FRUITS FROM THE TREE OF SUSTAINABILITY

VALUE CREATION IN GREEN STRATEGIC PARTNERSHIPS

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VALUE CREATION IN GREEN STRATEGIC PARTNERSHIPS

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Abstract

The importance of the environmental agenda has been rising exponentially in recent years. Firms face mounting pressure from multiple stakeholder groups to respond to environmental concerns. In a quest for ‘greener’ businesses, many companies increasingly rely on inter-firm strategic partnerships. Despite growing popularity among practitioners, green partnerships still remain a poorly understood phenomenon. The questions of how value is created in green partnerships, what factors drive their performance and what short-term and long-term implications of green partnerships are, still wait to be explored.

In this dissertation, the topic of value creation in green strategic partnerships is analyzed in a two-step project. Study 1 examines the financial outcomes of inter-firm green strategies by exploring variations in stock market valuation of green strategic partnerships across multiple industries and functional domains. Study 2 focuses on the innovation-related outcomes by examining firm green patenting activities in the context of inter-firm networks in the chemical industry.

Three complementary theoretical perspectives are utilized: corporate social responsibility (CSR) literature, organizational capabilities and social networks analysis. Data is collected based on extensive archival search of multiple sources.

The major insight from this dissertation is that green strategic partnerships can be instrumental in unlocking value creation potential of a firm, but this

phenomenon does not always happen and not for every firm. Financial implications of green partnerships vary depending on the functional domain of a partnership, a history of a firm's environmental performance and the environmental profile of the industry.

Green technology partnerships indeed enhance firm green innovation, as reflected in a greater number of successful green patent applications, but they do so at the level of firm networks, not at the level of the industry network. The properties of knowledge resources such as breadth of knowledge pool, knowledge compatibility, and knowledge specificity (green versus non-green), accumulated in a firm network do affect firm propensity to achieve green innovation. The structural properties of networks influence firm green innovation only at the firm network level. More specifically firm network density is positively related to firm green innovation. At the industry network level, however, none of the explored structural properties such as global network reach, global network clustering, and global network transitivity, have any impact on firm green innovation.

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Chapter 1
Introduction

The topic of corporate environmentalism has grown in importance in today's business world. In principle, corporate environmentalism aims at reducing negative social and environmental impacts and contributing to sustainable development (Kotler, 2011). Firms progressively recognize the need to align economic growth with the environmental demands of society and actively seek new ways to enhance firm environmental performance (Banerjee, Iyer, & Kashyap, 2003; Luo & Bhattacharya, 2006; Olsen, Slotegraaf, & Chandukala, 2014).

In the quest to make businesses greener, many firms increasingly rely on strategic partnerships with other organizations. Forbes recently announced sustainability-oriented alliances among the top ten trends in the business world (Forbes, Jan 18, 2012). Many large corporations increase their green partnership portfolios every year. For example, Wal-Mart's 2014 Corporate Social Responsibility Report lists more than 20 ongoing green collaborations with suppliers, research institutions and NGOs. In 2013-2014, Exxon Mobile engaged in 11 environmentally-oriented partnerships. Ford Motors' website touts nearly 30 collaborative green initiatives with North-American and international organizations, many extending over multiple years. A nascent, but rapidly developing stream of academic literature also suggests that green partnerships have become a popular approach of deploying corporate environmental strategies

(Lin & Darnall, 2010; Senge, Linchtenstein, Kaeufer, Bradbury & Carro, 2007; Peattie, 2011; Wassmer, Paquin & Sharma, 2014).

Inter-firm partnerships represent an established research area, shown to be an important vehicle to foster firm performance and account for as much as one-third of a firm's revenue (Gulati 1998; Mani & Luo, 2015). At the same time, practice reveals that inter-firm collaborations can be risky and costly projects; many of them fall short of meeting expectations and consequently diminish firm value (Kale & Singh, 2009; Wuyts & Geyskens, 2005). The sustainability context makes the prospects of inter-firm collaborations even less certain. As the decades of research have shown, there is no definitive conclusion among scholars as to whether the effect of green strategies on firm performance is exclusively positive (Chabowski, Mena, Gonzalez-Padron, 2011; Jacobs, Singhal & Subramanian, 2010; Dixon-Fowler, Slater, Johnson, Ellstrand, & Romi, 2013). Many practitioners also remain conservative regarding the economic potential of corporate environmentalism. As a recent survey about corporate sustainability practices (Lacy et al 2010) revealed, managers setting up a firm's environmental priorities tend to rely more on the legitimacy considerations than being driven by the economic motives. Skepticism among firm shareholders also persists if high costs and uncertain payoffs associated with improvements in a firm's environmental performance warrant such efforts (Engardio, Capel, Carey, & Hall, 2007). Thus, despite growing significance to business practice, environmentally-oriented partnerships still remain a "poorly understood phenomenon" (Selsky &

Parker, 2005; Sharma & Kearins, 2011) with unclear reward mechanisms (Wassmer et al., 2014).

Green technology partnerships represent one of the most exciting types of green inter-firm arrangements. The underlying objective of any sustainability efforts is to improve environmental and social well-being. Quality of life in society is greatly affected by the state of technology available to people (Schumpeter, 1942). In today's modern society increasingly driven by the environmental imperative, technologies that enable people to achieve the desirable environmental and social standards of living become increasingly important (Breitzman & Tomas, 2011; Loschel, 2002). Those technologies are often referred as green innovations, "novel and competitively priced goods, processes systems, and procedures that can satisfy human needs with a life-cycle minimal use of natural resources per unit output and minimal release of toxic substances "(Reid & Miedzinski, 2008, p. i).

Although beigh an attractive goal, green innovation represents a substantial challenge for organizations because those projects often require a radical departure from the established firm practices and involve a great amount of uncertainty (De Marchi 2012; Hall & Vredenburg, 2012). Not surprisingly, firms often collaborate to manage green innovation projects. Recently several studies have shown that environmental innovation iniatives are more cooperation-intensive than general innovations because of many systemic and complex features of those projects (Belin et al 2011; De Marchi 2012; Seuring & Mulle, 2008). However, deeper understanding of how value is created in green technology partnerships, what factors drive their performance and what the implications for partners, short-term and long-term, is mostly lacking (Rome & Wijen, 2006; Río, Peñasco, & Romero ‐ Jordán 2015; Wassmer et al. 2014). Studies examining green technology partnerships are rare, at best (De Marchi, 2012; Lin & Darnall, 2010).

Given the importance of inter-organizational relationships in the contemporary marketplace and responding to the repeated calls for more research into the implementation forms and outcomes of firm environmental strategies (Chabowski et. al., 2011; Cronin et. al, 2011), in this dissertation I explore the financial and innovation implications of green partnerships. Key research questions I address are as follows:

1. How do green partnerships contribute to shareholder wealth? What firm and industry-related greening factors affect the magnitude of the impact of green partnerships on shareholder wealth?

2. Does engagement in green technology partnerships help firms to create more green innovation? How do the structures of firm and industry technological networks affect firm propensity to create green innovation?

Understanding the drivers of eco-based competitive advantage and the conditions under which green partnerships can enhance value creation potential of a firm helps optimize organizational resource allocation and maximize benefits for a firm and stakeholder community. Following Gulati (1998), I define green strategic partnerships as voluntary arrangements between two or more organizations for the purposes of exchange, sharing or co-development of environmentally sustainable, or ‘green’, products, technologies or services to pursue a set of strategic environmental goals or address critical business needs. Businesses have used various terms to define those strategic arrangements, such as “green partnerships”, “green collaborations”, “sustainability-oriented partnerships”, “environmentally-oriented partnerships”. In this dissertation, I consider these terms interchangeably. Both equity-based and non-equity based partnerships are included in analysis

I explore the proposed research questions in a two-step project.

In Study 1, I examine the financial implications of environmental inter-firm strategies by looking at the stock market reaction to announcements of green strategic partnerships. I propose a model that relates inter-firm green strategies and firm stock market value and examine the boundary conditions, under which firms may experience positive or negative financial gains due to announcements of green strategic partnerships. Building on the corporate social responsibility (CSR) and organizational capabilities literature, I argue that in green strategic partnerships, firms can bundle market-driven organizational resources, such as marketing and technology capabilities, with firm environmental expertise for value-enhancing purposes.

Based on the extensive search of multiple archival sources, I develop a unique data set of 342 green strategic partnerships announced by 77 firms from multiple industries in the period from January 2005 to December 2007. I analyze it with event study and regression analyses. Specifically, I found that in the short run, stock markets react unfavorably towards the news about green technology partnerships, as compared to announcements of green marketing collaborative projects. Green technology partnerships are still able to accrue positive financial returns, but over longer periods of time.

A surprising shift in investors' valuation of green technology partnerships warrants further investigation into the forms and outcomes of those interfirm agreements. Considering the relevance of green innovation from the perspective of environmental and social well-being, understanding of the drivers of green innovation is of great importance to practitioners, academics, and policy makers.

In Study 2, I explore firms' green innovation performance in the context of inter-firm technological networks in the chemical and petrochemical industry (SIC 28, 29), observed over the period of 8 years, from January 2005 to December 2012. I propose a model that links a propensity of a firm to achieve green innovation to the structural and knowledge attributes at the firm and industry levels. The data set utilized to test the Study 2 model includes 55 firms and 314 firm-years. I employ the longitudinal research design and test the developed hypotheses with Poisson panel regression. I found that, in general, firms that invest in green technology partnerships are more likely to apply for green patents than firms that do not engage in interfirm green technology projects. However, there are certain limits to the benefits of green technology networks, and managers should be careful when making decisions about forming and maintaining those relationships.

The proposed contributions are as follows. First, as opposed to a broader perspective on corporate social responsibility (CSR) dominating in the literature and gauging its overall effect on firm performance, this dissertation focuses on the environmental aspects of CSR and parcels out their particular contributions to firm performance. Second, it zooms in on the inter-firm green partnerships, a type of CSR practices increasingly relevant for practitioners, and quantifies their impact on firm performance. Third, the dissertation identifies the roles that different organizational resources, for example technology versus marketing capabilities, play in green strategic partnerships and outline the pathways they can be leveraged for eco-based competitive advantage. Fourth, by bringing in other firm and industry-related green factors like a firm's prior environmental performance and industry's environmental profile (industry pollution levels), not considered before, it contributes to a long standing debate on what firms gain more from corporate environmentalism (Hart & Ahuja, 1996; Vardarajan, 2015). Fifth, while most of extant research on environmental innovation focuses solely on green innovators and uses cross-sectional data, this dissertation explores a mix of green and non-green innovations. Furthermore, it uses panel data, which allows for in-depth exploration of the ways green innovation is created and examining the causality relationships. Finally, this dissertation proposes and empirically tests a novel, multi-dimensional, conceptualization of the attribute of knowledge heterogeneity in technological networks and argues that domain specificity of knowledge, i.e. green versus non-green knowledge, might be a driver of the innovation outcomes in inter-firm partnerships.

