this factor as well as the provided security have a favourable effect on supplier performance. We hence associate a favourable net benefit for suppliers that apply their buyer's company standards for 'knowledge transfer, efficiency and security'.

P1: *The factor 'knowledge transfer, efficiency and security' has a positive impact on the net benefit of applying the buyer's company standards.*

Fulfil required quality and reputation

As the reduction of information asymmetries (Akerlof, 1970) and the increase of supplier performance with respect to quality (Dyer and Ouchi, 1993) is associated with horizontal integration and a reduced number of suppliers, we expect this to have a favourable effect on the suppliers economic performance. We threfore also associate a favourable net benefit for suppliers that apply their buyer's company standards for 'fulfil required quality and reputation'.

P2: *The factor 'fulfil required quality and reputation' has a positive impact on the net benefit of applying the buyer's company standards.*

Complementing external standards

From our descriptive statistics we revealed that suppliers on average do not judge company standards as a complement or alternative to existing external standards. Suppliers must adhere to existing external standards, usually independently of the buyer's requirements. We therefore assume that suppliers which apply company standards as complements to existing external standards will not be impacted by the expected economic net benefit of the buyer's standards. As a result, we propose the null hypotheses:

P3: *The factor 'complementing external standards' is independent of the net benefit of applying the buyer's company standards. standards.*

Access to the Buyer

As the suppliers need to implement the buyer-specific standards to gain access into the business relation with the buyer, we assume the importance of this factor to be independent for the suppliers of the net benefit of application. We therefore also propose the null hypothesis:

P3: *The factor 'access to the buyer' is independent of the net benefit of applying the buyer's company standards.*

Apart from the mentioned factors as dependent variables, we also include two control variables in the model. We first control for the size of the companies in our sample. Generally, larger companies have more to gain from standardisation and rationalisation and we hence assume the size to have a positive effect on the economic benefit of the application of the buyer's company standard. Secondly, the data relies on self-assessments of the employees dealing with standardisation within the company; the position occupied by surveyed employees might affect the answers provided. Managers are expected to evaluate the different motives for the application of private standards more critically. Therefore a dummy variable[3] for the respondent being a manager is included in the analysis.

In the investigation of the influences of company-specific factors on the different objectives, a linear model is used for an explorative assessment of the propositions. We considered the variable inflation factor (VIF) for the independent variables in our analysis and a correlation matrix is presented in the appendix (table 3.5). According to the VIF of 1.48, our independent variables are appropriate in the analysis.

As we want to consider the influence of the individual factors that were derived from the motives while controlling for company size and the position of the respondent, we fit the following model:

$$NetBenefit = \beta_0 + \beta_1 factor1 + ... + \beta_4 factor4 + \beta_5 size + \beta_6 manager + \varepsilon \tag{3.1}$$

The expected economic benefit $Net\ Benefit$ is derived from the questionnaire as a self-report of the cost-benefit relation of the application of the OEM's company standards on a five-point Likert-scale (beetween 2 = very positive and -2 = very negative). The explanatory variables are each of the respective factors derived in our previous analysis. These were constructed by

[3]The dummy variable $MANAGER$ = 1 if the respondent is a manager, =0 if the respondent is a clerk.

producing row mean average from the relevant motives we identified with the exploratory factor analysis. The variable $SIZE$ is the total turnover of the firm in the year 2011. $MANAGER$ is a dummy variable that indicates whether the respondent is a manager at the company.

Results of the Regression Analysis

Table 3.3: Results of the ordered logit regression

	Net Benefit[†]
Factor 1 'Knowledge transfer,efficiency and security'	1.422***
	(0.10)
Factor 2 'Fulfil required quality & reputation'	1.014**
	(0.440)
Factor 3 'Complementing external standards'	-0.071
	(0.374)
Factor 4 'Access to the buyer'	-0.237
	(0.375)
$SIZE$	0.738**
	(0.340)
$MANAGER$	0.238
	(0.504)
McFadden's R^2	0.183
Observations	89

[†] Robust standard errors in parentheses: *p<0.10, **p<0.05, ***p<0.01; Correlation Matrix of the endogenous variables can be found in the Appendix Table 3.5

The results of the regression analysis are reported in table 3. The overall fit of the model is reported in a McFadden's R-Squared of 18.3%. The results from our sample reveal three significant coefficients at the 5% significance level. Factor 1, Factor 2 and the size all have a positive impact on the net benefit that suppliers expect from applying the OEM's company standards.

Of the factors we developed within our analysis, we found the relationships that we expected from our propositions to be supported. Hereby the benefit derived from the buyer's standards applications seems to be mostly related to the knowledge transfer and efficiency factor and to a lower degree by the fulfilment of quality pattern we developed. As expected, neither the factors concerning external standards nor access to the buyer were significantly related to the net benefit.

3.5 Discussion

Our empirical analysis of 122 suppliers to one OEM reveals that company standards are most importantly but not exclusively applied to enter a business relation with the buyer, but also that a number of further motivations for suppliers exist. For example, company standards enable the transfer of knowledge from the buyer to the supplier, and improve the efficiency at the supplier. This could improve the problem of information asymmetries (Akerlof, 1970) and deepen the commitment in the buyer-supplier relationship (Anderson and Weitz, 1992).

In an increasingly globalized context, non-conformance with standards seems to pose a particular problem (Steven et al., 2014). If suppliers, however, were provided with essential knowledge via company standards and made aware of the potentially positive expected benefits, we would assume them to be more likely to adhere to these standards. The evident relation between knowledge transfer, efficiency gains, and learning effects shows how versatile this aspect is. This is reinforced by the positive influence that suppliers expect from employing the OEM's company standards for knowledge transfer.

When the supplier uses company standards to fulfil the required quality and reputation requirements, we relate this to the aspects of quality assurance (Gereffi and Lee, 2012; Schlippenbach and Teichmann, 2012) and enhancing supplier performance (Dyer and Ouchi, 1993; Nishigushi, 1992). Supplier quality assurance allows the OEM to differentiate itself on the market (Jaffee and Masakure, 2005; Reardon and Farina, 2002). Although a higher quality is generally associated with higher costs, the differentiation allows the firms to expect higher revenue from higher prices in the market. We assume that suppliers can increase their prices by delivering products which fulfil the high quality standards of the OEM and this is supported by our findings. Suppliers that use the OEM's company standards to fulfil the quality and reputation requirements also expect a higher net benefit from doing so.

Considering company standards in the light of existing external standards, such as those standards developed by SDOs shows that there seems to be neither a complementary nor a substitutionary relationship between the two types of standards. In contrast to formal standards, standards of private organisations can be more specific and goal-oriented towards the specific needs of the buyer. Following this, suppliers neither rate the motivation to apply company standards as complements to existing external standards highly, nor do they derive a significant positive or negative benefit from doing so. This reinforces the differences in company and external standards and we therefore emphasise that company standards should not be seen as a sub-category to external standards, but be considered independently. Finally, we found a positive influence of the size of the supplier on the expected benefit of applying external company standards of the OEM.

3.6 Conclusion, Implications and Limitations

The presented analysis provides a novelty to the existing literature on standardisation. It is the first paper to link the buyer-supplier relationship to the application of company standards by suppliers. It is also the first contribution to highlight both the knowledge transfer to as well as the quality requirements for suppliers as important objectives for the application of company standards.

We analysed a sample of 122 suppliers to a major automotive OEM based on their motivations to apply the OEM's company standards. An extensive list of general motives has been proposed to identify the underlying constructs. An exploratory factor analysis revealed the motives of 'knowledge transfer, efficiency and security', 'fulfil required quality and reputation', 'complements to external standards' and 'access to buyer'. The highest ranked motive was gaining access to business relations with the buyer, followed by the transfer of knowledge, efficiency and security motive. The former shows the importance of accomplishing company standards in the general relationship between the buyer and its supplier. The latter underlines the potential of company standards to resolve the overall problems of information asymmetries. The pattern of knowledge transfer is followed by the fulfilment of quality and reputation motive. This confirms the notion that company standards can be means to ensure the supplier quality and therefore overcome the problem of adverse selection. Least important are the motives for company standards to be an alternative to external standards. This is possibly because they cover completely different objectives to external and especially formal standards.

The second step was to explore propositions regarding the patterns of motivation driving a supplier's adoption of company standards and the economic benefit of doing so. The empirical results indicate that suppliers which apply the buyer's company standards for knowledge transfer or in order to fulfil the required quality expect a higher net benefit. We assume this to be because knowledge transfer reduces information asymmetries and a higher quality allows for differentiation and higher prices increases. A further result is that company standards seem to be neither a complement nor a substitute for external formal standards. We therefore emphasise that they deserve attention in their own right.

Our analysis allows us to draw implications for supply chain management. In the food industry, the possibility to achieve safety requirements of suppliers with company-specific standards has already caught the attention of policy makers (Farina et al., 2005; Jaffee and Masakure, 2005). We highlight that buyers should consider the potential favourable aspects of transferring

knowledge to their suppliers via company standard as well as the relation to efficiency gains and learning on part of the supplier. Finally, the aspect of quality assurance on part of the supplier can be favourably tackled by providing company standards to suppliers. The results also show how larger companies seem to be better equipped to derive benefits from the application of external company standards.

A final remark concerns the importance of further investigating the matter of private standards in the buyer-supplier relationship due to the limitations of this analysis. The data comprises only suppliers of one major OEM and therefore further analyses on a larger scale and on different industries would provide valuable insights in this new field of research.

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3.8 Appendix

Table 3.4: Exploratory Factor Analysis

Variable[†]	Factor 1	Factor 2	Factor 3	Factor 4	Uniqueness
Learning effects	0.422				0.297
Favouring company-preferred technologies	0.531			0.430	0.282
Transferring company-specific Know-how	0.424				0.302
Reducing product variety	0.936				0.338
Efficiency gain of repeated application	0.849				0.183
Efficiency gain through network effects	0.729				0.271
Improving technical compatibility of components	0.849				0.269
(Legal) Security	0.663				0.317
Using Company's state of the art	0.554				0.328
Improving reputation as suppliers		0.771			0.226
Improving delivered quality of suppliers		0.710			0.174
Improving quality of end-product		0.716			0.199
Improving reputation within own company		0.809			0.280
Application due to managerial order		0.503			0.781
Application costs of external standards higher			0.910		0.286
Comprehensibility of external standards insufficient			0.798		0.355
Insufficient quality requirements of external standards		0.431	0.611		0.463
Topic not available in external standards			0.600		0.563
Existing contradictions in external Standards			0.619		0.447
External standards used for superordinate topics			0.541		0.527
Access to business relation with Company				0.753	0.383
Application is contractually agreed upon				0.808	0.465

[†] Factor analysis method: Principal-Factor with oblique promax rotation
Amount of variance explained: 0.84
KMO=0.821, Bartlett test of sphericity p-value=0.000 (χ^2=1226.73, df=300)
Minimum Value of Eigenvalue to be retained = 1
Highest Factor-loading of each variable highlighted
Only sufficiently high loadings (>0.42) are reported

Table 3.5: Correlation Matrix of the Endogenous Variables

	$factor1$ †	$factor2$	$factor3$	$factor4$	$SIZE$	$MANAGER$
$factor1$	1.000					
$factor2$	0.474***	1.000				
$factor3$	0.432***	0.656***	1.000			
$factor4$	0.167*	0.367***	0.367***	1.000		
$SIZE$	0.112	0.018	-0.199*	-0.204*	1.000	
$MANAGER$	-0.085	-0.263*	-0.094	0.067	-0.048	1.000

† Significance levels: *p<0.10, **p<0.05, ***p<0.01

PAPER 4

Company Standard Implementation, Inter-Firm Relationships and Innovativeness

Firms set idiosyncratic standards in order to use them internally or to impose them on others, as company standards are imposed on suppliers. This paper therefore distinguishes between internal company standards that are developed and applied within the focal firm and external company standards that are developed by other companies, e.g. their customers, which must be applied by the focal firm. Both types of company standards are fundamentally distinct from standards produced by accredited standardisation bodies, such as ISO, or informal industry consortia, like IETF. We assume company standards to codify and diffuse knowledge and analyse these effects on relational embeddedness and supply chains as type of technological platforms. We hypothesise an interdependence of company standards with inter-firm relationships and innovativeness. By running a multinomial probit model based on a sample of 334 German companies we test how a company's size and its cooperative and innovation behaviour affect the propensity to set internal company standards and fulfil external company standards. We find that companies with process innovations are more likely to implement both types of company standards and are less likely to use no company standards at all. Our findings further indicate that the implementation of external company standards decreases the embeddedness with suppliers but increases the embeddedness with customers, as indicated by their innovation cooperation behaviour. We finally find that firms setting internal company standards are less likely to cooperate with their competitors.

Keywords: Company Standards, Innovation, Inter-firm relationship, Knowledge Transfer

4.1 Introduction

Considerable attention of the standardisation literature focuses on informal or formal de jure and de facto standards (see e.g. Blind, 2006; Blind and Jungmittag, 2008; Blind et al., 2013; Mattli and Buthe, 2005; Tassey, 2000). Nonetheless, little is known about the idiosyncratic standards: company standards. However, Hesser et al. (2007) found such internally developed standards to outweigh formal standards in most countries. Additionally, the number of applied company standards within firms outweigh the number of applied formal standards (de Vries, 1999). Compared to their use, company standards are considered an immensely under-researched topic (Riillo, 2013).

Both researchers and practitioners can benefit from a better understanding of the types of companies that use company standards and their relationships to other companies, but also their innovation activities. Standards set by private organisations play an important role in the governance of (global) value chains (Gereffi and Lee, 2012). Further, for a company's interfaces standardisation plays a key role in modularity and therefore the management of platforms not only within but also between companies (Cabigiosu et al., 2013; Gawer, 2014). Finally the relationship between innovation and standards is not completely understood and very context-specific (Choi et al., 2011).