The rest of the dissertation is organized as follows. In Study 1, I first briefly review literature on the impact of corporate CSR strategies on firm financial performance. Then I develop a set of hypotheses explaining how organizational capabilities can affect the inter-firm green partnerships – firm's stock market valuation relationship. I then proceed with the methodology, results, and discussion sections. In Study 2, I follow the same sequence of the theoretical development, methodology, results, and discussing sections. Then I provide the concluding discussion where I outline the implications of the dissertation for theory and managerial practice and conclude with the limitations and future research directions.

Chapter 2

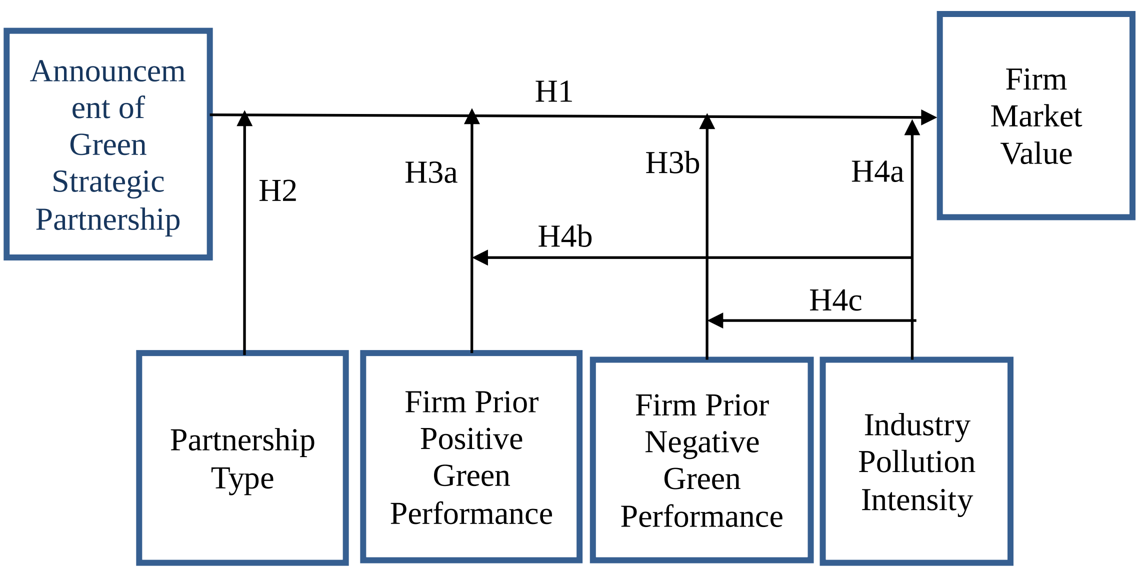
Study 1

Financial Implications of Green Strategic Partnerships.

Market-Driven Organizational Capabilities and Firm Financial Performance

Building on the CSR and organizational capabilities literature, firm environmental strategies are linked to organizational strategic capabilities and their impact on firm financial performance is explored. It is proposed that in green strategic partnerships, organizations can bundle market-driven (marketing versus technology) organizational capabilities with environmental knowledge and expertise for value-creating purposes. The patterns and predictors of the stock market reaction to announcements of green strategic partnerships are explained, based on the partnership, firm, and industry-specific factors. The hypothesized model is provided in Figure 1.

Figure 1. Study 1 Theoretical Model



Theory Development

2.1. Green strategies and firm financial performance

The paradigm of environmental sustainability is considered by many as a common goal for societal and economic development. The growing trend of environmental activism in society raises global concerns about ecological degradation and decreasing availability of many natural resources. In the corporate context, it draws attention to the ideas of a resource-constrained environment, intensifying competition for non-renewable materials, increasing costs of doing business and innovating for sustainability (Kotler, 2011; Vardarajan, 2015). Understanding what economic opportunities sustainability can provide, how organizations can deploy scarce resources more efficiently and exploit their productive potential to its fullest, while minimising negative impact on the environment have become paramount for organizational survival and growth (Connelly, Ketchen & Slater 2011; Russo & Fouts, 1997; Vardarajan, 2015).

Research on the economic impact of corporate environmentalism surfaced more than three decades ago. The literature offers two opposing theoretical perspectives. One view argues that firms face a trade-off between being environmentally sustainable and the objective of maximizing shareholder wealth (Friedman, 2007). According to this perspective, managers divert scarce organizational resources toward social causes that are non-productive per se and, thus, increase firm costs.

The other view proposes that costs are small in comparison to economic benefits associated with corporate environmentalism due to a greater competitive advantage and a better positioning of green firms in the marketplace (Orsato, 2006). In support of this view, marketing scholars argue that corporate environmentalism can enhance a firm's future cash flow by strengthening connections with firm stakeholders like customers, who are willing to buy more and pay premium prices for environmentally-responsible products (Luo & Bhattacharya, 2006), employees and channel members who are more motivated working towards helping a firm to meet its strategic objectives (Srivastava, 2007) and regulators holding a more favorable view of a firm, resulting in lower regulatory penalties (Wiles et al 2010).

The empirical evidence to date has also been conflicting: in some studies, the financial gains tied to corporate environmentalism were found positive (King & Lenox 2002; Leonidou, Katsikeas, & Morgan 2013), while other studies reported the effect to be negative or non-existing (Mathur & Mathur, 2000; Ameer & Othman, 2012). A recent meta-analytical review by Margolis, Elfenbein & Walsh (2009) concludes that the economic impact of corporate environmentalism is still unclear and a more nuanced research into the issue is warranted.

Market-driven organizational capabilities are the mainstream of marketing literature and have been shown to play a pivotal role in firm performance in multiple contexts (Day, 2011; Homburg & Pflesser, 2000). They are defined as subsets of firm-specific resources, which create value by extending, modifying and improving productivity of other firm resources (Helfat et al 2009). Market-based organizational capabilities bring other tangible and intangible firm resources together and enable them to be deployed for a long-term competitive advantage. Marketing capabilities help organizations to adjust their marketing strategies to fit complex and fast-changing markets, develop new channels to reach markets, find new ways for delivering customer value and build relationships with customer base (Day 2011). Technology capabilities span the processes that help firms to develop novel knowledge, convert it into novel technologies and design superior products and services (Krasnikov & Jayachandran, 2008).

Recently, several studies adopted the organizational capabilities perspective to explain why the association between firm CSR and its financial outcomes might not be strictly monotonic, but rather driven by other market-related organizational factors (Barnett & Salomon, 2006; Crittenden, Crittenden, Ferrell, Ferrell, & Pinney, 2011). For example, Luo & Bhattacharya (2006) show that firm investments in greater consumer satisfaction can help leverage CSR for shareholder wealth. Servaes & Tamayo (2013) test the moderating effects of firm advertising resources on the CSR-firm stock market value. Surroca, Tribó, & Waddock (2010) suggest that firm intangibles like firm reputation, human capital and firm innovation might mediate the link between CSR inputs and a firm's economic performance. Mishra & Modi (2016) explore how the complementarity effects between marketing capabilities and CSR activities impact firm financial performance. Hull and Rothenberg (2008) argue that the CSR-firm financial performance relationship is moderated by the firm innovation intensity. The articles by Chackrabarty & Wang (2012) and Katsikeas, Leonidou, & Zeriti (2016) advocate the mediation effects of firm R&D on the relationship between CSR and firm effectiveness, while Luo & Bhattacharya (2009) link CSR and firm R&D to show how these reduce firm idiosyncratic risks. Table 1 summarizes representative research on the topic.

I extend this line of research by proposing that market-driven organizational capabilities can affect the relationship between the inter-firm environmental strategies and firm financial performance. I then explore the relative importance of different types of organizational capabilities, specifically marketing versus technologycapabilities, in the context of inter-firm green strategic partnerships.

Table 1. Study 1. Research Examining the Role of Market-driven Resources in Shaping the Green CSR - Financial Performance Relationship

Empirical Research	Research Question	Empirical context	Marketing factors included	Technology factors included	Relevant Empirical Findings
Barnet & Salomon (2006)	The role of a firm's screening strategies in explaining the curvilinear relationship between CSR and firm's financial performance	Socially responsible mutual funds	No	No	Screening based on the environmental performance was negatively related to the average risk adjusted monthly returns of mutual funds
Hull & Rothenberg (2008)	Role of firm R&D in explaining the CSR-firm financial performance relationship	Firms on the KLD list	No	Yes	CSR benefits firms with lover R&D investments
Luo & Bhattacharya (2006)	The role of customer satisfaction in informing the CSR-financial performance relationship	Fortune 500 companies, multiple industries	Yes	No	Customer satisfaction mediates the relationship between CSR and firm financial performance
Luo & Bhattacharya (2009)	The role of CSR, marketing and R&D factors in reducing firm risks	Publicly-traded firms, multiple industries	Yes	Yes	CSR can reduce firm-specific risks, but the ultimate effect will depend on advertising and R&D strategies

Table 1 (continued). Study 1 Research Examining the Role of Market-driven Resources in Shaping the Corporate Environmentalism - Financial Performance Relationship

Empirical Research	Research Question	Empirical context	Marketing factors included	Technology factors included	Relevant Empirical Findings
Surroca et al (2010)	The mediating effects of firm intangible resources in the CSR - financial performance relationship	Publicly-traded firms, multiple industries	Yes	Yes	Firm intangibles mediate the relationship between CSR and firm financial performance
Chakrabarty & Wang (2012)	The role of R&D and Internationalization capabilities in long-term sustenance of corporate environmental practices	Publicly-traded firms, multiple industries	No	Yes	R&D and Internationalization capabilities are instrumental in long-term success of eco-friendly practices
Servaes & Tamayo (2013)	The role of customer awareness in the CSR - financial performance relationship	Publicly-traded firms, multiple industries	Yes	No	CSR has stronger positive effect on firm market value in the presence of high public awareness
Mishra & Modi (2016)	Complementarity effects of marketing capability in the CSR-financial performance relationship	Publicly-traded firms, multiple industries	Yes	No	The effect of marketing capability in the CSR-financial performance link varies depending on the type of CSR performed

Table 1 (continued). Study 1. Research Examining the Role of Market-driven Resources in Shaping the Corporate Environmentalism - Financial Performance Relationship

Empirical Research	Research Question	Empirical context	Marketing factors included	Technology factors included	Relevant Empirical Findings
This study	The role of marketing and technology capabilities in green interfirm strategies-financial performance relationship	Inter-firm partnerships, multiple industries	Yes	Yes	The effect of inter-firm green strategies on firm financial performance is contingent on firm capabilities utilized, firm's past green performance and industry pollution intensity

2.2. Market-driven organizational capabilities and green strategic partnerships

Marketing capabilities can be broadly defined as an organizational capacity to identify the critical needs of customers, based on market sensing and customer linking, to deliver superior market value proposition (Day, 1994, 2011). The notion of corporate environmentalism has broadened the traditional, purely economic view of value to encompass environmental and social benefits (Kotler 2011, Porter & Kramer, 2011). This invites a variety of perspectives on what constitutes value and places a firm in the center of a much broader network of stakeholders. Firms now are responsible for "creating, communicating, delivering and exchanging offerings that have value for *customers, clients, partners, and society at large*," (American Marketing Association, www.ama.org). It also extends the notion of market-driven capabilities so that they now can serve the needs of a much broader and diverse stakeholder community beyond the traditional groups such as customers, channel members, and investors (Bhattacharya & Korschun 2008; Day 2011; Ferrel, Gonzalez-Padron, Hult, & Maignan, 2010).

Firms with superior market sensing are able to identify and interpret information about stakeholder needs and the drivers of market response in the most insightful way and then successfully utilize that knowledge for value-creating purposes. Partnerships with environmental NGOs, activist groups, and research institutions can provide firms with access to unique environmental expertise accumulated by those organizations (Rodinelly & London, 2003). Strong market-sensing capabilities would enable a firm to identify environmental knowledge and competencies most relevant for addressing the needs of customers and broader stakeholder community. For example, in an alliance with Greenpeace, German refrigerator manufacturer Foron combined its market knowledge and the NGO's unique environmental expertise to successfully create a first-of-its-kind Freon-free refrigerator. The far-reaching outcome of the collaboration was an emergence of a whole new industry of eco-friendly refrigerators in Europe (Stafford, Polonsky, & Hartman, 2000).

Also, market-sensing capabilities can improve firm's ability to appropriate value by creating competitive barriers and extending firm competitive advantage (Day, 1994). In the green context, market-sensing capabilities can assist firms in dealing with emerging ecological policies and regulations by learning about them early on and responding preemptively (Delmas & Montes-Sancho, 2010; Diestre & Rajagopalan, 2011). Firms can leverage collaborations with government agencies to lobby regulations that favor firm products, thus improving firm's competitive positions, or they can join influential industry associations to promote private industry standards which could raise competitors' costs (King & Lenox 2000; London, Rondinelli, & O'Neill, 2005). For example, in 2006 Pacific Gas & Electric Company (PG&E) Corp. partnered with California Public Utility Commission (CPUC) to advocate a new voluntary utility program ClimateSmart. The 5-year initiative aimed to incentivize business and residential customers to neutralize greenhouse emissions associated with energy use (*PR Newswire US*, December 14, 2006). Through its partnership with CPUC, PG&E obtained environmental endorsement and aggressively promoted its energy saving products. The company had reinforced its reputation of a green leader in the region and strengthened connections with the local business community and environmental activist groups.

Stakeholder-linking marketing capabilities help organizations to build and maintain close relationships with their stakeholder community (Day, 2011). Consumers are increasingly aware of the role and impact of business on society welfare and often make choices to buy or not to buy based on environmental performance of a firm (Cronin et al., 2011). Firm's CSR activities are often a 'hidden' attribute of firm performance, not always easily visible to the external observers. Stakeholder-linking capabilities can help in communicating and informing stakeholders about corporate environmental practices, articulating and reinforcing green brand value and portraying firms in consumer eyes in a more favorable, "greener" way, to stimulate them for buying firms' eco-friendly products (Du, Bhattacharya, & Sen, 2011; Wagner, Lutz, & Weitz, 2009).

Because green products are typically credence-based goods, for which eco-friendly quality often cannot be fully asserted even after a purchase (Siegel, 2009), other factors like firm reputation for environmental values play an increasingly important role. Often, firms are judged by customers not only by their product offerings, but by with whom they partner. Prior research has shown that in consumer minds, companies become increasingly tied to environmental performance of their relational networks and can be 'overshadowed' by the green reputation of their business partners (Vachon & Klassen, 2006). In partnerships with other organizations with a strong environmental profile, firms can elevate their own green reputation and provide stronger, more reliable signals of green value to stakeholders (McWilliams & Siegel, 2001; van Marrewijk, 2003). For example, working on its new 'Green Works' product line, Clorox partnered with the Sierra Club, one of the most influential and respected environmental organization in the world. Through credible promises endorsed by the Sierra Club, Clorox was able to differentiate itself and stimulate demand for its product. Green products are generally perceived to having additional functional benefits of environmental friendliness, which reinforces consumer trust and loyalty and enables firms to charge premium prices and generate higher sales and profits (Homburg, Stierl, & Bornemann, 2013; Olsen et al 2014). In the long-run, the partnership with the Sierra Club has become a source of eco-based competitive advantage for Clorox and helped it not only to become a market-share leader, but lead the growth of the whole natural cleaning products industry (*PDMA Vision*, March 2009).

Technology capabilities reflect the organizational capacity to convert resource inputs into desirable outputs more effectively and efficiently via product and process innovation (Moorman & Slotegraaf, 1999). Marketing literature argues that firms with more advanced technology capabilities assume superior economic performance because of greater competitiveness, higher growth potential, and ability to address emerging consumer needs in a timely manner (Mizik & Jacobson, 2003). Products with innovative green technologies at the core can help not only better satisfy green consumer needs, but also optimize costs and improve operational efficiencies (Closs, Speier, & Meacham, 2011). For example, in green partnerships with channel members, firms can utilize their technology capabilities to develop and implement “greener and leaner” value chain (Chan, He, Chan, & Wang 2012). Partnering on the green goals with suppliers and distributors, firms are able to track environmental performance of their products from cradle to grave and develop innovative zero-waste products with a closed-loop life cycle, meaning essentially that no resource will be wasted or no waste will be produced. Getting channel members actively involved in environmental re-assessment of material and product design issues, firms can remove hazardous materials and implement substitutes for depleting and increasingly costly inputs, thus minimizing costs and improving the efficiency of firm operations (Pujari, Peattie & Wright, 2004; Vardarajan, 2015)

Through partnerships with unrelated partners, firms can implement unique environmentally-friendly solutions by innovating with joint production operation systems. In such collaborations, partners utilize each other's by-products and waste, which would otherwise be discarded (Mariadoss *et al*., 2011; Sharma *et al.*, 2010). For example, a beer producer Molson Coors Brewery and Merrick & Company, specializing in the renewable energy markets, have jointly developed a unique technology allowing to convert brewing by-products to gas substitute ethanol (Kwok & Rabe, 2010). Through this partnership, Molson minimized waste by converting it into a resalable product and lowered risks and the associated liabilities, and Merrick benefited from lower input costs of brewing refuse. The two partners hereby maximized their joint utilization of organizational resources, leveraged the efficiencies of material and energy savings and reduced their operating and production costs, thus creating economic benefits.

In summary, in green strategic partnerships firms can apply strategic marketing and technology capabilities to enable firm's green expertise and enhance its value creation potential, leading to superior financial performance. Partners mitigate the threats of resource scarcity by making valuable resources last longer; they optimize costs by improving operational efficiencies and profits, and they increase revenues by better linking with their stakeholders and exploiting emerging opportunities in eco-conscious markets. Consequently, I hypothesize that:

H1: Announcements of green strategic partnerships will positively affect firm market value.

2.3. Marketing versus technology capabilities in green strategic partnerships

Market-driven resources that are more unique and inimitable can become a better source of competitive advantage and have a greater value creation potential (Hunt, 2011; Kozlenkova *et al*., 2014). Marketing literature suggests that marketing capabilities might be difficult to copy and imitate due to their social complexity (Eisend, Evanschitzky & Calantone, 2015; Krasnikov & Jayachandran, 2008). By contrast, knowledge informing technology capabilities is more likely to be codified and disclosed in patents, which allows competitors to build on or work around those inventions, which renders technology capabilities to a greater risks of imitation (Joshi & Nerkar, 2011).

In the green context, those discrepancies are presumably even more pronounced. As noted before, firms nowadays are expected to attend and manage responsibly the unique and often conflicting aspirations of a broad community of social actors, firm stakeholders, beyond the traditional customers, employees, channel members, and investors (Ferrel et al, 2010). Obtaining 'a social license' to operate from multiple stakeholders with diverging, often conflicting, demands is not a trivial task. Disparate perspectives need to be negotiated, balanced, integrated and aligned with firm's economic objectives (Bhattacharya & Korschun, 2008). This requires fine-tuned market intelligence, higher order organizational learning, cultural sensitivity and openness to opposing viewpoints - the skills that are socially complex, tacit, and causally ambiguous (Hart & Sharma 2004, Hillebrandt, Driessen, & Koll, 2015; Mish & Scammon, 2010). Furthermore, with respect to the marketing capabilities, firms are not under any pressure to codify knowledge relating to those and disclose it in the public domain (Krasnikov & Jayachandran, 2008).

Contrary to that, technology capabilities in the green context are not only more likely to be codified and disclosed via patents as noted earlier, but because of the ethical considerations and social desirability of green technologies, firms might be under greater pressure to share those competencies in a public domain, to facilitate diffusion and faster adoption of green practices for greater good of the society. For example, after technological and commercial success of a new Freon-free refrigerator co-developed by Foron and Greenpeace was established, Greenpeace pressured its partner to share the newly-created technology with other firms in the market to ensure fast dissemination and mass adoption of a technology. Eventually, Greenpeace abandoned the partnership with Foron, to focus on promoting and disseminating the Freon-free technology to all interested parties (Stafford, Polonsky, & Hartman, 2000)**.**

Thus, marketing capabilities that enable organizations to effectively respond to the needs of diverse stakeholder groups are less tangible and less formalized and based on experiential learning, and thus more difficult for competitors to access and imitate than technology capabilities which are more likely to be codified and disclosed due to social pressures. Based on that, in the context of inter-firm green strategies, marketing capabilities can represent a better source of competitive advantage and have a greater potential to enhance firm performance, than technology capabilities do (Hunt, 2011). Accordingly, I hypothesize that:

H2: Announcements of green marketing partnerships will have a greater positive impact on firm market value than announcements of green technology partnerships.