A standard is defined as the consensus of different agents to perform certain key activities to agreed-upon specifications (Narayanan and Chen, 2012). We consider company standards from the perspective of a focal firm and differentiate between internal and external company standards. *Internal company standards* are developed within the focal company and either used within the company or with cooperating companies, such as suppliers[1]. *External company standards* are developed by other companies (e.g. customers) and used within the focal firm. We therefore isolate company standards from those developed by firms within strategic alliances, e.g. in consortia, (e.g. Axelrod et al., 1995) and formal standards developed by technical committees in formal standard setting organisations (see e.g. Blind, 2004; Mattli and Buthe, 2005).

In this paper, we first theoretically analyse company standards in light of their potential for codification and transfer of knowledge. In particular, company standards codify aspects of the issuing company which gives them the nature of a "codebook" (Bénézech et al., 2001) which can be used internally but also passed on to and implemented by external organisations. The codification of knowledge, about e.g. production processes, thereby requires the conscious identification of the core of these processes first, which in turn enhances learning and understanding. We connect

[1]These definitions lean on de Vries (p. 231 1999) definition of company standardisation as "[..] developing standards for use within the company and developing standards to be used in the company's relations with its direct business partners".

this codification of knowledge to company standards that are passed on to supply chain partners to the concepts of relational embeddeness and platforms. Embeddeness refers to how companies are anchored within their larger structure (Dacin et al., 1999; Johannisson et al., 2002). We focus on the dyadic relationships of the firms where we assume that transfer of knowledge increases the embeddedness of the inter-firm relationship: if companies manage to transfer their own codes, standards and culture to others, this inter-firm relationship set in the wider supply chain network tightens. Finally, we consider the literature on platforms and platform innovation where interfaces can be designed proprietarily to suit a company's specific interest (Cabigiosu et al., 2013; Gawer, 2014).

Based on review of the literature on knowledge transfer, embeddedness and platforms, we develop a conceptual framework of internal and external company standards. We are particularly interested how the implementation of company standards is related to a company's product and process innovation and its cooperation behaviour for innovation with other companies along the supply chain. Based on the conceptual model, we develop hypotheses on how companies' innovation and cooperation behaviour affects their use of internal and external company standards. Our hypotheses are tested on a sample of 334 German manufacturing and service firms. A multinomial probit model is used to test our hypotheses and reveals that innovative companies with process innovations are more likely to implement company standards. Further, companies that cooperate with their customers and competitors for innovation activities are more likely to use internal and external company standards while companies cooperating with their suppliers are less likely to use them.

This paper contributes to the literature by firstly investigating the link between inter-firm relationships as exemplified by their cooperation activities for innovation and a company's use of internal and external standards. Our findings provide valuable information for improving the governance of supply chains governance and the use of standards (Cabigiosu et al., 2013; Gereffi and Lee, 2012). Secondly, we demonstrate that especially (process) innovative firms implement company standards.

The remainder of this paper is structured as follows: in the next section we review the literature to conceptualize internal and external company standards. In the third section, we develop hypotheses on the influence of companies' innovation and cooperation activities on their need to develop company standards. The fourth section introduces the data and the applied methodologies. The last two sections present our results, discussion and conclusion as well as the contributions of this study.

4.2 Developing a Conceptual Framework

A Definition of Company Standards

Before exploring factors that influence a company's uptake of internal or external company standards, a comprehensive definition of these terms is required. As Narayanan and Chen (2012) conclude from an extensive literature analysis, the term "standard" already generates a challenge as it is inconsistently used in previous research. They define a standard as the consensus of different agents to perform certain key activities to agreed-upon rules. The process of arriving at a standard can take place on various levels. These can be on the micro, meso and macro level, on a formal national level within technical committees at standard developing organisations (for example at the International Organisation for Standardisation, ISO) or a within-firm level of standardisation. The decision to develop a company standard is part of the latter and therefore made within the company. In this paper we therefore consider the micro-level: the consensually agreed upon rules set by a company, for example a producer of automobiles. On the company level, standardisation has been identified to play an important role (Hesser et al., 2007; van Wessel et al., 2007). Company standards can be applied by the standard-setting company itself or by other companies to which the standard has exclusively been provided. Thus, they are generally not disclosed to other companies outside the buyer-seller relationship. They can therefore be considered private goods which contrasts with formal standards, which are considered to be public or at least club goods (Blind, 2004; Swann, 2000).

Because company standards can either be applied internally or passed on to external companies for application, e.g. to suppliers, we discriminate between internal and external company standards. We therefore define:

Internal company standards (ICS) *are documented specifications developed within the focal company that are either used within the company or within cooperating companies, such as suppliers.*

External company standards (ECS) *are documented specifications developed by other companies (e.g. customers/buyers), excluding standards produced by formal standardisation bodies or consortia that are used within the focal company*[2].

These definitions allow us to consider company standards from *two perspectives*: from the standard-setter's perspective and from the standard-recipient's perspective. In the following we will analyse how internal and external company standards relate to company-specific aspects.

[2]For the respective supplier, the internal company standard would therefore be an external company standard.

Codifying and Transferring Company Knowledge

Standardisation in markets can promote the diffusion of a technology (Blind and Gauch, 2009; Tassey, 2000) and hence benefit innovation. Standardisation within a company, on the other hand, can drive down costs, due to economies of scale by increased volume of products, or learning effects by repetition of processes or routines, for example. However, there is a threat: "if an enterprise standardises the process for creating its goods or services, it may disclose its core area of competence and thus throw away its competitive advantage" (Hesser et al., 2007). For such reasons, process-oriented innovators patent less than product-oriented innovators (Peters and van Pottelsberghe, 2006) as they fear losing their competitive advantage by sharing fundamental knowledge. The codification of fundamental knowledge for internal but also external companies can have benefits, however, such as enhanced performance due to the transfer of knowledge to cooperation partners or suppliers (Dyer and Hatch, 2006).

Analogous to Bénézech et al. (2001) considering the international quality management standards series ISO 9000 a "codebook" for companies, we argue that company standards codify and transfer relevant company-specific knowledge to outsiders. This means that company standards contribute to the "company codebook" that allows other firms connected to the focal company, for example along the supply chain, to understand the requirements and idiosyncrasies of the company. The codification of the company's knowledge for application within and outside of the company thereby has intrinsic effects. These are due to the fact that codification requires the identification of the necessary requirements and processes first, hence providing an opportunity to understand and learn about internal processes (Bénézech et al., 2001). Such articulation and codification of knowledge can positively impact the routinised activities that aim at the development and adoption of operational routines (Zollo and Winter, 2002). By providing internal knowledge codified in a company standard to other companies, the focal company benefits external institutions such as their supply-chain partners by transferring codified knowledge, like their codes.

As company standards codify a company's distinctive state-of the art for application not only within its own firm but also for applications in other firms, companies codify and transfer company-specific knowledge. This can enhance the diffusion of new processes or technologies within the company via internal company standards leading to economies of scale and cost reductions via fostering learning effects. External company standards can also improve the diffusion of knowledge on part of the external companies. Codification and disclosure of company standards thereby provides general learning opportunities, both internally and externally, where external companies learn from the external company standards provided by companies with whom they engage in business relations.

Embedding Value-Chain Partners within the Company

The fact that internal company standards of one firm can be external to another firm influences the balance of power and hence the relationship between buyers and suppliers (Henson and Reardon, 2005; Schuster and Maertens, 2013). For fulfilling the requirements of an external company standard, a company has to invest in the ability to fulfil these specific requirements. However, if one firm invests into the compliance or commitment to external company standards, this can potentially lead to a locking-in of standards specific to that company. We therefore propose that company standards relate to the embeddedness of firms, i.e. how the companies are anchored within their larger structure (Dacin et al., 1999; Johannisson et al., 2002). External company standards transfer the internal requirements and specifications of the standard-setting company to an external partner. This ties in with the view of Gulati (1998) which sees firms embedded in social networks as "voluntary arrangements between firms involving exchange, sharing, or co-development of products, technologies or services".

Embeddedness can impact the costs of a firm (Dacin et al., 1999). Past collaboration, for example, reduces transaction costs by the ability to rely on earlier agreements. It also discloses firms greater knowledge of each other's reliability and capabilities, thereby making mutual understanding easier (Ebers and Oerlemans, 2013). We assume external company standards to increase the embeddedness of companies with the standard setter. The provision of company standards to external partners can hence be considered a form of hybrid governance between market and hierarchy structures (Ebers and Oerlemans, 2013). Such structures relate to the embeddedness of firms, because this depends upon past collaboration, trust and industry standards - all of which are issues related to company standards. Cooperation with external partners therefore has an influence on companies' application of company standards.

Definition of Interfaces for Interoperability and Innovation Capabilities

The standardisation of interfaces eases the outsourcing of innovation activities to suppliers (Cabigiosu et al., 2013; Furlan et al., 2014; Gawer, 2014). Such interfaces can be designed specifically to suit a certain firm's requirement, these protocols are close and can be seen as proprietary standards used by a single firm or specific network of firms (Cabigiosu et al., 2013). They represent company standards requirements which are replicated across products and projects (Takeishi and Fujimoto, 2001). Standard interfaces and therefore modularity are important for platforms in their various classifications (Gawer, 2014), which can be technologies or products (e.g. automobiles can be seen as platforms), for example. We hereby refer to technological or standardisation platforms which mean pre-existing surfaces on which something rests, enabling things to be built on top of them. As platforms act as "conduits" between different categories of customers, this relates to standards which are aimed at the consensus between different users,

in our case on the company level. Further, external company standards disseminate the company codebook to other firms, providing them with a platform to develop parts of the final product.

Modularity and platforms raise important questions of inter-platform competition and platform innovation (Gawer, 2014). A similar competition can arise between dyads or networks of companies that work with competing company standards, for example set by the strong buyer in the supply chain. The literature on platforms also questions the governance of internal platform relationships. Generally, modularity is assumed with increased arms-length governance. Though Furlan et al. (2014) show that modularity and standardised components do not necessarily mean that the relationships between suppliers and buyers are further apart but instead that the relationship can be improved. According to Furlan et al. (2014), this is especially true in cases of high technological change. Gawer (2014) categorises three different types of technological platforms. A short review of her classifications provides further insights for understanding company standards.

Internal platforms (see e.g. Sanderson and Uzumeri, 1995) are interfaces within the firm that are not disclosed externally and thereby provide access to firm-specific innovation capabilities (Gawer, 2014). We can relate these to internal company standards that are not provided to external organisations. *Supply-chain platforms* (see e.g. Zirpoli and Becker, 2011) are interface specifications that are shared exclusively across the supply chain which provide access to supply-chain specific innovative capabilities. External company standards can be seen in a similar manner. Finally, *industry platforms* (see e.g. Eisenmann et al., 2011) provide interface specifications that are shared with competitors and thereby provide access to potentially unlimited external innovative capabilities. External company standards can gain wider acceptance and have the potential to become an industry standard and a component of an industry platforms.

As we assume company standards to have certain characteristics of platforms that allow companies to connect with each other, we also include insights from the platform literature.

A Conceptualisation of Company Standards

We have already highlighted some important insights relevant for company standards. To consider the effects that internal company standards and external company standards can have on the focal firm, we summarize our findings in table 4.1 in section 4.8 in the Appendix. The table highlights the different impacts of company standards on standard-setters and standard-recipients and how these can generate different benefits and costs. We herein consider the origin and the implementation of the standards in relation to the position of the focal company. Whereas the upper part of the matrix shows the aspects where the focal firm is the company standard setter, the lower part highlights implications for recipients of company standards from external

organisations. This concept will be utilized in the next section to develop hypotheses regarding a company's innovation and cooperation activities and their use of internal and external company standards.

4.3 Hypotheses

In this section, we link our theoretical considerations and concepts to characteristics of the firm in order to develop hypotheses. Our aim is to understand how the implementation of company standards within a focal firm is related to its size, innovativeness and cooperation behaviour. As we have defined two different types of company standards, we consider all possible combinations of implementing these, compared to the reference situation where a company uses no company standards at all. We therefore investigate four possible options for the focal company: a) the implementation of no company standards at all; b) the implementation of only internal company standards; c) the implementation of only external company standards; and lastly, d) the implementation of both internal and external company standards.

In formal standardisation, company size has been shown to have a significant positive effect on the probability of participation in standardisation (Blind, 2002, 2006). Smaller companies are more likely to behave as free riders in formal standardisation as they can gain from the standardisation efforts of larger companies (Blind, 2006). The development of formal standards requires a company's resources; because human and other resources are tied in the development of internal standards, we assume a similar relationship for company standards. Further, larger firms have a higher potential to derive benefits from rationalisation and standardisation. This is supported by Riillo (2013), who finds that up to a threshold, the involvement in company standardisation activities increases with firm size. We also considered learning and knowledge diffusion to be a central objective of developing internal company standards and hence assume that larger companies have more to gain from writing their own internal company standards.

When compared to smaller companies, larger companies potentially have more customers with different requirements that are specified in external company standards. However, we assume them to be less likely to fulfil external company standards only (case c), without their own ability to set internal company standards. This could mean that the company would prefer to set their own standards that encompass external company standards and other requirements or that consider the implementation of these (case d). For smaller companies, we assume this to be less likely. We hence formulate our first set of hypotheses:

H1.a: *Larger companies are more likely than smaller companies to implement both internal and*

external company standards (d).

H1.b: *Larger companies are less likely than smaller companies to implement external company standards only (c).*

Codifying and disclosing essential firm-specific technology and products in the market could lead to the loss of the company-standard-setting firm's unique knowledge assets. Diffusing firm-specific innovations within the firm, however, provides an advantage for learning and rationalization. As we conceptualise company standards as a codebook, we assume that processes rather than products are codified in company standards. This is in order to diffuse them within the standard-setting firm but also to cooperating companies, such as suppliers, that implement these as external company standards. For companies with process innovation, we assume a positive impact on their propensity to have both internal and external company standard (d), as this can codify important and potentially new knowledge on the company-specific procedures. On the other hand we assume that product innovation is less likely to be codified in a company's standard portfolio due to the potential loss of sensible information about new products. We hence postulate our second set of hypotheses:

H2.a: *Companies with process innovations are more likely to implement internal and external company standards (cases b, c and d) compared to companies without process innovations.*

H2.b: *Companies with product innovations are more likely to implement neither internal nor external company standards (case a).*

We have assumed that the process of knowledge codification and transfer increases the embeddedness of the inter-firm relationship between the standard-setting and the standard-receiving company. If companies manage to transfer their own codes, standards and culture to others, their position in inter-firm relations is strengthened. This influences the cooperation behaviour of relationship partners for innovation activities. The closer the embeddedness of the inter-firm relationship, the more likely that companies cooperate and benefit from this cooperation. We consider three potential supply chain partners for cooperation: customers, competitors and suppliers.