2.4. Firm's prior green performance and green strategic partnerships

Corporate environmental performance can be positive that reflects environmentally proactive activities. Or it can be negative that reflects environmentally reactive actions. A reactive firm keeps environmental activities to a legal minimum, for a mere purpose of reducing liabilities associated with non-compliance. A proactive firm goes beyond those legal minimums and voluntarily exceeds environmental standards (Hart & Dowel, 2011; Kärnä, Hansen, & Jusli, 2003). Importantly, firms may demonstrate good environmental behavior in some of their business operations, while exhibiting bad environmental practices in others functional areas (Aragon-Correa & Rubio-Lopez, 2007).

Firm's past green performance is indicative of green competencies and expertise it has developed. Prior negative (reactive) green performance indicates that the firm followed the course of action which is minimally acceptable and mandatory for everyone, for example, installing minimal end-of-pipe pollution control equipment to ensure that emissions do not exceed a certain threshold. By doing this, a firm incurs costs associated with environmental policy compliance, but does not acquire any competitive advantage, as anyone can follow the same nominal strategy (Hunt 2011; Leonidou & Leonidou, 2011). This behavior reflects that a firm has not developed unique environmental expertise per se to be blended with marketing and technology capabilities in a green partnership and is a subject to higher risks for environmental liabilities and potentially poor financial performance.

Prior positive (proactive) green performance indicates that a firm has transformed its business operations beyond the legally required minimums and offered products of a higher environmental quality (Russo & Fouts, 1997). By their nature, the proactive environmental activities are more complex in execution, involve multiple organizational levels and might be less visible to external observers (Connelly, Ketchen, & Slater, 2011; Sharma & Henriques, 2005). Those activities require managerial discretion and creative problem-solving (Aragon-Correa & Rubio-Lopez, 2007), which makes proactive green activities idiosyncratic and context dependent and, therefore, less imitable. An environmental expertise, which a proactive firm develops, is more unique and thus can be a better source of long-term competitive advantage than an environmental expertise of a reactive firm. Based on that, I hypothesize that

H3a: Firm's prior positive green performance will be positively associated with a change in firm's stock market value in response to announcements of strategic green partnerships.

H3b: Firm's prior negative green performance will be negatively associated with a change in firm's stock market value in response to announcements of strategic green partnerships.

2.5. Industry pollution intensity and green strategic partnerships

General management literature suggests that certain industry attributes can have a differential effect on the stock market valuation of strategic partnerships. Industries vary in terms of their pollution intensity - the average emission rates of various pollutants associated with producing specific industry activities. In those with higher pollution levels, so called 'dirty' industries, such as most of primary resource extraction industries, petroleum production, chemicals sectors, etc., firms face higher liability risks and are subjects to a more scrutiny and more stringent environmental regulations (Varadarajan, 2015). Prior research shows that firms under unfavorable regulatory regimes might assume higher capital costs and, furthermore, environmental costs comprise a sizable portion of their total operational costs (Filbeck & Gorman, 2004). In order to improve environmental performance, firms in those 'stigmatized' industries have to undergo significant upgrades of their operations, far above and beyond small-scale and easy to implement pollution prevention measures (Diestre & Rajagopalan, 2011). CSR literature argues that the advanced technological modernizations to improve firm's environmental performance can result in escalating costs and rapidly diminishing returns on investments (Aragon-Correa & Rubio-Lopez, 2007; Hart & Ahuja, 1996). Hence, in dirtier industries, cost-related benefits arising from bundling firm's technology capabilities with green expertise in a partnership might be lower than in less polluting economy sectors.

Similarly, in dirtier industries the potential of the marketing capabilities to enhance value creation potential of firm's green expertise might be limited due to a weaker stakeholder linking. According to a recent study by Barnett & King (2008), people often hold persistent and unquestioned beliefs regarding the potential ecological threats posed by highly polluting economy sectors. The negative predisposition makes stakeholders insensitive and unable to discriminate between the firms who are good corporate citizens working proactively towards better environmental performance and the 'offenders', who are not (King & Lenox 2000). As a result of the negative reputational commons associated with the industry as a whole, stakeholders push for more stringent control and additional liability measures for the total population of firms in the industry, rather than the underachievers only (Barnet & King, 2008; Rees 1997). Literature in the finance field also confirms the persistence of the negative industry-wide 'halo-effect', when the wrongdoings of a few firms may have long-term negative financial consequences for the whole industry (Jarrel & Peltzman, 1985; Mitchel, 1989). Therefore, I hypothesize that

H4a: All other things being equal, industry pollution intensity is negatively related to the change in firm's stock market value in response to announcements of strategic green partnerships.

With respect to the past, good or bad, performance of firms operating in the pollution-intensive industries, prior positive green performance suggests that a firm might have developed some of environmental expertise. However, it also indicates that a firm has already implemented at least some voluntary upgrades in excess of legal minimums. Given disproportionally high negative environmental impact of those industries and higher than average environmental compliance costs incurred by the industry incumbents, further and more advanced environmental improvements would necessitate substantial technological modernization of firm operations, highly risky and assuming escalating operational costs (Hart & Ahuja, 1996). As industry 'dirtiness' and the complexity of modernizations increase, raising costs of upgrades would gradually offset savings from the improvements implemented.

Contrary to that, a prior negative green performance indicates that a firm did not invest excessively into environmental upgrades and presumably faced higher ecological liability risks in the past. An announcement of a green partnership would signal about firm's intentions to improve its environmental performance. For ‘high-polluters’, who recently started implementing environmental upgrades, there are still sufficient opportunities for improvements via low cost pollution-prevention measures, even in the context of dirtier industries (Aragon-Correa & Rubio-Lopez, 2007). Based on that I argue that improvements in environmental performance would lead to lower environmental liabilities and better financial performance in future. Therefore, I hypothesize that

H4 b, (c): As the level of industry pollution intensity increases, a firm with more positive (negative) green performance in the past will experience lower (higher) returns to announcements of green strategic partnerships.

Chapter 3

Study 1. Research Methodology

In this chapter I discuss the methodology issues pertinent to Study 1. To test the theory, I use a combination of event study and regression analyses. The event study methodology allows for testing the causal effects of announcements of green partnerships on a change in firm market value (Srinivasan & Hanssens, 2009). With cross-sectional analyses, I explore the determinants of the magnitude of change in firm market value in response to green partnership announcements, specifically the type of a partnership, the firm's prior environmental performances and the pollution intensity levels of the industry. I provide details on data sources and data collection procedures. Then I present definitions and operationalizations of the model constructs. I conclude with the models and statistical estimation procedures.

3.1. Event Study Design

The event study methodology is based on the efficient market hypothesis, which argues that at any moment a stock market price reflects all information regarding that stock in the public domain, up to that point (Brown & Warner 1985). The methodology allows the impact of an event to be measured by examining the change in stock price around the time when the event becomes public knowledge. The significance of the abnormal return above the normally expected return which concerns the general market, captures the effect of the event in question.

I calculated the abnormal return for the stock of a firm *i* on the day *t* as follows:

$$AR_{it} = R_{it} - NR_{it},$$

where AR_{it} is the abnormal return for a firm i on day t, R_{it} is the actual return for a firm i on day t, NR_{it} is the predicted return of a firm i on day t. The event date is labeled as time t=0.

To predict NR_{it}, I utilize the Market Index model:

$$NR_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

where α_i and β_i represent ordinary least square estimates of the regression coefficients, R_{mt} is the equal-weighted market return on day t, and ε_{it} is an independent and identically distributed disturbance term. I estimate NR_{it} over an estimation period of 255 days which ends 30 days before the event date. I assume that during the estimation period no information regarding the event of interest is released.

I calculated cumulative abnormal return (CAR) of a firm i as a sum of daily abnormal returns over the event window $[t_1, t_2]$:

$$CAR_i\,[t_1, t_2] = \sum_{t1}^{t2} AR_{it}$$

Recently, criticism has been raised regarding the misapplication of the short-term event study approach in the field of corporate social responsibility, related to using excessively long event windows, the "noise" caused by multiple confounding events, and reduced power of the test statistics (McWilliams, Siegel, & Teoh, 1999). In response to these concerns, I utilize short event windows and estimate the abnormal return at day 0, the date of announcement, and the cumulative abnormal returns over the various event windows within 10 days either side of the announcement day, to control for information leaks and delayed stock market reaction to partnership news. To assess whether the average cumulative abnormal returns are significantly different from zero and the results are not driven by a few firm events, I used a combination of the parametric Patell's standardized residual method and the non-parametric generalized sign test (Kothary & Warner, 2006). The Patell's test estimates a separate standard error for each security-event and assumes crosssectional independence. The generalized sign test adjusts for the fraction of positive abnormal returns in the estimated period instead of assuming 0.5, to control for the normal assymetry of positive and negative abnormal returns.

I also estimated the long-term effects of announcements of green partnership announcements on firm stock market value with the long-term event study. This approach allows to test for abnormal returns spread over long horizons, usually of one to five years (Kothary & Warner 2006). Two alternative approaches can be used, the buy-and-hold long-term abnormal returns and the calendar-time portfolio returns with the Fama-French benchmark.

The buy-and-hold long-term abnormal return (BHAR) approach is reflective of a strategy of investing into the stock which completed an event of interest, and selling it at the end of the pre-determined holding period. The return earned by that stock is compared to the return of a similar, but non-event benchmark firm or portfolio.

$$AR_i = R_i - BR_i,$$

where R_i is the long-term buy-and-hold return of firm *i*, and BR_i is the long-term return on a particular benchmark of firm *i.* The buy-and-hold return of firm *i* over *τ* months is calculated by compounding monthly returns, that is:

$$R_i=\Pi_1^{\tau}(1-r_{it})-1,$$

where r_{it} is firm *i*'s return in month *t.* The benchmark return BR_i estimates the return that the event firm would have received if the event did not happen.

The calendar-time portfolio long-term abnormal return approach is based on calculating calendar-time portfolio returns for the firms completed the event of interests and calibrating whether those returns are abnormal in a multi-factor regression model. Monthly return of the event portfolio is computed as the equally weighted average of monthly returns of all firms in the portfolio. Excess returns of the event portfolio are regressed on the Fama-French three factors:

$$R_{pt} - R_{ft}= \alpha + \beta(R_{mt}-R_{ft}) + sSMB_t + hHML_t + \varepsilon_t$$

where R_{pt} is the event portfolio's return in month *t*, R_{ft} is the one-month Treasury bill rate observed at the beginning of the month, R_{mt} is the monthly market return, SMB_t is a monthly return on the zero investment portfolio for the common size factor in stock returns, and HML_t is the monthly return on the zero investment portfolio for the common book-to-market equity factor in stock returns. The inferences about the long-term abnormal returns are done based on the significance of the estimated intercept α from the regression of portfolio returns against the factor returns, over t-month post-event period.