According to our conceptualisation, an enhanced relational embeddedness with a customer positively relates to external company standards, as these are usually set by and received from customers. We hence assume companies that cooperate with their customers to be more likely to employ either external company standards (c) or both internal and external company standards (d) to diffuse the requirements. Companies that cooperate with competitors might do so because they need to fulfil requirements set by their buyers, as the cooperation can enhance the fulfilment of shared customer needs. We therefore assume companies cooperating with their competitors to

be more likely to fulfil either only external company standards (c) or both internal and external company standards (d). On the other hand, there are companies that cooperate with suppliers more likely to provide them with their internal company standards rather than implementing external company standards. This is because external company standards are mostly received from buyers. We hence assume that firms that cooperate with their suppliers are less likely to implement external company standards only (c) or both internal and external company standards (d). Hence, we develop the third set of hypotheses:

H3.a: *Companies that cooperate with their customers are more likely to employ either only external company standards (case c) or both internal and external company standards (case d) compared to companies that do not cooperate with their customers.*

H3.b: *Companies that cooperate with their competitors are more likely to employ only external company standards (case c) or both internal and external company standards (case d) compared to companies that do not cooperate with their competitors.*

H3.c: *Companies that cooperate with their suppliers are less likely to rely on only external company standards (case c) compared to companies that do not cooperate with their suppliers.*

In the next step we will introduce the data sample we employed to test these hypotheses, as well as the methodology of the multinomial probit model used.

4.4 Data and Methods

Sample Selection

In this paper we use data from German companies to test our hypotheses. The data are collected within the second wave of the "German Standardisation Panel" (DNP) conducted on a sample of 1,316 German firms. The survey was initiated by both the German Institute for Standardisation (DIN) and the German Society for the Promotion of Research on Standardisation e.V. (FNS), and conducted in 2013 by researchers at the Technische Universität Berlin. This survey was distributed to all companies active at either the German standardisation institute (DIN) or the German Commission for Electrical, Electronic & Information Technologies (DKE). The sample is therefore composed of companies familiar with formal standardisation activities. Thus, we should consider whether a potential bias exists in the surveyed companies' implementation of company standards.

We would like to draw attention to potential influences between the implementation of external company standards and a firm's participation in formal standardisation. Standardisation participation is usually done by larger firms motivated by accessing knowledge from other standardisation participants or by influencing the outcome of the final standard (Blind, 2006). However, we cannot formulate any expectations on the relation of these kind of firms to external company standards. With regards to internal company standards, the argument could be proposed that firms active in formal standardisation are more prone to set internal company standards. However, also the reverse argument can be supported - that instead of participating in formal standardisation, firms set their own standards. Therefore we do set aside this potential bias of formal standardisation activities that influence the implementation of internal or external company standards and provide the results with this sample selection that we hope does not affect the significance of the relative influences.

The DNP survey is based on the OECD's taxonomy of innovation implemented also within the community innovation survey (CIS) extensively used in innovation research[3], but comprises various question on the types of standardisation activities exercised, e.g. formal, consortia and company standardisation. The unit of analysis is the company and the survey questionnaire is composed of both qualitative and quantitative aspects. Qualitative aspects consider issues related to the importance of various standardisations, innovation and cooperation activities as well as their supply chain position. Quantitative aspects refer to the number of the various standard types implemented by the firms and firm-level data such as size, turnover and the number of employees.

Variable Description

As we are interested in the implementation of the two different types of company standards we defined, internal and external company standards, we consider the firms' possible company standard regimes within our sample. The DNP survey asks companies to report the number of types of company standards used in the year 2012. Table 4.1 provides an overview of the implementation reported in the sample. We distinguish between the four possible company standard regimes: a) no company standards implemented; b) only internal company standards implemented; c) only external company standards implemented; and d) both internal and external company standards implemented. Around 72% of the companies in the sample reported implementing both internal and external company standards (case d); only 4% used external but no internal company standards (case c). Just 14% reported using internal company standards, but no external company standards (case b), and 10% of the companies in our sample use no

[3]For further information on the CIS and its uses in innovation research, the interested reader can consult Tether (2002) and Brouwer and Kleinknecht (1999).

company standards at all (case a).

Table 4.1: Overview of the use of Company Standards of the 334 firms in the sample

		ECS	
		yes	no
ICS	yes	240	46
	no	15	33

In section three, we hypothesise that the operative characteristics of the companies influence the implemented company standard regime. We need to consider the dependent variable that we want to explain with our sample. Therefore, we developed a categorical variable CAT_i that we coded according to the company standard regime that company i is employing. $CAT_i = 0$ is the case where a company uses neither internal nor external company standards (case a); $CAT_i = 1$ is where company i uses only internal company standards (case b); $CAT_i = 2$ when company i uses only external company standards (case c); and $CAT_i = 3$ in the case where both internal and external company standards are used (case d).

Additionally, we constructed the explanatory variables according to the conceptual model we developed. An overview of the descriptive statistics of all the variables is given in table A.1 in the appendix. We considered the $Size$ as the log of the average number of employees employed in the company in 2012. We considered the innovativeness of the companies on product and process dimensions, where the variables $ProdInno$ and $ProcInno$ respectively consider whether the company introduced new or noticeably improved products on the market in 2012 or implemented new or noticeably improved processes within the firm in 2012. Further, we constructed variables for the cooperation activities for innovation activities with suppliers, customers and competitors in 2012. Each of the variables was constructed as indicators based on how often the company had cooperated with each of these types of firms. As answers were given on a scale of -3 (very infrequently) to 3 (very frequently), the variables $CoSu$, $CoCu$ and $CoCo$ for cooperation with suppliers, customers and competitors, respectively, were coded as 1 for a value of 1 to 3 and 0 for zero to -3[4] .

As we consider the position of the companies within their supply chain as fundamentally important for the usage of company standards, we also considered the supply chain position of the companies. We created indicators on the position of $Supplier$, $Contractor$, $Researcher$, $Manufacturer$, $Retailer$ and $Other$ based on the company's core business activities in 2012. We also developed industry dummies for the companies in our sample, where we discriminate

[4] Additional robustness checks were undertaken with different coding of these explanatory variables. The significance of the results, however, does not change.

between the sectors of manufacturing, service and utility, which are composed of the water, energy, building, and mining industries. The appendix provides a detailed description of the data in our sample, with descriptive statistics on table 4.3, the distribution of the company standard regimes over the different supply chain positions in 4.4 and the industry sectors that the firms in our sample are active in tabulated in table 4.5.

We focus on the firm-specific characteristics that we expect to be associated with the differing company standard regimes of the companies studied. Our dependent variable CAT will be regressed on the company-specific attributes that we identified in our theoretical development, namely the innovativeness of firms, the cooperative behaviour with respect to suppliers, customers and competitors, the supply chain position and sectors that the firms' core business activities are in. The supply chain position and the sector of the company are grouped in the vector of controls Z_i.

Our empirical model therefore estimates the following equation:

$$CAT_i = f(Size_i, ProdInno_i, ProcInno_i, CoSu_i, CoCu_i, CoCo_i, Z_i) \tag{4.1}$$

In the following we will lay out the estimation technique used to approximate this model.

Empirical Model

We consider the multinomial probit model (MNP) for the discrete choice between the different regimes of implementing company standards. The advantage of the MNP is that it allows for correlated errors across choices, meaning that the independence of irrelevant alternative (IIA) restriction of other discrete choice models is not binding (Long, 1997). This is important as we do not consider the decision of implementing internal or external companies or both to be independent of each other.

This model considers the choice among multiple, mutually exclusive alternatives that a decision maker (an individual but also an organisation) faces, in terms of the utility U_{ij} that the decision maker derives from the choice. We model the choice of individual i that alternative j is chosen based on the organization-specific vector of attributes x_{ij} as well as a statistical error term ε_{ij}. The error terms are normally distributed with a variance-covariance matrix σ (Greene, 2012). We consider J available alternatives for the decision maker:

$$U_{ij} = x'_{ij}\beta + \varepsilon_{ij} \; where \; = 1,...,J; [\varepsilon_{i1}, \varepsilon_{i2}, ..., \varepsilon_{iJ}] \sim N[0, \sigma] \tag{4.2}$$

We consider the probability that a company i chooses an alternative q (in our case one of the standardisation regimes a, b, c or d) as the probability that the utility derived from this choice exceeds the utility from any of the $J-1$ other available choices:

$$Prob[choice_{iq}] = Prob[U_{iq} > U_{ij}, j = 1,..,J, j \neq q]. \tag{4.3}$$

Therefore we can express this probability in terms of the attributes and error terms of all other $J-1$ alternatives as:

$$Prob[choice_{iq}] = Prob[\varepsilon_{i1} - \varepsilon_{iq} < (x_{iq} - x_{i1})'\beta, .., \varepsilon_{iJ} - \varepsilon_{iq} < (x_{iq} - x_{iJ})'\beta] \tag{4.4}$$

This is a cumulative probability from a $(J-1)$-variate normal distribution. Thereby, this model allows an unrestricted $(J-1)x(J-1)$ correlation structure, meaning that it allows for unrestricted correlation of the error terms, therefore relaxing the independence of irrelevant alternative (IIA) assumption. This allows for a connection between the likelihood of choosing alternative b, c or d - because we assume the decision to implement both internal and external company standards (case d) to be correlated with the decision to either implement only internal or external company standards (case b or c).

In our case, we have four (i.e. $J = 4$) available alternative "choices" that an organisation faces: chose to employ no company standards (case a); use only internal company standards (b); or only external company standards (c); and using both (case d). We therefore employ the MNP model to compute the marginal effects that a change in each of the attribute (size, innovation and cooperation activities) has on the probability that the decision maker i takes alternative j. This is the increase or decrease in probability to choose case a, b, c or d that occurs with a change in an attribute of the firm. This allows us to consider the effects that organisation-specific characteristics such as their innovation and cooperative behaviour have on a company's choice of company standard regime implementation:

$$\delta_q \frac{\delta Prob[choice_{nq}]}{\delta x_q} \tag{4.5}$$

The marginal effects can be interpreted as the percentage increase or decrease that the change in this explanatory variable has on the company's likelihood to fall into a specific category.

We hence go on to consider the results of the multinomial probit regression in the next section, where we also link them to a discussion on the previous considerations.

4.5 Results and Discussion

Table 3 reports the resulting marginal effects from our multinomial probit regression were we explicitly control for a firm's supply chain position and its industry sector. Although we only included supply chain position as a dummy, we explicitly report the marginal effects of the supply chain positions, as the position of $Supplier$ provides us some interesting insights.

With regards to the first set of hypotheses both H1.a and H1.b are confirmed based on our regression. The result highlights that larger firms are significantly more likely to have both internal and external company standards and less likely to have only external company standards or no company standards at all when compared to smaller firms. We first consider this to be due to the necessary size that is required for rationalisation, e.g. economies of scale, but consider learning effects which occur with routinizing firm-specific tasks. It also becomes obvious that if larger firms are implementing external company standards, this is positively linked to the implementation of their own internal company standards. This might be because larger firms develop internal company standards to include the external requirements within their own "codebook" or because they find common aspects in their external company standards that they can bundle together in their internal company standards.

The second set of hypotheses is only partly confirmed. Our data show a significant positive relation between process innovative companies (H2.a) and the implementation of a combination of internal and external company standards. However, there is no significant association between product innovative companies (H2.b) and the implementation of a particular company standard regime. As we assume company standards to be appropriate instruments to codify and diffuse relevant knowledge within a company's own firm and supplier base, this can indicate that information on improved processes is diffused in this way and potentially even that standard-receiving companies' innovativeness can be enhanced by the process innovation of the standard-setting company.

The third set of hypotheses is also partly supported by our data.Companies that cooperate with their customers (H3.a) or competitors (H3.b) related to innovation activities are significantly more likely to implement both internal and external company standards compared to the companies that do not cooperate. Cooperation with suppliers (H3.c) to perform innovation, however, significantly reduces the probability that a company implements both internal and external

Table 4.2: Marginal Effects on the use of company standards

MNP†	CAT=0 No CS dy/dx	CAT=1 ICS only dy/dx	CAT=2 ECS only dy/dx	CAT=3 ICS and ECS dy/dx
Size	-0.019***	-0.001	-0.007*	0.027**
	(0.008)	(0.010)	(0.004)	(0.012)
ProcInno	-0.104***	-0.047	-0.010	0.161***
	(0.037)	(0.048)	(0.017)	(0.057)
ProdInno	0.029	0.066	-0.008	-0.087
	(0.023)	(0.048)	(0.019)	(0.056)
CoCu	-0.074*	-0.095	0.009	0.159**
	(0.040)	(0.058)	(0.012)	(0.066)
CoCo	-0.066***	-0.091**	0.032	0.126**
	(0.021)	(0.042)	(0.028)	(0.053)
CoSu	0.024	0.075	-0.007	-0.092*
	(0.026)	(0.046)	(0.016)	(0.053)
Supplier	-0.089***	-0.107**	0.038	0.158**
	(0.030)	(0.050)	(0.040)	(0.065)
Contractor	-0.009	-0.043	0.067	-0.013
	(0.038)	(0.071)	(0.080)	(0.100)
Researcher	-0.024	-0.085	0.043	0.066
	(0.030)	(0.053)	(0.070)	(0.085)
Manufacturer	-0.037	-0.049	0.070	0.016
	(0.023)	(0.056)	(0.089)	(0.129)
Retailer	-0.055***	-0.048	0.066	0.039
	(0.016)	(0.087)	(0.108)	(0.129)
Industry Sector Dummies		Included		
Observations		334		
Wald χ^2 (45)		72.08		
Prob > χ^2		0.001		

† The table presents the marginal effects of the multinomial probit regression at means of the independent variables. Asterisk ***,**,* denote statistically significant coefficients at the 1%, 5% and 10% level of significance.

company standards. This positive link to suppliers supports our concept that the codification and sharing of company knowledge enhances partner embeddedness.

Our results confirm our considerations that passing on company standards to suppliers as external partners relates to the embeddeness of firms (Dacin et al., 1999; Johannisson et al., 2002). Our findings support that the provision of the "company codebook" is positively linked with the inter-firm relationship as evidenced by increased cooperative activities with the buyer. We also find support for the claim that the implementation of internal and external company

standards relates to the modularity aspects as proposed by the literature on platforms (see e.g. Gawer, 2014), especially when we consider the aspects of supply-chain platforms. The results of this paper therefore call on the research on platforms to consider the findings from the standardisation literature. The regression reveals that the implementation not only of internal but also of external company standards is positively associated with process innovation, providing an opportunity for the diffusion of improved processes with supply-chain partners. This is also evident in the positive connection between suppliers and their implementation of internal and external company standards, however a negative link exists in the sole implementation of internal company standards. Finally, the implementation of company standards is associated with increased customer cooperation activities for innovation. This proves a good example for how shared standards can enhance inter-firm relationships.

4.6 Conclusion and Limitations

In this paper, we developed a better understanding of company standards as providing a codebook that enables the codification and transfer of a company's state of the art for both internal aspects and external organisations alike. We identify the need for a differentiated analysis of internal and external company standards, which is relative to the focal company implementing these standards. The aim of this paper was to investigate how a company's size and its innovation and cooperation activities affect its implementation of internal and external company standards. For this we analysed data from the German standardisation panel on firms active in German formal standardisation institutes (DIN and DKE).

Our study highlights two important insights - the favourable relationship between process innovations and the use of company standards, and the significant relationship between a company's cooperation behaviour for innovation and the use of company standards. The latter insight depends on the position of the partner in the supply chain. This supports the theoretical consideration that company standards are positively linked to the relational embeddedness of the companies (Ebers and Oerlemans, 2013). Our results provide further indication that company standards relate to supply-chain platforms, as Gawer (2014) classified them. We therefore highlight the future prospective for joint efforts in the research on standards and platforms.

Our analysis is limited insofar as it considered only companies that are already active in formal standardisation institutions. We provided a first indication of firm-level characteristics that seem to drive the use of internal and external company standards but future research opportunity has to extend the analysis to companies without engagement in formal standardisation. Finally, research on the connections between firms along the supply chain via company standards

is needed to provide a qualitative counterpart to this first qualitative analysis.

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4.8 Appendix

Table 4.3: Descriptive Statistics of the Sample

Variable		Mean	Std. Dev.	Min	Max	Obs
Dependent Variable						
CAT	Categorical Variable	2.38	1.05	0	3	334
Explanatory Variables						
Size	Log No of Employees	5.72	2.25	0	13.22	334
ProdInno	Dummy	0.81	0.39	0	1	334
ProcInno	Dummy	0.66	0.47	0	1	334
CoSu	Dummy	0.55	0.50	0	1	334
CoCu	Dummy	0.73	0.44	0	1	334
CoCo	Dummy	0.24	0.43	0	1	334
Supply Chain (SC) Position						
Supplier	Dummy	0.38	0.49	0	1	334
Contractor	Dummy	0.13	0.34	0	1	334
Researcher	Dummy	0.10	0.30	0	1	334
Endproductmanufacturer	Dummy	0.16	0.37	0	1	334
Retailer	Dummy	0.04	0.20	0	1	334
Other(*Base*)	Dummy	0.18	0.38	0	1	334
Sector						
Manufacturing Sector Dummy	0.68	0.47	0	1	334	
Service Sector Dummy	0.24	0.43	0	1	334	
Water, *Energy*, *Building* & *Mining* (*Base*)	Dummy	0.08	0.27	0	1	334

Table 4.4: Company standard uptake across supply chain positions (in %)

	No CS	ICS only	ECS only	ICS & ECS	Total
Supplier	4.69	11.72	2.34	81.25	100
Contractor	20.93	9.30	13.95	55.81	100
Researcher	11.76	8.82	5.88	73.53	100
Manufacturer	10.91	20.00	3.64	65.45	100
Retailer	7.14	14.29	7.14	71.43	100
Other	11.67	18.33	1.67	68.33	100

Table 4.5: Company standard uptake across industries (in %)

	No CS	ICS only	ECS only	ICS & ECS	Total
Manufacturing	7.08	15.49	1.33	76.11	100
Service	18.52	11.11	12.35	58.02	100
Water, Energy, Building & Mining	7.41	7.41	7.41	77.78	100

		Availability & Implementation of the standard	
		Internal	External
Development of the standard	Internal	*The focal company sets internal company standards for internal use* Strategic considerations for the focal firm: • Codification & internal diffusion of knowledge • Signalling effect: 'this is our standard" to strengthen corporate identity • Preserves unique selling proposition • Learning opportunities for internal processes • Economies of scale *Platform analogue:* internal (Gawer, 2014) *Example:* Setting internal process requirements and manufacturing specifications as the internal standard	*The focal company provides its internal company standards to an organization* Strategic considerations for the focal firm: • Outflow of knowledge • Transfers internal best practises to suppliers and cooperation partners • Transfers the focal firm's "codebook" (Cowan et al, 2000), enabling learning and understanding by external firms without closer involvement • Increase relational embeddedness with a cooperation partner or supplier *Platform analogue:* supply-chain (Gawer, 2014) *Example:* Providing testing instructions to a supplier; requiring a certain quality from suppliers
	external	*The focal company receives external company standards from an organization* Strategic considerations for the focal firm: • Inflow of knowledge • Necessary requirement for entering a trade relationship • Transfers know-how/"codebook" into the company • May lead to lock-ins with a certain buyer, if processes etc. need to be altered • Increasing relational embeddedness with a cooperation partner or buyer *Platform analogue:* supply-chain (Gawer, 2014) *Example:* Having to fulfil quality requirements of a buyer	*Codifies an external organizations' specific information to the general market* Strategic considerations for the focal firm: • Is this standard generally available? If yes: • Adoption decision by the focal company • Consider relevance for their own technology, processes and production • Potential to become industry standard - Strengthens external technology in the market *Platform analogue: (if established)* industry (Gawer, 2014) *Example:* Würth offering screws according to Daimler's CS in their web-shop to all market participants (see http://eshop.wuerth.de/Gesamtkatalog/MBN-10105-Stahl-10.9-Zink-Lamelle-Regel-u.-Fein-/140135111110501.cyid/1401.ceid/de/DE/EUR)

Figure 4.1: A Classification of Company Standards

PAPER 5

Company Standards in Supply Chains: Inter-Firm Relationships and Strategic Positioning

A company's idiosyncratic standards cover aspects such as quality assurance, testing procedures and terms of delivery. They are not only used internally, but also imposed on suppliers. In this function, company standards can facilitate knowledge diffusion along the supply chain and ensure a supplier's quality and thereby relate to the bargaining power equilibrium between the buyer and its supplier. This article qualitatively explores the employment of company standards along the supply chain with a special focus on a company's position within this supply chain. An extensive qualitative analysis of 21 companies active in the global automotive industry reveals how company standards play a role in the supply chain. We highlight the various ways of knowledge diffusion and supply chain partner management by examining the network of company standards spans between manufacturers, suppliers and raw material producers. Our analysis reveals that large and powerful buyers are able to impose their company standards on their suppliers, which is either due to their position or their product portfolio. The firms which fulfil these company standards (e.g. Supplier) use different tactics to deal with the heterogeneous external requirements. From the results we derive implications for supply chain management. Company standards can be a tool to manage suppliers, but the differing company standards of multiple buyers can lead to increased efforts on part of the suppliers. Also, the direction of enforcement of company standards is not exclusively from the buyer to the supplier but can also be enforced in the opposite direction.

Keywords: Company Standardisation; Inter-Firm Relationships; Supply-Chain Management; Supply Chain Networks

5.1 Introduction

The rising importance of idiosyncratic standards set by buyers, especially in a global context, has become evident in the supply chain literature (Gereffi et al., 2005; Gereffi and Lee, 2012; Henson and Humphrey, 2010). The main focus has been on retailers in the context of the agro-food industry, primarily the relations between buyers and their suppliers. The standardisation literature, on the other hand, indentifies the mutual influence of standard setting and inter-organisational networks. Inter-organisational networks are simultaneously important for both joint standards setting (Axelrod et al., 1995) and the potential influence of common standard setting on the inter-organisational network (van den Ende et al., 2012). We therefore identify a need to investigate company-specific standards in the context of the buyer-supplier relationship and their repercussions for the supplier network in other industries than the agro-food industry.

As they are developed to fulfil the needs of one specific company, this paper refers to idiosyncratic standards (set, for example, by buyers) as *company standards* rather than private standards (as in Gereffi and Lee, 2012) in order to delineate them from standards set in private consortia and to emphasise their company-specific nature. We also differentiate between *internal company standards*, which are developed and applied within a single company, and *external company standards*, which are developed by another company, e.g. a buyer, but implemented within the focal firm to fulfil their specific requirements. This distinction permits us to evaluate the use of company standards within a focal company, depending on their internal or external origin. We thereby emphasise the effects that one company's standards have on their supply chain partners.

We first consider how the provision of a company's standards affects the dyadic relationship between a buyer and its supplier. Certification of the International Organisation of Standardisation (ISO) has become the "price of admission for many supply chains" (Mann, 2012) by being the pre-condition to participate in international trade. Similarly, adherence to company standards seems to have become such a "price of admission" into a buyer-supplier relation by facilitating business between them (see e.g. Gereffi and Lee, 2012). The aspect of power in these relationships is also of importance, as relationships between the dyad of buyer and supplier typically involve power asymmetries (Nyaga et al., 2013).

The management of supply chain relationships is of increasing importance as firms are required to change business processes and systems to fulfil the needs of their relationship partners (Nyaga et al., 2013). We consider the effects of company standards on the buyer-supplier relationship and how the relationship governance is affected by the imposition of external company standards on the supplier. We assume the provision of company standards to enhance modular governance (Gereffi and Lee, 2012; Sturgeon, 2007), which means that products are made by

suppliers specifically to a buyers specifications. This is implemented by the provision of codified, standardised information to supply-chain partners via company standards. “True” value chain modularity, however, is prevented over the whole supply chain network due to the idiosyncratic nature of company standards. We therefore consider the power relations between the standard-setter and the standard-receiver as an important aspect for the governance of external company standards. This occurs not only in the dyadic relation, but also has repercussions within the whole supply chain network. Particular attention is paid to the position of the company within this network.

We empirically investigate the handling of internal and external company standards at various levels of the supply chain in an exemplary, globally active industry. We conducted an in-depth qualitative analysis of 21 deliberately chosen players within the automotive industry - 4 Original Equipment Manufacturers (OEMs), 13 suppliers and 4 raw material producers (RMPs). The automotive industry was chosen because its value chain has a considerable complexity with various intermediaries adding value. Our study follows the established procedures for developing a methodologically sound qualitative analysis (Maxwell, 2005; Yin, 2014) by conducting semi-structured interviews with experts on the topic. Our analysis extends the scant available literature on the topic of company standards by an empirical analysis of company standards in the manufacturing sector.

We find that especially large and powerful buyers are able to enforce their company standards on their suppliers. This relates to the firm’s position in the network, their research activities and their product portfolio. However, upstream producers are also able to impose their standards on their customers. Suppliers thereby use different tactics to deal with the heterogeneous external company standards they receive from their buyers, and to consider the provisioning of these external standards to their sub-suppliers. We find that the network position is a further decisive element; this was not only because strong actors are located at either end of the supply chain we investigated, but also becausse the position within the supplier network seems to influence the ability to set and renegotiate standards. From the results we derive implications for supply chain management, as company standards can be a tool to manage suppliers or even customers. This is important as the differing company standards of multiple buyers can increase the efforts on part of suppliers.

In the following section we conceptualise company standards as a way of governing the buyer-supplier relationship and consider the resulting effect on this relationship. In the third section we introduce the case study methodology that we apply in our analysis. The fourth section provides a detailed case analysis. In the fifth section we discuss our findings and their implications for supply chain management. In a final section, we conclude and highlight the limitations of our

study as well as avenues for further research.

5.2 Conceptual Background

An Introduction to Company Standards

A standard is the consensus of various agents to do certain activities to agreed-upon rules (Narayanan and Chen, 2012). A *company standard* is the outcome of the idiosyncratic standard-setting carried out by an organisation with regard to its own requirements (Düsterbeck et al., 1995). However, confining this definition to internal aspects is not sufficient, as company standards can also be shared with direct supply chain partners to exchange basic information (De Vries, 1999). Company standards are provided to other companies, e.g. suppliers, to ensure the fulfilment of their requirements. For the purpose of this analysis, it is therefore useful to distinguish between *internal* and *external* company standards. Internal company standards are defined[1] as "documented specifications developed within a company that are either used within the company or within cooperating companies, such as suppliers". External company standards are "documented specifications developed by other companies (e.g. customers/buyers), excluding standards produced by formal standardisation bodies or consortia, that are used within the own firm".

Company standards can cover a variety of topics by codifying firm-specific knowledge, that differ from the market standard, but also internal processes (Henson and Humphrey, 2010). They carry know-how on idiosyncratic aspects of the standard-issuing company and codify not only the end-product, but also how they are to be achieved within the focal company (Henson and Humphrey, 2010). In this paper we do not focus on one particular type of standard (e.g. interface or process standard), but rather on the collective portfolio of external company standards as provided to business partners. As company standards are specific to the developing firm, they can counteract the commoditisation of goods, similar to proprietary platforms (see e.g. West, 2003). Also, company-specific product standards allow firms to obtain dominant leadership positions (Gruber, 2000).