Both the BHAR approach and the calendar-time portfolio approach have some limitations. Thus, BHAR approach is more adversely affected by the skeweness in the sample due to the impact of compounding, which might result in the inflated estimates (Ang & Zhang, 2011). Contrary to that, the calendar-time portfolio approach is being criticized as having very low power and being overly conservative (Kothari & Warner, 2006). To address these criticisms, I used both approaches to ensure robustness of the results.

3.2. Data Collection

For the purpose of this research, I define an event of interest as a public announcement of a strategic partnership between a publicly traded company and other organizations in the market, with explicit environmental objectives as stated in the announcement.

To test the proposed research hypotheses, I collected a dataset of green partnership announcements from publicly traded US companies for the period of 2005-2007. I used the KLD Research and Analytics Database to generate the initial list of firms. This database is extensively utilized in environmental and social responsibility management literature (i.e. Luo, Wang, Raithel & Zheng, 2015; Surroca, Tribó, & Waddock, 2010) and provides an independent, third-party assessment of the environmental performance of over 3000 large publicly traded U.S. companies. For the list of firms drawn from KLD, I searched the Corporate Register database which provides access to corporate social responsibility reports of many largest global companies. I did a content analysis of the reports to highlight information relevant to the events of interest. The keywords used in this search were 'alliance', 'partnership', 'partner', 'cooperation', 'cooperate', 'collaboration', 'collaborate', 'association', 'associate', 'conjunction', 'co-venture', 'joint venture', 'agreement' and 'relationship'. Only those partnerships with explicitly stated environmental goals, for instance developing a new environmentally-sustainable technology, or bringing eco-friendly products to the market, were retained.

Next, I searched Lexis-Nexis, FACTIVA, newswire services and company websites to identify the dates of the first information release relating to each event. Firm news often reaches markets through different channels, and examining a variety of sources ensures accuracy and comprehensiveness in data collection. If there was an ambiguity about the precise announcement date, I excluded that announcement from the sample. To minimize any potential confounding effects, I checked for whether any contemporaneous financial (such as dividend announcements) and management announcements (mergers and acquisitions, other partnerships, law suits, environmental awards, executive management changes, new product launches) had occurred. If any such events had occurred in the three days either side of the announcement day, I removed these announcements from the dataset. The final data set comprises 81 observations for 2005, 106 observations for 2006 and 155 observations for 2007, 342 announcements in total. At this stage, an immediately interesting observation was that, over time, the number of green strategic partnerships announced annually was increasing. Stock market data was obtained from the Centre for Research in Security Prices (CRSP).

Variables

Dependent Variable

The dependent variable is a firm's short-term abnormal stock returns, calculated using the event study methodology described above.

Independent Variables

Partnership Type: I hypothesize that engagement in a green strategic partnership is positively associated with a firm market value, and that the effect of the partnership type differs depending on whether a firm utilizes marketing or technology capabilities. I assume that a firm would engage in a green marketing partnership, if interested in blending environmental expertise with marketing capabilities, and a firm will form a green technology partnership, if interested in exploiting technology capabilities for eco-based competitive advantage. To classify partnerships into marketing vs. technology types, I borrowed the following well-established definitions from the literature. A marketing partnership is an agreement among organizations, focusing on the value chain activities, promotion of product and services, penetration of new markets, customer acquisition and retention (i.e. Park, Mezias & Song 2004; Swaminathan & Moorman, 2009). In a green marketing partnership, partners collaborate to stimulate demand for eco-sustainable products and services, strengthen green brand name recognition and customer loyalty and improve the firm's green reputation within local communities and among general public.

A technology partnership is an agreement among organizations to jointly develop new products and services or implement novel production technologies (i.e. Das, Sen & Sengupta 1998; Mowery 1998). In a green technology partnership, firms jointly develop new green products or services, or implement green production and supply chain practices, such as waste management, pollution control measures

I also excluded minor, short-term events which are unlikely to have an effect on a firm stock market valuation, such as a one-day computer recycling event organized by a manufacturer in the distributor's location. Examples of each type of green strategic partnerships in the dataset are provided in Table 2.

Firm's Prior Green Performance (positive vs. negative): I operationalized firm's prior green performance, positive and negative, based on the environmental indexes obtained from the KLD Research and Analytics database. I utilized the KLD rating instruments because these are reliable and well-established measures, which provide a serious advantage over alternative indexes by allowing for a multidimensional nature of environmental performance (Mishra & Modi, 2015).

Table 2. Study 1. Examples of Green Strategic Partnerships

Partnership Type	Focal Firm	Partner(s)	Goals and objectives as announced	Source
Examples of Green Marketing Partnerships	General Motors	State of Florida and Inland Food Stores	To market new eco-friendly E85 ethanol fuel in North Florida markets	*Company Reports*, FACTIVA, 13-Sep-2006
	Praxair	Petrobras	To supply liquefied cleaner-burning natural gas to areas not served by pipelines and help Petrobras expand natural gas supply network	Praxair press release, firm website, 21-Aug-2006
Examples of Green Technology partnerships	United Technologies	Navantia	To develop advanced fuel cell power modules for use in military and civil vessels	UT press release, firm website, 18-Jul-2006
	PPL Corp	Pennsylvania Department of Environmental Protection and undisclosed partner	To implement novel pollution control equipment at two Pennsylvania power plants	*Waste News*, FACTIVA, 28-Feb-2005

The KLD environmental indexes represent a set of six positive and seven negative indicators, reflective of how firms allocate resources with respect to the environmental objectives. The positive indicators, or 'strengths' refer to positive environmental actions a company undertakes, such as running notably strong pollution prevention programs, reliance on renewable energy and clean fuels, substantial use of recycled materials in firm manufacturing processes, notable conservation projects, superior commitment to voluntary environmental programs. The negative indicators, or 'concerns', indicate that a substantial portion of a firm's revenues come from hazardous agricultural or ozone depleting chemicals, or fossil fuel products, falling behind industry competitors in implementing environmental improvement measures, having high emissions and environmental liabilities (KLD Research and Analytics, Inc., 2003). A firm can have a variety of strengths and concerns, and being evaluated positively from the environmental perspective in some of its business operations and negatively in others.

Following the other studies in the field, I transformed the individual KLD scores into aggregate measures of the Positive Green Performance by totaling up all the positive indicators, and of the Negative Green Performance by totaling up the negative indicators. However, these were not aggregated further to form a single measure of the corporate green performance because prior research has shown that environmental strengths and environmental concerns are related, yet theoretically and empirically distinct constructs (Delmas & Doctori-Blass, 2010; Mattingly & Bergman, 2006).

Industry Pollution Intensity: I operationalized industry pollution intensity, based on the capital expenditures associated with pollution abatement activities in that industry (Klassen & McLaughlin, 1996; Zaim, 2004). Data on industry pollution abatement costs is available from the Pollution Abatement Costs and Expenditures database, provided by the U.S. Census Bureau every two to five years. The Pollution Abatement Costs and Expenditures Report 1999, published in 2002, was used for the analysis. The next Pollution Abatement Costs and Expenditures Report 2005 was published in 2008 and therefore was not available to investors.

Control variables

To rule out alternative explanations of the hypothesized relationships, the model includes the following control variables, chosen based on literature review.

Firm Reputation: Prior research showed that corporate reputation can be a valuable asset reflective of how a firm is perceived by its stakeholders and signaling of underlying quality of its products and services (Roberts & Dowling, 2002). Reputational rank data was collected from Fortune's 'Most Admired Companies' list.

Firm Size: Prior research suggests that firm size might affect the cumulative abnormal returns by a firm. Smaller firms were shown to benefit more than larger ones (i.e. Koh & Venkatraman, 1991). Firm size was operationalized with firm sales obtained from COMPUSTAT.

Firm Partnership Experience: A firm's prior experience with managing interorganizational partnerships might have an effect on stock market valuation of the following partnership announcements (Oxley, Sampson, & Silverman, 2009). More experienced firms can better identify promising opportunities in the market and form most beneficial partnerships. Firm prior partnership experience was operationalized with a number of partnerships a firm engaged in 5 years preceding the announcement, obtained from Thompson SDC Platinum Join Venture and Alliances Database.

Firm Financial Leverage: Extant literature suggests that firms' capital structures might affect their financial performance (Welch, 2004). Firms with higher financial leverage might experience more tight financial constraints and be less motivated to invest in green initiatives. Firm's financial leverage was operationalized as a ratio of firm's long-term debt to firm's total assets, obtained from COMPUSTAT.

Firm Book-to-Market Ratio: I controlled for a firm's book-to-market ratio as it was shown to affect a firm's stock market performance substantially (Fama & French, 1993, 1995). Firm book-to-market data was obtained from COMPUSTAT

Stock Market Beta: I also controlled for stock market beta for the same reason (Fama & French, 1993, 1995). Stock market betas were estimated prior to the event over (-275 to -25) days.

Dummy 'For-profit Partner': I controlled for the potential effects of partnerships with for-profit organizations versus non-profit organizations. The underlying purpose of environmental initiatives is a creation of social value. Non-profit organizations are known to be better equipped to create public goods and address interests of secondary stakeholder groups like general public, local communities, activist groups (Abzug & Webb, 1999).

Dummy 'First Green Partnership': I controlled for the potential effects of the first green partnership. Although a firm might be experienced in managing interfirm partnerships in general, green partnerships might require special green domain-related knowledge and expertise which a firm has not possessed yet.

Dummy 'Multi-firm partnership': Partnerships involving multiple firms have greater chances to face coordination difficulties and experience higher operational costs (Oxley, Sampson, & Silverman, 2009). Information regarding the number of participating firms in each partnership was obtained from announcements.

Dummy 'Partnership with regulators': Partnering with government agency for environmental cause might signal that the initiative is endorsed by the government, gaining more legitimacy and reducing investor risks.

Dummies for industry effects: I used dummies to control for potential industry effects

Dummies for year effects: I controlled for potential time shocks with year dummies.

Table 3 provides a summary of variables and the sources from which the data was drawn.