A study of Blind et al. (2014) is the first broad-scale empirical study on the matter of company standardisation across multiple sectors. The study analyses the use and importance of the varying degrees of standardisation in 1,300 German companies across all sectors and firm sizes, including formal standardisation in standard development organisations (SDOs), consortia, specification, de facto[2], and company standards. The authors find that company standards are more important

[1] This definition stems from Paper 4 of this dissertation.

[2] De facto standards are established in the market but not formalised or documented.

for the surveyed companies than consortia or de facto standards. Internal company standards are therefore more heavily developed and used by large companies and are especially important for improvements in quality and productivity, more so than any other type of standard. In the sample, a high correlation exists between the innovativeness of companies and the setting of internal company standards. External company standards have an important impact on the bargaining position of such industries as vehicle engineering, metal production, chemistry, and pharmaceuticals; they also provide companies with legal securities. These results encouraged our deeper investigation into company standards with regards to inter-firm relationships.

The topic of idiosyncratic standards to date is covered in the value chain literature predominantly in the retail and global agro-food industry (Fulponi, 2006; Gereffi and Lee, 2012; Henson and Humphrey, 2010; Schuster and Maertens, 2013). In these industries, increased market concentration and buying power pushed the development of such standards (Fulponi, 2006). Although a variety of private standards have recently caught the attention of researchers, company standards are resembling "voluntary private standards" (Henson and Humphrey, 2010) set, for example, by a commercial body or private organisation where the adoption and implementation is by private firms. But for these standards, a conformity assessment by a private auditor is required for certification (Henson and Humphrey, 2010). The literature on private voluntary standards shows how relevant these can be for the dyadic relationship between buyers and suppliers (Latouche and Chevassus-Lozza, 2014; Vandemoortele and Deconinck, 2014).

It is important to note that we do not endorse the term "private standards" for this analysis. Private standards, as they are established[3], include consortia standards and we aim to delineate company standards from those standards set in collaboration with potential competitors. Although *company standards* as we investigate them do not require third-party certification[4], we nevertheless find some of the literature on the topic appropriate to understand the conceptual background for the use of company standards in supply chains. We hence look at this literature to understand how company standards are linked to inter-firm relationships.

[3]See e.g. the Definition of the United Nations Industrial Development Organisations (UNIDO): "Industry/private/buyer standards can be broken down into three categories: 1. Consortia standards - which are often developed by a sector-specific consortium (ie. GlobalGAP); 2. Civil society standards - established as an initiative by an non-profit organisation usually as a response to concerns over social and environmental conditions (e.g. Forest Stewardship Council); 3. Company-specific standards - which are developed internally and apply to the whole supply chain of a company (i.e. codes of conduct)." (http://www.unido.org/en/what-we-do/trade/quality-and-compliance-infrastructure/standards-and-conformity/private-standards.html, last accessed on 01.12.2014). What becomes apparent in this analysis, however, is that the latter mentioned company-specific standards are not just codes of conduct but also contain technical, potentially secret information.

[4] Approval of the first inspection for the products with company standards is needed even without third party certification.

Company Standards and Inter-Firm Relationships

As company standards transfer knowledge and technical requirements from one company to its supply-chain partners, we consider insights from the literature on knowledge transfer and supply chain management to understand the potential effects on inter-firm relationships. We additionally refer to the emerging importance of inter-network competition that requires successful integration and management of key business processes across members of the supply chain (Lambert and Cooper, 2000).

We first focus on the effects of the *knowledge flows* supported by providing company standards to a supply chain partner. Fawcett et al. (2008) show how misalignments in technology, information and measurement systems can be major barriers to successful supply chain collaboration. Company standards can provide the appropriate interfaces, terminology and information from one company to its business partners, thereby reducing such barriers. The agro-food industry demonstrates how buyer-specific standards are generally much higher than public or market standards (Latouche and Chevassus-Lozza, 2014; Vandemoortele and Deconinck, 2014). Company standards provide additional information to supply chain partners that is potentially unavailable in the general market. Adherence to such company-specific standards thereby enhances vertical integration (Schuster and Maertens, 2013) and provides incentives for suppliers to raise technical competencies to fulfil these standards (Fulponi, 2006).

Organisations aim to create efficient and competitive supply networks. Therefore they increase supplier performance and capabilities by diffusing their codified manufacturing and production expertise into their supply bases (Modi and Mabert, 2007), for example in the form of company standards. The acquisition of knowledge from the buyer has a positive impact on the performance of supply chain firms, as the supply chain partner benefits from inter-firm knowledge transfer activities (He et al., 2013). A transfer of knowledge and technology through the provision of company standards seems to tighten the links between supply chain partners, extending through the whole supply chain network. The aspect of the wider influence on the supply chain network will be discussed later on.

The requirement to fulfil buyer-specific standards can be a barrier to entering into trade relations for some suppliers (Von Schlippenbach and Teichmann, 2012). These barriers can arise for example due to investments in technology, change in production layout or testing, and documentation specifications. Similar to the concept of market entry barriers, Mann (2012) describes that ISO certification is the “price of admission for many supply chains” to participate in international trade. The adherence to company standards seems to have become such a “price of admission” into a particular buyer-supplier relation to enable the business between them (see e.g. Gereffi and Lee, 2012). Thus, if buyers require higher idiosyncratic standards than the

general market standard from their suppliers, this can promote lock-in effects and dependence due to increased switching costs (Baake and Schlippenbach, 2011) and investments in assets specific to these transactions (Banterle and Stranieri, 2013).

Generally, once a standard is established and, for example, a commitment to a particular interface is made, switching costs arise (Farrell and Saloner, 1985). Therefore, if a supplier has chosen to fulfil the company standards of their buyer, they might be locked-in this trade relationship. This raises the costs of serving a different buyer and thereby switching to an alternative standard (Farrell and Saloner, 1986). But this dependence is not necessarily one-directional. A buyer may have less outside options if only a small number of suppliers can fulfil its company standards. If there is a high mutual dependence of the buyer and supplier, company-specific quality standards are shown to lead to more efficient contracts and qualities (Baake and Schlippenbach, 2011).

Increasing the lock-in effect and integration into a specific dyadic relationship can have additional favourable impacts on the relationship. He et al. (2013) show that the availability of alternatives, e.g. alternative suppliers or customers, hampers cooperative relationships between supply chain partners. This is associated with a lower level of knowledge exchange. If the buyer and supplier depend more on each other, they are more embedded in their relationship and therefore more willing to exchange further information. A firm's strategic decision of how to govern its supply-chain structure can determine their embeddedness within its network (Gulati, 1998). We therefore take a closer look at the relation between company standards and supply chain governance.

Company Standards and Supply Chain Governance

With the rising complexity and global expansion of supply chains, their governance becomes increasingly important. Firms often need to change their business processes and systems in order to accommodate the needs of their relationship partners (Nyaga et al., 2013). Idiosyncratic quality standards have been identified as one of the key mechanisms by which buyers can govern their supply chains (Gereffi et al., 2005; Gereffi and Lee, 2012). We therefore look at the relation between company standards and governance as well as power relations in supply-chains.

Providing company standards to supply chain partners can be seen as a type of modular governance (Sturgeon, 2007), which requires more hierarchical relationships than governance via "arms-length" agreements (Gereffi et al., 2005). Such modular governance arises when "suppliers make products to a customer's specifications that are complex but relatively easy to codify. By exchanging information in the form of standards, buyers and suppliers reduce coordination costs" (Gereffi and Lee, 2012). By codifying firm-specific aspects of products and processes, greater

flexibility can be achieved by outsourcing these to supply chain partners (Sturgeon, 2007). Such governance is enhanced if the standards are more widely accepted. As company standards are idiosyncratic in contrast to the standard-issuing firm, the rise of "true value chain modularity" is limited (Sturgeon et al., 2008). Due to codification, complex information can be exchanged with little explicit coordination and, as a simple market exchange, the cost of switching partners remains relatively low (Gereffi et al., 2005). However, this provides a greater problem the more complex and particular company standards are to a certain buyer: as we elaborated earlier, we assume these to have considerable effects on switching costs. Cheng et al. (2014) indicate a positive link between contract manufacturing and the extension of the supply chain network, such as the heterogeneity of supply sources, and scale economies. Such greater degree of organisational flexibility can arise on the part of the stronger partner in the transaction, but we do not assume this to be the case for weaker partners.

When considering governance of supply chain relationships we need to consider power imbalances between the dyadic relations. Hatanaka et al. (2005) argue that retailers in the agro-food industry can impose their idiosyncratic standards as "de facto condition of market access" on their respective suppliers by exerting the power inherent to their size and position at the top of the supply chain. Power imbalances, for example, can prevent collaboration as the actor in a powerful position may not be willing to form collaborative relationships with other actors (Kähkönen, 2014). We assume a higher power to increase the likelihood of enforcement of buyer-specific standards. However, sharing information encoded in such standards may also increase the embeddedness of this relationship (Gulati, 1998). As innovation means a break from established routines or standards, a problem associated with too-strong ties could be the weakening of innovation potential created by an overly high level of consensus (Granovetter, 2005).

We need to consider that not only buyers occupy a powerful position in a supply chain. Powerful suppliers, for example, can try to renegotiate the standards set by the buyer in their favour and become even more valuable as suppliers. The position in the supply chain network, on the other hand, can also have a decisive effect on the power relation, as we will consider next.

Company Standards and Supply Chain Network Position

Although we carved out the (more obvious) direct effects of company standards on the dyadic relationship between a buyer and a supplier, we further aim to relate these to the network and network position of the focal firm. The *supply network* is an extension of the direct business relations of the supply chain. The supply network is a multi-faceted entity including active and inactive members across a firm's supply chain (Braziotis et al., 2013). In this manner, the dyadic relationships are embedded in a broader system of stronger and weaker relations (Burt, 2005;

Granovetter, 1985). We thereby focus on two aspects with regards to company standards: the effect of the position within the network; and the penetration and diffusion of the company standards through the network enabled by the focal firm's position. The position of an organisation within its supply chain network can have a considerable effect on its power relations (Braziotis et al., 2013) where the notion of power is embedded in the relationship between two organisations.

A case study of Kähkönen (2014) shows how the powerful position of buyers decrease their willingness to collaborate, affecting information sharing and trust between parties. If the necessary information for the production of a product can be provided in the form of an external company standard, this has a potential to limit the level of information sharing to a minimum and thereby reinforces a powerful position. An additional aspect of power relates to the distance to the end customer: it seems that power increases as the distance from the end market decreases (Kähkönen, 2014). An exception is the providers of raw materials; because they substantially affect input prices, raw material providers generally have considerable power (Agrawal et al., 2014). Raw material producers accumulate vital knowledge on the raw material as the basis of the products. If we therefore assume strong players at either end of the supply network, i.e. the buyers and the providers of raw materials, then the "suppliers in between" could be seen as structural holes (Burt, 2005). An organisation with the power of these structural holes is well placed to innovate (Granovetter, 2005), placing the standard-setter in a very valuable position.

External company standards are also prone to "knock-on" effects extending the dyadic relationship. For example, if a supplier needs to fulfil the company standards of a buyer, these must also be fulfilled by the suppliers and sub-suppliers to this supplier. Hence the standards diffuse deeper into the supply chain and potentially even to satellite organisations without any direct relevance for the focal firm. Depending on the position in the network of the standard-issuing company, its provision of the company standards can have far-reaching effects. These effects can go beyond the mere diffusion of information in the supply bases (Modi and Mabert, 2007) by enforcing their power on the whole supply chain network. As the supply network structure has an important effect on how this can be dealt with (Kim et al., 2015), the relations along the supply chain network can also be important when disruptions occur.

As the theoretical development of the relation between company standards, supply chains and supply network has raised many ambiguities, we now introduce the methods to our empirical analysis aimed at illuminating these issues.

5.3 Methods

The shortage of studies concerning the role of company standards outside of agro-food supply chains warrants a careful and in-depth analysis to facilitate a thorough understanding of the topic (Yin, 2014). In our study, we consider companies active in the automotive industry in Germany. This industry consists of larger and smaller globally active players with varying levels of power along the supply chain. The automotive industry therefore provides an interesting case study environment from the manufacturing sector. A rise in product complexity and a paucity of sufficient industry standards in the automotive industry has tightened the relationship between buyers and suppliers over the last decade (Sturgeon et al., 2008). On a global level, the supply base has consolidated and outsourcing by OEMs has grown, which led to an increase in value added by suppliers compared to the OEM (Sturgeon et al., 2008). Sturgeon et al. (2008) further stated that "the industry has historically relied on inter-personal interaction and proprietary standards [...] to manage the flow of tacit information" (Sturgeon et al., 2008). The specific role of company standards (i.e. proprietary standards) in this industry is therefore recognised. At the same time, a step towards the automotive industry's goal to achieve worldwide quality standards (Sturgeon and van Biesebroeck, 2011) can be reached by understanding the status quo.

At the downstream end of the automotive supply chain, the original equipment manufacturers (OEMs) produce final parts and assemble the end product. The fierce competition in the industry led to only a small number of remaining OEMs (Sturgeon et al., 2008). Although these OEMs have a large number of direct suppliers, only a small number of raw material producers (RMPs) exist upstream in the supply chain (Agrawal et al., 2014). Due to the low number of OEMs and RMPs, we assume oligopolistic structures on both ends. Due to the resulting increase in purchasing power on the side of the OEM, Sturgeon et al. (2008) found that OEMs can force their suppliers to accommodate their idiosyncratic standards. Unfortunately, they did not consider the particularities related to company standards within the supply chain in depth. We aim to enhance this current understanding by introducing the important dynamics of the upstream handling of company standards provided primarily by downstream companies.