Table 3. Study 1. Variables and Data Sources

Variable	Description	Source
Dependent variable:	A firm's abnormal returns	Event study
Independent variables:		
Partnership Type	Dummy (marketing partnership=1, technology partnership=0)	Press Releases
Firm’s Green Positive Performance	Aggregate of a firm's environmental strengths	KLD Database
Firm’s Green Negative Performance	Aggregate of a firm's environmental concerns	KLD Database
Industry Pollution Intensity	Industry pollution abatement costs	Pollution Abatement Costs Report, U.S. Census Bureau 2002
Firm Reputation	Firm reputation index	Fortune's Most Admired Companies Ranking
Firm Market Share	Firm's sales relative to total industry sales	COMPUSTAT
Firm Size	Firm sales	COMPUSTAT
Firm Market Capitalization	Firm market capitalization	COMPUSTAT
Firm Financial Leverage	Firm’s long-term debt relative to firm’s total assets	COMPUSTAT

Table 3 (continued). Study 1. Variables and Data Sources

Independent Variable	Description	Source
Firm Partnership Experience	Number of partnerships firm engaged in 5 years preceding the announcement	Thompson SDC Platinum
Firm Book-to-Market Value	Book-to-market value of equity	COMPUSTAT
Partner Type	Dummy, for-profit partner (1), not for-profit partner (0)	Press Releases
Partnerships with Regulators	Dummy	Press Releases
Multi-firm partnership	Dummy	Press Releases
Firm Stock Market Beta	Stock betas computed prior to the event over -275 to -25 days	Event study
Firm Age	Number of years since firm foundation	Firm SIC filings
Industry Growth	Average 3-year sales growth of the industry	COMPUSTAT
Industry Competitive Intensity	Inverse Herfindahl-Hirschman index	COMPUSTAT
Industry SIC	Industry dummies	COMPUSTAT
Industry Sensitivity to Environmental Regulations	Dummies for SIC 26xx, 28xx (except 283x), 2911, 33xx	COMPUSTAT
Year of Partnership Announcement	Year dummies	Press Releases

3.3. Model Specification

I apply two-step regression analysis. The decision of a firm to undertake a strategic move can be influenced by certain private information not observable by the stock market (Prabhala & Li, 2007). Due to those idiosyncrasies, some firms might be more motivated to pursue green strategies than others. Margolis et al (2009) in the meta-analytical review stress the importance of controlling for likelihood that firms will engage in sustainability and corporate social responsibility (CSR) activities, before testing the link between the firm's CSR and economic outcomes. Addressing these concerns, I used two-stage Heckman (1979) sample selection model to control for any potential selection bias resulting from systematic differences between the firms that chose to engage in green strategic partnerships and those that do not.

Selection Model with the Heckman Procedure

In the first stage, I obtained a matched sample portfolio consisting of publicly listed firms that did not announce green strategic partnerships during the period under study. Consistent with prior literature, I selected the matched firms based on the same industry sector and similar market capitalization (+/- 20%), for the same year (Homburg, Vollmayr, & Hahn, 2014; Purnanandham & Swaminathan, 2004). In a few cases, when the announcing firm was the largest in the industry and no other firm satisfied the selection criterion of similar size, I matched those with the second largest company in that industry. Next, I run a probit selection model, where the firms' choices to engage in a green strategic partnership was coded as 1, and 0 if they chose to abstain. Based on literature review (Gulatti, 1998; Kale, Dyer, & Singh, 2002; Shan, Walker, & Kogut, 1994), the following factors were included as being likely to affect firms' decisions to form green strategic partnerships: firm age, firm's market capitalization, firm sales, firm's financial leverage, firm's market share, firm's partnership experience, competitive intensity of the industry, industry growth rate and dummies to control for industry and year-specific effects. Firm age was operationalized as a number of years since incorporation. Industry competitive intensity was operationalized as the inverse Herfindahl-Hirschman index (Homburg et al 2014). Industry growth rate was operationalized as an average three-year sales growth of the industry (Luo, Homburg, & Wieseke, 2010). Firm market share was calculated as firm sales relative to the industry sales (Homburg et al 2014). A dummy was also included to control for the industries with a higher sensitivity to environmental regulations (chemicals SIC 28xx (excluding pharmaceuticals SIC 283x), metals SIC 33xx, paper SIC 26xx and petroleum 2911). Prior studies have shown that firms in those industries are subjects to greater scrutiny from general stakeholders and thus may be more motivated to pursue green efficiencies (Cho & Patten, 2007). For the full details on the variable operationalizations and data sources please refer to Table 3. As some companies in the dataset announced more than one partnership, I estimated the model with robust errors for clustered events.

Decision to form a green partnership$_{it}$ *= f (Firm Age; Firm Market Capitalization; Firm Financial Leverage; Firm Sales; Firm Market Share; Firm Partnership Experience; Industry Competitive Intensity; Industry Growth; Environmentally Sensitive Industries Effects; Industry Effects; Time Effects)+* ε_{it}.

The results of the first-stage selection model are provided in Table 9 in the Results section. I used the resulting parameters to calculate the inverse Mills ratio lambda

$$\Lambda=f(z)/F(z),$$

where z is an estimated value from the first-stage model, f is a standard normal density function and F is a cumulative distribution function (Heckman, 1979). Then I included Mills ratio lambda as an additional explanatory variable in the second-stage model, to control for selection bias and obtain unbiased parameter estimates.

Second-Stage Model.

The dependent variable is a firm's abnormal returns, obtained in the event study. The independent variables include industry pollution intensity, firm's prior positive green performance, firm's prior negative green performance and the interaction terms of industry pollution intensity with past positive and negative green performance, respectively. I mean-centered the industry pollution intensity and firm's prior green performance variables before creating the interaction terms. The model also controls for the partnership type, firm size as measured by firm sales, firm's financial leverage, firm reputation, firm's partnership experience, stock betas computed prior to the event of interest over -275 to -25 days, book-to-market value of equity, dummy for first green partnership, dummy for multi-firm partnerships, industry and time effects. I added those factors to the model as prior research indicates that they can drive stock market prices and thus condition the effects of announcements (Fama & French, 1993, 1995; Fang, Lee, Palmatier, & Guo, 2016 forthcoming; Luo & Bhattacharya 2009, Mathur & Mathur, 2000; Oxley, Sampson, & Silverman, 2009; Park, Mezias, & Song, 2004; Roberts & Dowling, 2002). I included a dummy for partnerships with regulators, government agencies and offices because those might provide endorsements and increase firm legitimacy in investors' eyes. I also controlled for a partner type, for-profit organizations (suppliers, competitors, distributors, buyers and so on) versus not-for-profit organizations (government agencies, NGOs, or universities). If the organizational capabilities argument holds, it can be expected that green partnerships with for-profit partners would generate higher abnormal returns than partnerships with not-for-profit organizations. For-profit organizations driven by a desire for competitive advantage in the marketplace are more likely to develop valuable strategic capabilities and bring these to the partnership. I controlled for a potential selection bias by including the inverse Mills ratio lambda from the first-stage Heckman selection model.

Firm's Abnormal Returns$_{it}$ *=f (Partnership Type; Firm's Prior Positive Green Performance; Firm's Prior Negative Green Performance; Industry Pollution Intensity; Firm's Prior Positive Green Performance* * *Industry Pollution Intensity; Firm's Negative Green Performance* * *Industry Pollution Intensity; Firm Sales; Firm Reputation; Firm Financial Leverage; Stock Market Beta ; Book-to-Market Value Ratio; Firm Partnership Experience; First Green Partnership; Firm Partner Type; Multi-firm Partnerships; Partnerships with Regulators; Mills Lambda; Industry Effects; Time Effects)+* ε_{it}.

Chapter 4

Study 1 Results

In this chapter I report the results of the tests of the proposed hypotheses. I briefly start with the descriptive statistics. Then I provide the event study results, followed by the details of the regression analyses. I conclude with discussion on the additional robustness checks.

4.1. Descriptive Statistics

The data set consists of 342 partnerships formed by 77 companies. It includes 235 marketing partnerships and 107 technology partnerships. Of the 77 companies, 37 were engaged in both green marketing and green technology partnerships. Among those preferring one or another partnership type, 12 companies were exclusively engaged in green marketing partnerships only. One company repeatedly engaged in green technology partnerships only. Twenty seven companies in the dataset announce only one, green marketing or green technology, partnership. In 158 partnerships, the focal firm partnered with at least one for-profit partner, such as suppliers, competitors, distributors, buyers. In the remaining 184 partnerships, the focal firm partnered with non-profit organizations such as government agencies, NGOs, or universities. The average market capitalization of the firms in the dataset was $ 44203.7 million. With respect to the industries, the data set covered three broad economy sectors inclusive of 16 industries, as described by 2-digit SIC codes. Food, textile chemical sector (SIC 20, 24, 25, 26, 28, 29) comprised of 118 partnerships, or 35% of the total data set.

Table 4. Study 1. Descriptive Statistics and Correlations

		N	Mean	Std. Dev.	1	2	3	4	5	6	7	8
1	Abnormal Returns (day 0)	342	0.70	12.33	1							
2	Cumulative Abnormal Returns (0; +1)	342	1.05	16.85	0.67*	1						
3	Partnership Type	342	0.69	0.46	0.17*	.18*	1					
4	Firm Sales	342	10.06	0.96	0.04	0.07	-0.06	1				
5	Firm Reputation	227	6.78	0.86	-.14*	-0.12	0.01	.36*	1			
6	Firm Partnership Experience	342	5.04	5.36	0.09	0.09	0.02	.33*	-.14*	1		
7	Firm's First Green Partnership	342	0.20	0.40	-0.06	-0.01	0.00	-.15*	-0.09	-0.11*	1	
8	Firm's Financial Leverage	342	0.22	0.11	-.12*	-.13*	-0.03	-.40*	-.17*	-.22*	0.02	1
9	Book-to-market Value	252	0.43	0.21	0.04	0.07	0.04	.22*	0.06	-0.01	-0.04	-0.10
10	Beta	342	0.90	0.31	0.09	-0.08	-0.05	-0.09	-.14*	0.00	-0.06	0.29*
11	Partner Type	342	0.46	0.50	0.07	0.08	-.20*	0.01	-0.11	0.08	0.00	-0.06
12	Industry' Pollution Intensity	325	2.64	0.46	-0.05	-0.03	-0.03	-.38*	-0.03	-0.19*	-0.06	0.23*
13	Firm Past Negative Green Behavior	260	-68.15	32.95	0.00	-0.04	.21*	-.26*	-.27*	0.13*	0.28*	-.19*
14	Firm Past Positive Green Behavior	260	46.65	25.74	-0.05	0.02	0.04	.21*	0.06	0.27*	-0.07	-.27*

Table 4 (continued). Study 1. Descriptive Statistics and Correlations

		9	10	11	12	13
9	Book-to-market Value	1				
10	Beta	0.04	1			
11	Partner Type	0.03	0.02	1		
12	Industry' Pollution Intensity	-0.22*	.020*	-0.01	1	
13	Firm Past Negative Green Behavior	-0.00	-0.29*	-0.09	-0.45*	1
14	Firm Past Positive Green Behavior	0.12*	-0.32*	0.11	-0.27*	0.08

***p<.01, *p<.05*

Plastic, metal, and machinery (SIC 30, 33, 34, 35, 36, 37) comprised of 92 partnerships or 27% of the total data set. Transportation and public utilities sector (SIC 40, 42, 48, 49) constituted 132 partnerships, 38% of the data set. Table 4 provides the descriptive statistics and correlation information for this dataset.