The first criterion to be included in the sample of our analysis is membership to the German association of the automotive industry (VDA). We identified 606 companies that we classified either as OEMs, Suppliers or RMPs in this industry. Throughout our analysis, we paid close attention to the measures of internal validity, construct validity, external validity and reliability (Gibbert et al., 2008). We choose an inductive approach whereby we utilised "detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data" (Thomas, 2006). We chose this qualitative approach to avoid the constraints imposed by structured methodologies that could hinder uncovering of important particularities arising in this topic of yet limited attention.

The companies were chosen to mirror the spread of companies in the automotive industry and we deliberately balanced the sample with regards to membership in formal standardisation organisations[5], size and product portfolio. We interviewed representatives of 4 OEMs, 13 suppliers and 4 RMPs, and hence conducted 21 interviews in total. For construct validity, we interviewed in each of the companies either a member of the standardisation department or, if the company had no such department, an employee responsible for standardisation, procurement or quality management. An overview of the companies and interview partners can be seen in table A.1 of the appendix. In addition to qualitative data, we consulted the business reports and web-sites of the companies we studied to enhance our understanding of their network, power position, and innovative capabilities. The telephone interviews with company experts were conducted within a three week time frame. The interview guidelines were modelled after our review and in-depth analysis of the study by Blind et al. (2014) (see section 5.2) in order to ensure consistency and reliability of our analysis.

Table 5.1 in the appendix lays out the instrument for these interviews. All interviews were recorded, transcribed, repeatedly coded and translated into English by a team of two researchers. We used rigorous and systematic attribute coding for the information about the participants as well as structural coding for the content related to each question (Saldana, 2009). The usability of the data required us to make decisions on the aspects of the data we found more important than others (Thomas, 2006) and we therefore went through the raw data multiple times to ensure that fundamental findings were carved out appropriately. Also, we allowed for stakeholder checks (Thomas, 2006) by providing the results of our analysis to the interviewed experts as well as presenting them in an industry expert group. For our findings we considered similarities and differences in a within-case (i.e. within the groups RMPs, Suppliers, and OEMs) and between-case analyses (this is a comparison of the three groups, as described in Yin, 2014) to reveal the grounded relationships between the companies in the supply chain via company standards, which we present in the following section.

5.4 Findings

As outlined in table 5.1, the position of our interview partners qualifies them to appropriately assess the handling of company standards within their company and their company's supply chain. All interview partners are responsible for standardisation, procurement or quality management. The table also reports the size (number of employees), business description and their

[5]As we believe that membership in formal standardisation organisations has an effect on the likelihood to develop own company standards.

supply chain position.

We differentiate between three main supply chain levels. For every stage, an adequate number of participants were chosen, corresponding to the overall membership within the German automotive association, the VDA. As a smaller number of OEMs and RMPs stand against a very large number of suppliers in the automotive industry, the sample consists of 4 OEMs and 4 RMPs as well as 13 Suppliers. All but one of the 21 interviewees said that they are developing company standards within their company. This supplier (SUP11), however, stated that it is issuing testing instructions and other general internal documents for repeating application which fall within our definition of company standards.

Overall, we find that participants develop internal company standards to document and manage their accumulated knowledge on their products and processes. These standards relate to, for example, testing and quality requirements, connecting elements and technical requirements (e.g. material requirements). But these company standards are not exclusively used to exchange and diffuse information within the boundaries of the focal company, but are also provided externally to suppliers or cooperating partners. The analysed companies report that if they provide only part of their company standards portfolio to external companies, they usually keep confidential those that codify know-how on internal process requirements and product development.

Within-Case Analysis: Companies on the Same Supply Chain Level

In the following, we separately review the observations within the three groups of interest (OEMs, Suppliers and RMP) before comparing these three supply chain levels with each other in order to highlight their similarities and differences.

OEMs

Reflecting the structure of the automotive industry, the analysed OEMs are larger than most of the suppliers in our sample (only SUP7, SUP10 and SUP14 are larger than OEM2). These OEMs develop company standards and provide parts of their internal company standards to their suppliers. Three of the four OEMs in our sample provide their suppliers with access to more than 90% of their internal company standards through a document provision system. OEM3 even permits its suppliers to access all company standards. Only OEM4 provides just 50% of their standards to suppliers, as the other half are product development standards for internal use only. The OEMs have to fulfil external company standards only in exceptions, for example if they act in turn as suppliers to other OEMs (OEM3 and OEM2) or if they cooperate in specific projects with each other. The standardisation manager at OEM2 acknowledges that his company

usually develops its own company standards in areas where no formal standards exist. Other instances are where requirement levels set in formal standards are not sufficient for the required application; the company standards of OEM2, for example, often demand higher quality levels for material requirements. On this matter the manager of the standardisation department of OEM1 stated, “with topics concerning quality, we develop internal company standards. This cannot be done externally [e.g. in formal or consortia standardisation], because then everybody would be required to fulfil our standard and this might be too expensive for some”. Further, this manager notes that they aim to develop company standards for coherence and simplification reasons, saying, “we are a big company and therefore things need to be standardised so that our internal operations work well”.

The specific downstream position of the OEMs in the supply chain towards the end-customer enables them to enforce their own standards on others. All of the interview partners at the OEMs claim that company standards highly influence their supplier relationship management. For the OEMs, internal company standards provide transparency on technical requirements, where potential benefits derive from reduced non-conformance costs. Company standards further provide a contractual basis for their orders, as these are legally binding. By imposing their company standards on their suppliers, the OEMs particularly aim to ensure their suppliers’ fulfilment of specific quality requirements. The standardisation manager of OEM2 states that they do not pass on process standards that contain company-specific know-how because these have no relevance for the supplier. For OEM1, the revelation of internal knowledge generally seems to play a minor role in the external provision of their company standards, as its standardisation manager states, “if something is standardised in our company [in product-specific standards] this is usually already known by industry insiders. [[6]...] A lot of [these] issues are also discussed in committees and at trade fairs”. Further, the expert assumes that even if competitors (e.g. other OEMs) would get their information and codified know-how through a shared supplier, in the end competition comes down to the ability of most efficient production and lower costs. At the same time, however, the manager at OEM1 states that it is common to have nondisclosure contracts applicable to the information and knowledge of an internal company standard.

The standardisation manager of OEM4 highlights an exception in the provision of internal company standards: in the case where a whole product segment is outsourced to a supplier, who is then considered a “development partner”, this supplier is then also provided with confidential company standards (such as development testing procedures, etc.). To protect this knowledge, however, it is not provided via their document provision system, but is instead passed on manually when required.

[6] Industry insiders refers to the technical experts in the industry, especially in other OEMs.

The manager of the standardisation department at OEM1 states that, they do not fear to lose their technological competitive advantage due to too much information and know-how spillovers into the market. Rather, a faster diffusion of their required standard levels throughout the market and adaptation by competitors can lead to decreasing purchasing prices of products. Furthermore, it can foster the development of future market standards (e.g. ISO standard) in that area, with favourable effects such as the enlargement of the product market or even lower purchasing prices and a greater supplier base.

Suppliers

As reported in table 5.1, the surveyed suppliers are generally of smaller size and have narrower product portfolios compared to the OEMs. This is actually representative of the German automotive industry. All the suppliers have OEMs as their direct customers and some also indirectly sub-supply to OEMs.

The surveyed suppliers report to develop company standards for internal quality control. Eight of the 14 total suppliers also control quality externally by providing their company standards to their suppliers. The majority of suppliers define product and process specifications in their company standards, such as construction measures, product characteristics or testing procedures. Furthermore, seven out of the 14 suppliers state that they codify specific internal know-how in the form of company standards as well as the technical state of the art within the company. Suppliers also use internal company standards to narrow down external requirements: for example, a member of the standardisation department of SUP8 states that "company standards are generally more detailed than external standards". Similarly, the responsible party for standardisation at SUP9 stresses that company standards reduce complexity because "once an issue is defined in a company standard, it can be referenced for all forthcoming projects, which makes it easier for everybody". This expert also acknowledges the simplification effects of company standards; tender documents and product specifications for their supplier can reference company standards, making these documents shorter and easier to handle.

Nine out of 14 suppliers state that they pass on company standards to their sub-supplier. These suppliers report to pass on more than 50% of their internal company standards to external companies. External companies are mostly sub-suppliers located upstream in the supply chain, cooperation partners or RMPs. Only SUP11, a manufacturer of chemicals, provides only a minor share (0.1%) to their customers. Generally, when suppliers provide their own company standards to the sub-suppliers, they aim to manage these sub-suppliers regarding delivery specifications, quality assurance and to lower transaction costs, which is similar to the OEMs.

All suppliers confirm that they have to fulfil the external company standards provided by their customers to some extent. These customers are either OEMs or direct suppliers to the OEMs. The companies' capability to fulfil external company standards varies across suppliers and depends on the type of company standard in question. We encountered three ways the surveyed suppliers deal with the company standards: a) they already produce to the highest quality and hence easily fulfil the required quality level; b) they renegotiate the company standards with their buyers; and c) they are forced to implement the requirements of the company standards within their own company.

For the first example, four of the 14 suppliers (SUP5, SUP7, SUP8 and SUP9) state they already produce to the highest quality level and thus already cover the quality requirements laid out in the external company standards of their different customers. These four companies are system suppliers that provide the OEMs with integral solutions. Further, they are more strongly engaged in their own research and development (R&D) for the required products. Hence, they develop their products more independently using their own company standards.

The second example is reported by experts at SUP2, SUP10 and SUP14. The standardisation manager of SUP2 reports that they have an internal mechanism testing its ability to fulfil the external company standards. SUP2 and SUP10 fulfil only a minority of the external company standards they receive 1:1. Whenever possible or necessary, modifications are made in accordance with the customer. SUP14 tries to renegotiate the terms and requirements with the supplier when a similar product is already provided to another customer. Both SUP2 and SUP10 are also highly engaged in R&D: SUP2 invests about 8% of their annual turnover into R&D and SUP10 is a product development cooperation partner of the automotive industry. Furthermore, these suppliers resemble each other in their product types; all of them supply product system solutions as a direct supplier to the OEM. This specific position can indicate why they might be able to renegotiate the fulfilment of the external company standards.

In the third instance, suppliers (SUP1, SUP4, SUP6 and SUP13) know that they have to fulfil the external company standards of their customers to overcome the market entry barriers: "if we do not fulfil the quality requirements of our external company standards, we will lose our position as supplier" (*Standardisation employee at SUP6*). SUP6 fulfils the external company standards it receives from its customers 1:1. In the past this supplier tried to fulfil multiple external company standards of their respective buyers at once by merging them into their own company standard, but this led to a negative cost-benefit ratio. The negative effect resulted from high maintenance costs due to the frequently changing requirements of customers. The reports of those four suppliers imply a high dependence on the external company standards of their customers. Not only has the higher dependence distinguished this third group from suppliers the

first two, it has also distinguished their product types: SUP1, SUP4, SUP6 and SUP13 produce product components rather than complete systems (as a sub- supplier but also directly to the OEM).

The varying requirements laid out in external company standards prove high in documentation costs for the suppliers. As the standardisation manager of SUP5 points out, “our customers demand different sampling documentation. Despite the fact that this is the same procedure, we have to do the documentation differently according to each of the external company standards”. These higher costs of production for the supplier also lead to higher costs for the OEM, as a member of the standardisation department at SUP2 acknowledges.

A further expenditure for the suppliers is the non-disclosure to third parties that is often required in external company standards. The suppliers themselves, however, source semi-finished goods or raw materials from sub-suppliers or RMPs, who also need to fulfil their end-customers' company standards. To address this problem, suppliers can convert requirements in external company standards into their own internal company standards. This might mean that the content stays the same, but the formal appearance changes. The latter, however, could bring about legal issues.

We now consider the question of how suppliers incorporate external company standards into their internal company standards. Some suppliers bundle their external company standards and the requirements laid out therein of different customers into their own company standards. This is reported by the six of 14 suppliers (SUP5, SUP7, SUP8, SUP9 SUP12 and SUP14) that were also able to avoid the complete fulfilment of their external company standards. On this topic, a standardisation employee at SUP2 states that sometimes certain customer groups (e.g. OEMs) already agreed on a common standard for their modular production systems. The external company standards that SUP1 receives occasionally need to be split up into their own different company standards, which are then passed on separately to the respective supplier (more on that in 4.2). The issue of knowledge revelation is also apparent in the passing on of the suppliers' self-developed standards. The standardisation interviewee at SUP9 states, “internal company standards are an instrument to transfer know-how and this can be dangerous, as our suppliers could provide our company standards to our competitors”.

RMPs

The RMPs in our sample are smaller compared to the OEMs. Apart from commodities, they also offer components or materials that they can supply directly to the OEMs. Like the OEMs and the suppliers, these upstream RMPs develop internal company standards. Of these stan-

dards, some share is provided to their customers and cooperation partners or even developed in accordance with their customers (such as RMP2).

The RMPs state that they generally do not discriminate between company standards that are used internally and provided externally. However, if they are kept internally, topics include manufacturing specifications or process know-how. The RMPs in our sample also claim that they fulfil some external company standards from their customers (especially the automotive OEMs) without being able to influence them, as the compliance is mandatory for their business relationship. However, RMP4's head of technical product management tries to get their customers to waive their company standards and accept its own internal company standards. The RMPs prove a special case as they provide their internal company standards to their customers but also receive external company standards from their customers.

Another relevant aspect was raised by RMP1 and RMP4. Frequently, information asymmetries between the RMPs and their customers exist. An example of this is includes a customer's demand (i.e. the "suppliers") for testing procedures in their company standards which cannot be fulfilled by the RMP, are redundant or lead to an unnecessary increase in costs. This further raises the selling price. The technical product manager of RMP3 also states that they usually fulfil the highest quality that is required in the external company standards they receive.

In the development process of a company standard, different company departments are involved. The responsible product manager at RMP3 states that they formulate internal company standards to provide an internal agreement on what they are able to produce (for a reasonable price). In providing these internal standards to their customer, they want to ensure that their customers do not demand requirements they are unable to fulfil, or able to fulfil only at a very high price. The head of technical product management at RMP1 states that they pass on internal company standards only in very few cases. In such cases, company standards are only passed to deliberately selected customers, which can be described as partners with whom they want to develop "keiretsu"[7] type relationships.