4.2. Estimation Results

H1: Announcements of green strategic partnerships will positively affect firm market value.

H2: Announcements of green marketing partnerships will have a greater positive impact on firm market value than announcements of green technology partnerships.

To explore the effects of green partnership announcements, an event study with market model estimation procedure was implemented with EVENTUS software and according to the methodology described in Chapter 3. Table 5 contains the results of the regression coefficients for each company-event. The results of calculations of abnormal returns are shown in Table 6. The results demonstrate that the stock market does not react significantly to the aggregate announcements of green partnerships. The aggregation of announcements of different types might obscure the relationships that exist. After the dataset was split into green marketing versus green technology partnerships, an analysis of the daily abnormal returns for the 20 days around the announcements reveals that the day of the event and one day after show significant stock market reactions.

Consistent with previous studies, the event windows with the most significant parametric Patells' and non-parametric generalized sign statistics (Kothary & Warner, 2006) in both partnership categories were selected for further analysis and discussion (Chaney, Devinney, & Winer 1991; Homburg, Vollmayr, & Hahn 2014). The reason for using both the parametric Patell's standardized residual method and the non-parametric generalized sign test was to ensure the results are not driven by a few influential outliers (Kothary & Warner, 2006).

Green marketing partnerships report positive average abnormal return (+.21%), $p<0.01$ on the day of announcement $t=0$ and cumulative abnormal returns (+.32%), $p<0.01$ for the event window (0; +1). Both parametric Patell's standardized residual method and non-parametric generalized sign tests (Kothary & Warner, 2006) are significant, confirming that the results are not driven by a few outliers. Green technology partnerships report negative average abnormal returns (-.28%), $p<0.01$ on the day of announcement $t=0$ and cumulative average abnormal returns (-.35%), $p<0.05$ for the event window (0, +1). Both parametric and non-parametric tests are significant, confirming that the results are not driven by the outliers. The use of the traditional market model and a combination of the Patell's method and generalized sign test deems appropriate on the grounds of a sufficient sample size ($n=342$) and short event windows ($t=0$ and (0; +1) event window) (McWilliams & McWilliams, 2011).

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residuals proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
11081	15-2-05	0.0008	0.53	0.0000	0.94	0.49	0.0002	0.0120	0.0254
11081	17-5-05	0.0010	0.53	0.0007	0.75	0.49	0.0002	0.0112	0.0434
11081	20-6-05	0.0001	0.49	0.0000	0.8	0.49	0.0002	0.0110	0.0223
11081	23-11-05	-0.0001	0.48	-0.0009	0.88	0.48	0.0002	0.0121	0.0810
11081	15-6-06	-0.0009	0.47	-0.0017	0.93	0.48	0.0002	0.0136	0.0658
11081	5-6-07	-0.0008	0.45	-0.0014	1.13	0.47	0.0004	0.0170	-0.0229
11081	12-6-07	-0.0008	0.45	-0.0014	1.12	0.47	0.0004	0.0170	-0.0201
11308	5-6-07	0.0006	0.49	0.0004	0.44	0.43	0.0000	0.0071	0.1918
11703	20-6-06	-0.0004	0.46	-0.0012	0.91	0.48	0.0001	0.0104	0.1044
11762	23-3-06	-0.0001	0.50	-0.0009	1.34	0.51	0.0002	0.0099	-0.0583
11955	21-3-05	0.0002	0.48	-0.0001	0.66	0.48	0.0001	0.0104	0.0333
13688	27-4-05	0.0010	0.56	0.0007	0.77	0.47	0.0001	0.0092	0.0202
13688	1-8-05	0.0012	0.56	0.0008	0.76	0.47	0.0001	0.0089	-0.0558
13688	25-8-05	0.0011	0.57	0.0007	0.7	0.50	0.0001	0.0086	-0.0052
13688	23-9-05	0.0012	0.58	0.0005	0.73	0.51	0.0001	0.0084	-0.0221
13688	14-7-06	0.0006	0.52	-0.0004	0.89	0.53	0.0001	0.0099	-0.1142
13688	28-7-06	0.0005	0.52	-0.0002	0.85	0.52	0.0001	0.0100	-0.1184
13688	10-8-06	0.0006	0.53	0.0000	0.82	0.53	0.0001	0.0101	-0.1270
13688	12-2-07	0.0011	0.53	0.0008	0.38	0.54	0.0001	0.0102	-0.1501
13688	21-3-07	0.0010	0.52	0.0007	0.39	0.53	0.0001	0.0103	-0.1067
13688	23-7-07	0.0011	0.54	0.0009	0.51	0.52	0.0001	0.0091	-0.0970
13688	26-9-07	0.0008	0.53	0.0001	0.74	0.50	0.0001	0.0091	-0.0292
13688	3-10-07	0.0004	0.52	-0.0002	0.81	0.51	0.0001	0.0093	-0.0427
13688	29-10-07	0.0005	0.52	0.0001	0.88	0.48	0.0002	0.0108	-0.0729
13688	18-12-07	0.0008	0.53	0.0001	0.94	0.46	0.0002	0.0108	-0.0696
13856	30-4-07	0.0005	0.54	0.0004	0.21	0.51	0.0001	0.0086	-0.0813
14541	28-9-05	0.0011	0.57	0.0002	0.9	0.54	0.0002	0.0118	-0.0216

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation (Continued)

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residuals proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
14541	7-3-06	0.0005	0.55	0.0001	1.24	0.51	0.0002	0.0122	-0.0853
14541	13-3-06	0.0007	0.55	0.0002	1.27	0.50	0.0002	0.0123	-0.0915
14541	16-10-06	0.0007	0.52	0.0004	0.98	0.49	0.0002	0.0122	-0.0961
17830	28-2-06	0.0006	0.52	0.0002	0.92	0.50	0.0001	0.0090	0.0319
17830	28-3-06	0.0005	0.52	-0.0001	0.93	0.49	0.0001	0.0089	0.0405
17830	13-11-06	0.0010	0.52	0.0006	0.96	0.47	0.0001	0.0094	0.1607
17830	4-12-06	0.0010	0.52	0.0005	0.95	0.47	0.0001	0.0096	0.1354
17830	18-10-07	0.0008	0.54	0.0003	0.86	0.48	0.0001	0.0081	-0.0623
18542	18-5-06	0.0018	0.57	0.0007	1.61	0.49	0.0003	0.0134	0.0002
19350	31-1-06	0.0000	0.48	-0.0007	1.33	0.49	0.0002	0.0129	-0.0026
19561	18-6-07	0.0007	0.52	0.0002	0.98	0.47	0.0002	0.0125	0.0260
20626	19-7-07	0.0005	0.52	0.0000	1.11	0.47	0.0002	0.0112	0.0161
20626	30-7-07	0.0007	0.52	-0.0001	1.1	0.45	0.0002	0.0112	0.0215
21178	16-6-05	0.0012	0.54	0.0010	0.58	0.51	0.0001	0.0107	-0.0260
21573	19-9-07	0.0010	0.54	0.0000	1.11	0.52	0.0002	0.0100	-0.0478
21776	27-1-06	0.0011	0.55	0.0004	1.2	0.49	0.0002	0.0116	0.0503
21776	30-8-07	0.0011	0.54	0.0004	0.75	0.49	0.0002	0.0112	0.0742
22517	27-9-06	0.0007	0.54	0.0004	0.88	0.49	0.0002	0.0113	0.0703
22947	29-3-05	0.0005	0.50	0.0003	0.47	0.47	0.0001	0.0089	0.0490
23114	20-2-07	0.0006	0.56	0.0004	0.37	0.51	0.0001	0.0085	-0.0410
23501	27-3-07	0.0006	0.53	0.0003	0.54	0.48	0.0001	0.0091	-0.0574
23931	31-10-05	0.0006	0.56	-0.0002	0.77	0.49	0.0001	0.0075	-0.0334
23931	25-9-06	0.0003	0.50	0.0001	0.62	0.47	0.0001	0.0089	-0.0658
23931	25-10-07	0.0002	0.53	-0.0003	0.98	0.45	0.0001	0.0099	-0.0941
24109	22-6-07	0.0018	0.56	0.0015	0.53	0.47	0.0001	0.0091	-0.0478
24109	24-9-07	0.0014	0.56	0.0007	0.71	0.51	0.0001	0.0096	-0.0601
24221	8-2-07	0.0011	0.54	0.0007	0.56	0.50	0.0002	0.0122	0.0236
24221	23-7-07	0.0023	0.61	0.0020	0.61	0.49	0.0001	0.0091	0.0434
24643	11-6-07	0.0007	0.53	0.0000	1.39	0.50	0.0003	0.0142	0.0448

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation (Continued)