Between-Case Analysis: The Relation and Ties Along the Supply Chain Network

We now continue with the comparison of the three supply chain positions of interest. We are particularly interested in the links along the supply chain that develop through the provision of company standards. As our analysis of the three different supply chain levels has shown, the position within the supply chain network seems to have a fundamental effect on the ability to

[7] Keiretsu is a set of companies with interlocking business relationships. The term originated in Japan.

handle external company standards. Whereas OEMs do not need to care about external company standards (as they are mainly concerned with setting their own company standards), some suppliers encounter difficulties in dealing with external company standards. These suppliers are not just provided with the requirements of their OEMs but also have to "stick" to the provisions of the raw material producers. With regards to the position within the supply network, it can be said that both the OEMs and RMPs come with a more relaxed attitude towards the fulfilment of company-specific standards as do the suppliers.

Figure 5.1 provides an overview of the three most intriguing examples of how company standards are imposed on and dealt with by supply chain partners, as we encountered and described in the previous sub-section. For analytical convenience we condensed these cases to emphasise how company standards are dealt with in different ways at the different supply chain positions.

Example 1 shows a possible way a supplier can deal with company standards that it receives from its OEM which in turn need to be passed on to its sub-supplier. The dashed line through "SUP A" highlights the instance where a supplier to an OEM has to provide these requirements to its sub-suppliers and whether or not these standards are provided with a non-disclosure agreement. In this example, the supplier is contractually bound not to provide the standards to their sub-suppliers. Although some suppliers conceal the origin of their external company standards when they pass them to their sub-suppliers, they still need to provide the requested standard from the OEM upstream as these sub-suppliers need to fulfil them as well; hence the information will necessarily flow to the sub-supplier. Other external company standards (required by the OEM) do not need to be passed on to sub-supplier ("SUP C") and remain with the "SUP A". "SUP A", however, might also have its own standards that will be passed on to "SUP C". Hence "SUP C" receives two different kinds of external company standards: one that originates from and contains information about the OEM; and one that originates from and contains information about "SUP A". We encountered this example in the cases where the "SUP A" was a system supplier and "SUP C" a component supplier. The link between the RMP and "SUP C" in case 1 shows the instance where the RMP passes its company standards to their customers. This can lead to a situation where a supplier in the "middle of the supply chain" has two external company standards coming from both upstream and downstream supply chain partners, as is exemplified in "SUP C".

Example 2 provides the instance where a supplier bundles the external company standards that it receives from different customers together and issues them as its own company standards to their sub-suppliers. As SUP9 states, "if we have similar standards that are requested by more than 70% of our clients, it makes sense to incorporate them in our own standard rather than making a special solution for each of them". This means that the requirements stated and

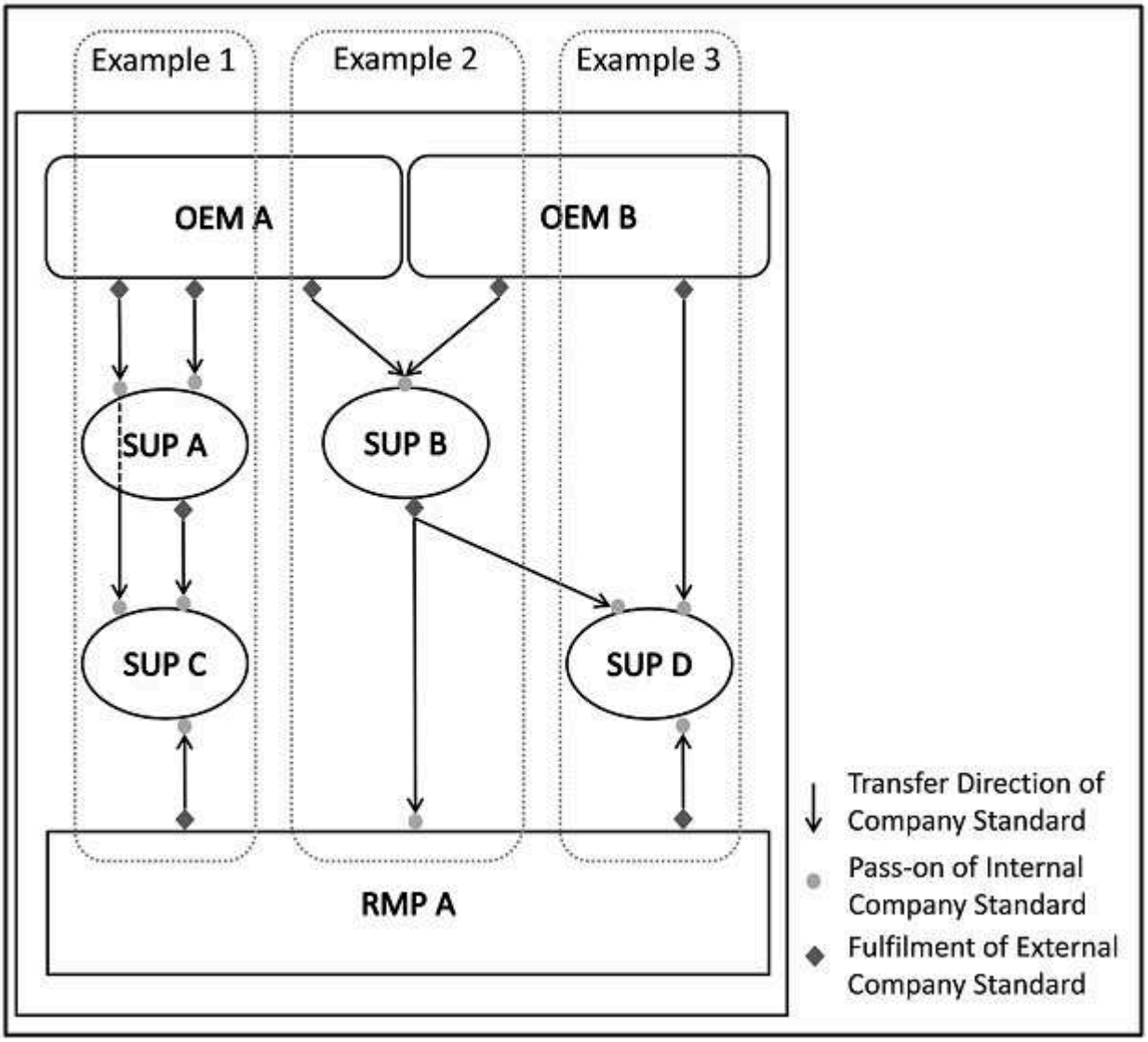

FIGURE 5.1. Exemplary cases of the diffusion of company standards through the automotive supply chain

know-how contained in the external company standards of different customers are combined into one internal company standard which sits at the highest requirement level appropriate for the company. In this instance, all customers will receive the same level of requirement (e.g. a very high quality), even if they have asked for a lower level. Customers, however, might only pay for the lower requirement level they have asked for. The supplier in this case can afford these additional costs due to synergy effects during the production process in case of higher production volumes. More benefits accrue due to a reduction in product variety. This holds for issues such as maintenance, service, stock, storage and documentation, among others. These

"unified" standards can then be provided to sub-suppliers or even RMPs, meaning that condensed information and requirements are diffusing through the supply chain. However, requirements in the form of customers' external company standards must sometimes be divided into many different internal company standards which can then be passed on to the respective sub-supplier. Standards are split up to reduce complexity for the supplier, so that they only get the part of the company standards which are relevant for them.

Example 3 illustrates how external company standards within the same company (i.e. "SUP D") can contain the codified know-how and requirements from various stages of the supply chain. As the suppliers in the automotive industry seek to deliver not only to the OEM directly but also to other suppliers of OEMs, the same supplier can act as both a direct supplier and a sub-supplier within the supply chain. This means that the external company standards that need to be implemented come from various stages and hence knowledge transfer is taking place from these various stages of the supply chain.

Figure 5.1 models the differing ways company standards are provided along the supply chain network, as evidenced by our case studies. In the next section these findings and potential implications are discussed.

5.5 Discussion and Implications

Our case study allows a discussion of the findings in light of the previous theoretical consideration, where we conceptualised company standards in the inter-firm relationship, as means for supply chain governance and their relation to the supply chain network position.

Firstly, our findings support that company standards can be a barrier to entering a trade relationship (Von Schlippenbach and Teichmann, 2012) and that their fulfilment can hence be seen as the "price of admission" for entering into a trade relationship (Mann, 2012). This is however mostly true for the weaker suppliers in the supply chain network. Thereby company standards promote lock-ins due to increased switching costs (Baake and Schlippenbach, 2011), as suppliers can potentially lose their position as a supplier (see comment of SUP6). However, this also depends on the degree of power that the supplier possesses, for example due to its position in the supply chain and the supply chain network. Overall, the OEMs seem to have the strongest power to influence company standards that diffuse through the whole supply chain. However, as we found companies at all supply chain levels which provide standards to their supply chain partners, OEMs are not the only market player to display this ability. At least for the automotive industry this shows that the commoditization of goods is counteracted by the

provision of non-market standards (West, 2003). The second main finding concerns the direction of influence within the supply chain. Suppliers are not only influenced by the diffusion of expertise from their buyers - i.e. the OEMs (Modi and Mabert, 2007), but we also find that the producers of raw materials try to enforce their expertise on their customers by providing company standards. Hereby raw material producers utilise their specialised knowledge to set company standards for their customers so that they can fulfil the requirements of their customer better (e.g. other supplier or OEMs). This reinforces the importance of their position within the supply chain with regards to the enforcement of company standards. On the other hand, OEMs are closely located to the customers and thereby able to dictate their standards on both suppliers and raw material producers.

We further find the governance of supply chains to be linked to the provision of company standards (Gereffi et al., 2005; Gereffi and Lee, 2012). The provisioning of company standards allows the standard-issuing company to enforce specific requirements that it otherwise would not get from the general market. This could imply that strong players in the market (i.e. the OEMs, RMPs and large suppliers) exercise their specific standards to keep the weaker players weak. This link should therefore be carefully considered in the management of supply chains, as such power imbalances and enforcement of idiosyncratic standards can prevent collaborative relationships between the actors (Kähkönen, 2014).

As not only manufacturers provide their company standards to their suppliers but also raw material manufacturers provide their company standards to their customers, our findings further show how the position of an organisation within its supply chain network can have a considerable impact on its power relations (Braziotis et al., 2013). Thereby the multiple suppliers in between the OEM and RMP have to make sure that they are managing their knowledge according to the strategy of their customers (OEMs) and their suppliers (RMP). The position alone, however, is not the only aspect of interest; the relevant links to other partners in the network are also important (Granovetter, 1985). It seems that suppliers of parts are in a weaker position to renegotiate the content received in external company standards compared to system suppliers that are better able to do this.

The aspects of the supply chain network can be important if we consider supply network disrupture which is significantly affected by the network structure (Kim et al., 2015). If, for example, a direct supply would encounter problems with delivering products according to the buyer's standards, a problem arises if inactive supply network partners are unable to fulfil these standards.

With regards to the quality requirements set in company standards, we find that some suppli-

ers fulfil the external company standards with the highest requirement, thereby automatically meeting the required quality of all other external company standards. This reduces complexity and increases the production volume of these suppliers, but it can come at the expense of higher production costs. Even if OEMs set lower quality standards for their components (e.g. to save costs) and provide them to their supplier, they could potentially receive higher quality components. SUP7 for example provides a case where the customers (OEMs) of a supplier did not know that they were getting the same standard as their competitors. OEM1 points out, however, that this might not pose a problem as industry insiders are generally aware of the demands of their competitors at the OEM level.

We also found that some information asymmetries exist with regards to the content of company standards. Internal company standards might include redundant testing procedures, for example, which unnecessarily raise the costs of the products. It is therefore important to consider the benefit of imposing certain standards on a supplier, if that supplier potentially has a better understanding of and competence in the matter. As OEM1 said, "you should not restrict your supplier too much through tight requirements, so that too little flexibility is left for him to realise [his] own ideas. He might find a material which leads to lower production costs [and further to a lower price]".

Our analysis has considerable implications for the management of inter-firm relationships across the supply chain. We propose that supply chain strategies for the handling company standards be developed. The knock-on effects along the whole supply chain and wider network should also be considered. Better understanding of company standards in supply chains is important as they seem to be positively linked with the market dominance of the issuing company (Gruber, 2000). Also does the increased globalization of the supply chains - not only in the automotive industry - increase the importance of regulations and standards on market but also on company level to gain safety and security (Marucheck et al., 2011).

Some suppliers are able to use their bargaining strength to renegotiate external company standards in their favour, while others have to fulfil the requirements of external company standards without such a possibility. These findings suggests that there is potential for coalition formation between suppliers that would collectively have more power than a buyer (Bastl et al., 2013) to enforce a "supplier-standard"; at the very least, such a collective would enable renegotiation to an easier obtainable standard. In some instances, the alignment of buyer-specific standards forced on suppliers could also reduce costs on the part of the supplier (e.g. as in the quality level case).

We further propose that the non-disclosure clauses of external company standards should be

lifted to ease provisioning to sub-suppliers. This could reduce transaction and documentation costs. We also found that some companies navigate this limitation by bundling external standards requirement with their own internal company standards.

Finally, we would like to highlight that companies also have the potential to strategically implement an internally developed, externally applied standard that could later become an industry or market standard. They would thereby have the chance to serve the wider supply chain network both indirectly and directly, potentially even across industries (van den Ende et al., 2012). This would imply that the size and the diversity of the standard-supporting network could increase beyond the established inter-firm relationships.

5.6 Conclusion and Limitations

This paper considers the usage of company standards along the supply chain. By considering existing studies and their perspectives on inter-firm relationships, supply chain governance, and supply chain networks, we explore how companies along the chain deal with internal and external company standards. We claim that company standards facilitate knowledge diffusion along the supply chain and enhance quality assurance and thereby have an impact on the bargaining power equilibrium between a buyer and its supplier.

Our first result is that company standards seem to be an entry barrier for entering into a trade-relationship and can thereby lock-in the buyer-supplier relationship. Our findings suggest that especially large and powerful downstream players are able to burden their suppliers with their own company standards. However, suppliers of raw materials also try to enforce their expertise on their customers by providing company standards. We hence observe bi-directional flows of company standards. We further find that the key network positions of raw material producers and original equipment manufacturers have a positive impact on their ability to put forward requirements in supply chain relations through company standards. Some supplying companies with system solutions also seem to be in a stronger position to renegotiate the degree of implementation of their buyers' company standards, compared to parts suppliers. Finally, we identify various ways in which suppliers deal with the heterogeneous quality requirements they receive via the external company standards of their buyers.

Although this study provides the first in-depth empirical analysis of the ability of firms to deal with company standards within their supply chain, we are aware of the limitations of our study. The perspective on the automotive industry might not transfer to other industries in the same manner. However, other highly regulated industries such as food, pharmaceuticals,

medical devices and consumer products are facing similar challenges in their supply chains (Marucheck et al., 2011). Also, information on the general governance structures of the value chain partners of the companies analysed would have been valuable. A next step in the research is to differentiate between the different contents codified in company standards, as we have seen how different aspects relate to different contents (e.g. process vs. product standards). This would further enhance our understanding of the use of company standards along supply chains.

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5.8 Appendix

Semi-Structured Interview Instrument

1. Respondent and company information (closed questions)
   a) Company name
   b) OEM /Supplier/RMP
   c) Number of employees
   d) Name of the interviewee
   e) Position of the interviewee
2. Short introduction and overview of content.

   Introduce the topic of the research. Explain the terminology of the study: Internal Company Standards (ICS) and External Company standards (ECS). Try to understand how familiar they are with the topic.
3. Use of Internal Company Standards and External Company Standards in the company (open-ended questions)
   a) Is your company developing Internal Company Standards?
   b) What share of Internal Company Standards is passed onto external organisations?
   c) Who are these external organisations?
   d) What is the topical difference between confidential internal company standards and those provided to these organisations?
   e) Does your company comply with External Company Standards?
   f) What kind of organisations provides External Company Standards to your company
4. Handling of External Company Standards in the company (open-ended questions)
   a) What is the effect of compliance to External Company Standards of different organisations?
   b) What hindrances and possibilities results from the compliance to External Company Standards?
   c) How does your company deal with these?
   d) What influence do External Company Standards have on the Internal Company Standards developed in your company?
   e) Do you also provide your External Company Standards to your suppliers? If so, do you alter the topics in these External Company Standards?
5. Company standards and supplier relationships (open-ended questions)
   a) What influence do company standards have on your relationships with your suppliers?
   b) Which goals is your company trying to achieve in providing Internal Company Standards to other organisations?

Table 5.1: Overview of the interview respondents

Abbr.	Position in company	No. of employees	Type of company Business description	
OEM 1	Manager; standard. department	250,000-500,000	Producer of premium cars and trucks	Design, assembly, manufacture and distribution of cars and trucks on a global scale under different brands
OEM 2	Manager; standard. department	50,000-100,000	Producer of trucks and commercial vehicle	Design, assembly, manufacture and distribution of trucks and commercial vehicles on a global scale
OEM 3	Manager; Standard., Technical Translation	100,000- 150,000	Producer of premium cars	Design, assembly, manufacture and distribution of premium cars on a global scale
OEM 4	Manager; standard. department	>500,000	Producer of small, medium and premium cars	Design, assembly, manufacture and distribution of cars on a global scale under different brands
SUP 1	Staff member; purchasing dept.	1,000-5,000	Manufacturer of car body parts and engineering apparatus	Production of system solutions and ready-to-fit components for the body panel
SUP 2	Staff member; standard. department	10,000-50,000	Manufacturer of vehicle parts	Develops, produces and distributes mechatronic components and systems for vehicle doors, seats and body
SUP 3	Manager; Standard. department	1,000-5,000	Manufacturer of electric components	Researches, develops, manufactures and distributes electronic connectors and fittings
SUP 4	Manager; Standard. department	500-1,000	Manufacturer of car communications systems	Develops and produces telecommunication technology and radio systems
SUP 5	Responsible for standardisation	5,000-10,000	Manufacturer of radiator systems	Develops and produces radiator systems for vehicles
SUP 6	Standard. responsible; Engineering dept.	10,000-25,000	Manufacturer of engine components and radiator systems	Develops and produces exhaustion systems and engine components
SUP 7	Manager; Standard. department	150,000-200,000	Manufacturer of automotive components	Develops and produces tires, brake systems, automotive safety, powertrain and chassis components
SUP 8	Staff member; standard. department	1,000-5,000	Gearing and brakes manufacturer	Develops and produces brakes and gearing systems
SUP 9	Responsible for standardisation	10,000-25,000	Manufacturer of car parts and vehicle lighting	Production of vehicle lighting and electronics systems and development of vehicle diagnostics and thermal management
SUP 10	Staff member; standard. department	50,000-100,000	Manufacturer of engine components	Researches, develops and manufactures system solutions for engine parts as well as air and liquid management for vehicles
SUP 11	Quality management officer	5,000-10,000	Producer of pressed metal components	Producer of pressed components, bearings and metal moulded part
SUP 12	Quality management officer	10,000-25,000	Manufacturer of chemicals	Production of chemical components for bonding, reinforcing and protection
SUP 13	Responsible for standardisation	5,000-10,000	Producer of structural components and assemblies	Manufacture of large metal stampings as well as exterior surfaces
SUP 14	Responsible for standard.; product marketing	50,000-100,000	Wholesaler of screws and installation material	Producer of metal equipment and development of storage solution
RMP 1	Head; technical product management	10,000-25,000	Producer of coatings, sealants and polycarbonates	Develops and manufactures materials and polymers
RMP 2	Responsible; testing procedures	1,000-5,000	Producer of lubricants	Produces lubricants, hydraulic and biodegradable products
RMP 3	Head; technical product management	10,000-25,000	Producer of steel and components	Producer of steel products and steel components
RMP 4	Head; technical product management	5,000-10,000	Manufacturer of carbon and ceramic components	Researches, develops and produces composites, ceramics and sintered metal

6

Conclusion

This dissertation contributes to the understanding of the microeconomics of standards with a special focus on formal standards and the neglected topic of company standards. Particular attention is paid to the behaviour of companies with regards to their innovation activities as well as their links with supply-chain partners, for example the relationship between buyer and supplier. This dissertation thereby adds to the literature on standardisation and inter-firm relationships and allows insights for managerial and economic policy.

This dissertation contributes five individual papers on the topic of standards. The first paper finds that a company's choice of innovation sources significantly influences its probability of being involved in formal standardisation. If companies enhance their innovation activities with information from competitors and scientific organisations, they are more likely involved in formal standardisation. Companies that use their suppliers as innovation sources, however, are less likely to participate in formal standardisation. In the second paper I develop a recommendation for the management of new product development processes. Linking standardisation and patenting to enhance open innovation thereby avoids costs that accrue due to the neglect of standardisation activities. The results of these first two papers supports that standards and standardisation participation can (and should) be strategically utilised in open innovation practices. The third paper reveals that suppliers neither implement their buyer's company standards to remedy potential insufficiencies of external formal standards, nor do they see these standards as alternatives to external standards. This finding supports a differentiated analysis of company standards with respect to the existing standardisation literature focussed on formal or consortia standards. The third paper further finds that when suppliers implement their buyer's company standards for knowledge transfer and fulfilment of quality requirements, they derive a higher

expected new benefit from the application of these company standards. In the fourth paper a multinomial probit model assesses the relation of a company's innovation and cooperation activities to their probability of implementing company standards. Larger companies, companies with process innovations and companies cooperating with customers and competitors have a significantly higher probability of implementing company standards. Cooperation with suppliers, on the other hand, significantly reduces this probability. In paper five I find that depending on their position in the supply chain network, companies employ different strategies to handle the external company standards of their supply chain partner.

6.1 Main results

Open Innovation Strategies Should Include Standardisation Participation

This dissertation shows how sourcing knowledge from the participants of technical standardisation committees provides firms with early information on the direction of technological development. This finding is relevant for new product development processes.I have shown how the probability of being active in formal standardisation increases when a company sources knowledge from its customers, but decreases when sourcing knowledge from suppliers. This provides support for standardisation as an option for demand-pull innovation. The results are important in the context of innovation policy and open avenues for further research.

Following Patenting, Standardisation Strategies Should be Linked to the Individual Product Development Processes

As I have proposed standardisation activities for the non-monetary revealing and sourcing of knowledge for innovation, I link these to the consideration of patenting as established monetary open innovation strategies. My analysis showed how the neglect of ongoing standardisation activities can lead to considerable cost and delays within a company's new product development. I further found that firms with different overall strategies develop patenting and standardisation strategies quite differently in their new product development processes. I have therefore proposed that a product-specific strategy for patenting and standardisation activities should enhance the development process both for inbound and outbound knowledge transfer. The evaluation of the effectiveness of such strategies is left as an avenue for future research.

Company Standards Reflect Firm-Specific Knowledge and Significantly Influence Suppliers

Contrasting the existing focus of the standardisation literature, I found that company standards are not just implemented to complement and extend external standards. Rather, they provide potential for internal optimisation as well as allow suppliers to fulfil their buyer's requirements. Company standards are thereby implemented as an instrument of knowledge transfer between companies, such as between a buyer and a supplier. Suppliers that implement their buyer's company standards for accessing knowledge and to fulfil quality requirements expect a higher economic net benefit from the application of their buyer's company standards. This finding supports the link between company standards and the buyer-supplier relationship and is therefore not only interesting for standardisation managers but also for supply chain management.

Companies With Process Innovations are More Likely to Develop and Implement Company Standards

Companies with successful process innovation display a higher probability of having company standards, compared to non-innovative companies. This finding contributes to the still unsolved understanding of the relation between innovation and standards. Unexpectedly, this positive link is not just associated with internally developed and implemented company standards but also with external company standards that were provided from supply chain partners.

Company Standards can Enhance the Governance of Inter-Firm Relationships

Lastly, my research found significant links between the cooperation activities of a company and its implementation of company standards. Whereas cooperation with suppliers significantly decreases the probability of implementing external company standards, the opposite holds for cooperation with competitors and customers. Suppliers are less likely to be able to only implement their own company standards but significantly more likely to implement external company standards. I further found that not only powerful buyers enforce their standards on suppliers, but that these are also passed from raw material producers to suppliers. These results enhance our understanding of the governance of inter-firm relationships with company standards.

6.2 Implications

Economic Policy

The result that formal standardisation participation can enhance a firms open innovation strategy provides a basis for innovation policy. The particular focus of companies active in formal standardisation on gaining knowledge from customers and scientific institutions coupled with

their reduced interest in supplier know-how provides evidence for the potential for market-driven innovation. This result can enhance future policies concerned with collaborative innovations.

National and formal standardisation organisations should also increase their attention to company standards. In contrast to the emphasis in the standardisation literature, company standards are not implemented to complement formal standards but are developed, implemented and also passed on to fulfil the goals of individual companies. This transfer of knowledge is on one hand beneficial for the buyer-supplier relationship, but it may deter the emergence of industry-wide standards and the associated benefits of compatibility and cost reductions.

Research Policy

The findings from this dissertation provide an avenue for standardisation researchers to focus their attention on company standards. They are not just a matter of supplementing formal standards or for internal organisation, but deserve attention in their own right. Their influences on inter-firm relationships can especially enhance the literature on governance and supply chain management.

This thesis further aims to establish the different forms of standards in the literature on platforms. Understanding the dynamic evolution of platforms from internal via supply-chain towards industry platforms can be supported by the standardisation literature.

Management

A variety of implications for managers can be derived from this thesis. Specifically, the results can enhance the innovation management, supply chain management and general management of companies.

Monitoring standardisation activities and actively partaking in the standard-setting process can provide an additional open innovation strategy for firms. As the second paper of this dissertation has shown, however, this strategy should be linked to the monetary open innovation strategy of patenting. A tangible managerial recommendation was provided to enhance new product development processes with knowledge sourcing and revelation via standards and standardisation participation.

Various findings of this thesis can also aid supply chain managers. As we have established company standards as an enhancing factor in the governance of supply-chain partners, the requirements laid out herein should be carefully considered. A further potential is provided by

the positive link between company standards and process innovations. It thereby seems that internal company standards are not only associated with process innovations within a company, but also the external company standards of a buyer.

Although managers should consider the implication of developing individual company standards for the optimisation of internal operations, they should not neglect the potential of either their internal company standards for their supply chain partners or of the external company standards for internal aspects.

6.3 Limitations and Further Research

The aim of this dissertation was to enhance the understanding of the microeconomics of standards especially in light of their relation to innovation and inter-firm relationships. However, it only provides a first step in this direction, as a myriad of further questions arise with each finding within this research sphere. Also, due to limitations in the analysed data, some results should be confined to the realm of their analysis.

Although standardisation participation is considered a form of open innovation, the actual knowledge revelation and sourcing within standardisation committees was not analysed. Although the results show how firms active in formal standardisation do significantly differ in their knowledge sourcing activities, this does not mean that these are actually a result of the participation. The recommended inclusion of sourcing and revealing via standardisation for new product development could not be tested for effectiveness. These questions are left for a further exciting avenue of research.

A second limitation stems from the lack of larger-scale cross-sectional or panel data. Although the first paper of this thesis is based on a large-scale sample from the Netherlands, it is nevertheless confined to this regional space. The papers two, three and five specifically investigate the automotive industry and therefore may not be representative of other industries. A replication of these empirical investigation in other sectors could provide valuable insight for wider implications.

Finally I would like to conclude this dissertation by highlighting the latent potential of company standards for research on supply chain governance and platform strategies. With increasing globalisation and international collaboration, the battle for the dominant standard may be influenced by the strategic development of a company standard.