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residuals proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
11308	15-6-06	0.0001	0.49	-0.0005	0.66	0.49	0.0001	0.0068	-0.0410
11404	27-9-07	0.0001	0.54	-0.0005	0.61	0.51	0.0001	0.0068	-0.0309
11703	6-2-06	0.0000	0.48	-0.0005	1.08	0.47	0.0001	0.0102	0.0553
11850	26-9-06	0.0005	0.54	0.0002	1.05	0.52	0.0002	0.0110	-0.0086
12570	21-9-05	0.0009	0.53	0.0001	1.06	0.48	0.0001	0.0085	-0.0579
13688	19-1-05	0.0013	0.55	0.0007	0.72	0.46	0.0001	0.0096	-0.0185
13688	27-6-05	0.0009	0.56	0.0007	0.8	0.47	0.0001	0.0088	-0.0606
13688	30-1-06	0.0004	0.54	-0.0001	0.97	0.51	0.0001	0.0092	-0.0373
13688	5-4-06	0.0005	0.54	-0.0002	0.96	0.52	0.0001	0.0092	-0.1163
13688	31-7-06	0.0006	0.52	-0.0001	0.83	0.52	0.0001	0.0101	-0.1325
13688	14-12-06	0.0006	0.50	0.0003	0.49	0.52	0.0001	0.0106	-0.1477
13688	18-1-07	0.0010	0.50	0.0007	0.41	0.52	0.0001	0.0103	-0.1578
13688	22-1-07	0.0011	0.51	0.0008	0.41	0.52	0.0001	0.0103	-0.1544
13688	12-6-07	0.0011	0.53	0.0008	0.53	0.52	0.0001	0.0098	-0.1423
13928	12-12-07	0.0016	0.55	0.0008	1.21	0.51	0.0002	0.0129	0.0598
14541	18-10-06	0.0006	0.52	0.0003	0.98	0.49	0.0002	0.0122	-0.1007
17750	17-2-05	0.0007	0.51	0.0004	0.42	0.46	0.0001	0.0109	-0.2376
17750	10-6-05	0.0004	0.49	0.0002	0.45	0.49	0.0001	0.0101	-0.3003
17750	14-11-06	0.0003	0.51	0.0002	0.48	0.49	0.0001	0.0089	-0.1144
17750	18-9-07	0.0005	0.53	0.0001	0.56	0.50	0.0001	0.0070	-0.1055
18163	20-12-05	0.0003	0.48	-0.0001	0.6	0.47	0.0001	0.0094	0.0427
18411	1-8-06	-0.0001	0.51	-0.0008	0.83	0.48	0.0001	0.0073	-0.0800
18411	8-3-07	0.0004	0.53	0.0001	0.4	0.49	0.0001	0.0083	-0.1656
18542	14-9-06	0.0019	0.55	0.0011	1.46	0.47	0.0003	0.0138	0.0760
19350	14-8-06	0.0011	0.56	0.0002	1.27	0.50	0.0002	0.0134	-0.0201
19350	22-3-07	0.0017	0.57	0.0006	1.69	0.47	0.0003	0.0145	-0.0050
20626	15-6-07	0.0006	0.54	0.0001	1.1	0.48	0.0002	0.0114	-0.0117
20626	24-12-07	0.0007	0.52	0.0001	1.2	0.45	0.0002	0.0101	0.0043
21776	6-5-05	0.0014	0.54	0.0011	0.54	0.52	0.0001	0.0103	-0.0439

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation (Continued)

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residul. proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
21776	23-5-05	0.0014	0.54	0.0011	0.59	0.53	0.0001	0.0103	-0.0649
21776	16-8-07	0.0010	0.53	0.0006	0.64	0.50	0.0001	0.0111	0.1079
21776	6-9-07	0.0013	0.54	0.0006	0.81	0.49	0.0002	0.0115	0.0841
22111	8-5-07	0.0004	0.51	0.0003	0.22	0.47	0.0000	0.0082	0.1420
22947	6-6-05	0.0002	0.52	0.0000	0.55	0.47	0.0001	0.0085	-0.0053
23501	27-9-07	0.0009	0.55	0.0002	0.84	0.49	0.0001	0.0087	-0.0200
23931	26-7-06	0.0003	0.51	-0.0005	0.8	0.50	0.0001	0.0082	-0.0755
23931	27-9-07	0.0004	0.54	-0.0004	0.83	0.50	0.0001	0.0083	-0.0165
24109	17-12-07	0.0012	0.53	0.0006	0.95	0.51	0.0002	0.0113	-0.0794
24205	19-1-07	0.0011	0.54	0.0008	0.34	0.50	0.0001	0.0102	0.0805
24643	20-2-07	0.0006	0.53	-0.0005	1.4	0.50	0.0003	0.0141	0.0238
24643	19-3-07	0.0002	0.52	-0.0007	1.45	0.51	0.0003	0.0146	0.0352
25013	13-8-07	0.0019	0.53	0.0013	0.83	0.42	0.0002	0.0118	0.0301
25785	23-3-05	-0.0004	0.47	-0.0010	1.09	0.47	0.0003	0.0147	0.0804
25785	10-6-05	-0.0006	0.46	-0.0009	1.11	0.45	0.0003	0.0141	0.0627
25785	28-7-05	-0.0011	0.46	-0.0019	1.25	0.49	0.0003	0.0143	-0.0362
25785	27-6-07	0.0006	0.49	0.0001	0.86	0.47	0.0005	0.0217	0.0398
25785	27-11-07	0.0003	0.46	-0.0004	1.09	0.46	0.0004	0.0181	0.0293
27828	13-6-07	0.0010	0.53	0.0006	0.93	0.53	0.0002	0.0129	-0.0751
27828	18-9-07	0.0015	0.58	0.0007	0.97	0.53	0.0002	0.0107	-0.0656
27959	12-9-05	0.0018	0.56	0.0013	0.68	0.50	0.0001	0.0100	-0.0838
27959	31-7-06	0.0001	0.51	-0.0006	0.91	0.48	0.0001	0.0088	-0.0453
27959	1-10-07	0.0003	0.52	-0.0002	0.67	0.48	0.0001	0.0092	-0.0776
27983	18-7-07	0.0008	0.51	0.0004	0.9	0.45	0.0002	0.0105	-0.2794
39917	16-8-05	0.0004	0.49	-0.0001	1.04	0.44	0.0002	0.0106	0.0998
42534	12-6-07	0.0011	0.53	0.0006	1.17	0.49	0.0003	0.0159	-0.2814
42534	25-6-07	0.0012	0.54	0.0005	1.17	0.49	0.0003	0.0159	-0.2791
48725	2-5-05	0.0001	0.45	-0.0002	0.65	0.47	0.0001	0.0099	0.0454
59328	10-2-06	0.0007	0.50	0.0002	1.14	0.52	0.0002	0.0117	-0.0163

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation (Continued)

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residual proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
59328	11-5-06	-0.0006	0.49	-0.0013	1.06	0.53	0.0002	0.0133	0.1154
59328	27-2-07	-0.0008	0.48	-0.0016	1.26	0.49	0.0003	0.0146	0.1021
62148	16-3-07	0.0014	0.55	0.0004	1.49	0.50	0.0003	0.0153	-0.1494
64311	27-5-05	0.0025	0.56	0.0020	1.17	0.47	0.0002	0.0134	-0.0311
65875	21-4-06	-0.0001	0.46	-0.0005	0.63	0.47	0.0001	0.0083	0.0544
70033	15-11-07	-0.0006	0.50	-0.0012	1.07	0.47	0.0002	0.0137	0.0684
70923	1-8-05	0.0005	0.50	-0.0001	0.86	0.44	0.0002	0.0140	0.0428
70923	26-2-07	-0.0006	0.48	-0.0008	0.28	0.52	0.0002	0.0129	-0.0641
70923	4-6-07	0.0002	0.48	0.0000	0.32	0.49	0.0001	0.0125	-0.0737
70923	19-10-07	0.0003	0.48	0.0000	0.67	0.46	0.0002	0.0134	0.0512
77730	3-1-05	0.0003	0.48	-0.0002	0.68	0.47	0.0003	0.0179	0.0343
77730	21-1-05	0.0009	0.49	0.0003	0.74	0.47	0.0004	0.0181	0.0574
77730	21-11-07	0.0009	0.52	0.0003	1.04	0.51	0.0003	0.0160	0.0069
90558	13-4-06	-0.0004	0.44	-0.0015	1.76	0.49	0.0006	0.0237	0.0919
91531	29-5-07	0.0017	0.56	0.0006	1.14	0.41	0.0003	0.0166	0.1254
24643	25-1-06	-0.0009	0.48	-0.0014	1.26	0.46	0.0002	0.0114	0.2089
24643	8-8-06	0.0009	0.52	-0.0003	1.41	0.47	0.0002	0.0135	0.0707
24643	27-3-07	0.0006	0.52	-0.0003	1.48	0.49	0.0003	0.0145	0.0221
24643	5-6-07	0.0007	0.53	0.0001	1.39	0.51	0.0003	0.0142	0.0464
24643	22-6-07	0.0003	0.52	-0.0006	1.42	0.51	0.0003	0.0137	0.0262
24643	26-6-07	0.0003	0.53	-0.0006	1.42	0.51	0.0003	0.0137	0.0275
24109	20-2-07	0.0008	0.54	0.0004	0.44	0.52	0.0001	0.0094	-0.0655
59184	26-9-06	0.0002	0.48	0.0001	0.4	0.49	0.0001	0.0097	-0.1205
19561	1-3-07	0.0011	0.54	0.0004	1.02	0.50	0.0002	0.0127	0.0451
19561	12-10-07	0.0012	0.55	0.0007	0.68	0.45	0.0001	0.0112	-0.0280
50227	5-4-07	0.0004	0.52	-0.0006	1.64	0.50	0.0003	0.0153	-0.0912
18542	27-4-06	0.0020	0.58	0.0010	1.66	0.50	0.0003	0.0135	-0.0089
18542	14-1-05	0.0008	0.52	0.0000	1.12	0.51	0.0002	0.0127	0.0093
14541	5-10-06	0.0007	0.52	0.0004	1.01	0.49	0.0002	0.0122	-0.0932

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation (Continued)

PERM NO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residual proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
14541	18-1-07	0.0008	0.52	0.0002	0.82	0.49	0.0002	0.0119	-0.0296
11308	22-3-07	0.0007	0.51	0.0005	0.44	0.45	0.0001	0.0071	0.1886
11308	17-4-07	0.0007	0.51	0.0005	0.41	0.44	0.0000	0.0070	0.1865
11308	5-6-07	0.0006	0.49	0.0004	0.44	0.43	0.0000	0.0071	0.1918
11308	6-8-07	0.0009	0.53	0.0005	0.47	0.43	0.0001	0.0072	0.1688
70500	5-6-07	-0.0001	0.46	-0.0003	0.47	0.47	0.0001	0.0097	0.0118
70500	24-11-06	0.0003	0.48	0.0001	0.53	0.49	0.0001	0.0102	-0.0477
11081	9-1-07	-0.0009	0.46	-0.0018	1.19	0.50	0.0003	0.0166	-0.0064
11081	22-10-07	0.0010	0.52	0.0004	1.16	0.45	0.0003	0.0149	-0.0202
11081	5-11-07	0.0012	0.52	0.0005	1.15	0.44	0.0003	0.0148	-0.0394
20626	2-10-07	0.0008	0.53	-0.0001	1.18	0.49	0.0002	0.0114	0.0333
11674	11-4-05	0.0007	0.53	0.0004	0.51	0.49	0.0001	0.0082	0.0163
27959	27-2-06	0.0004	0.52	0.0001	0.95	0.49	0.0001	0.0090	0.0055
27959	29-11-06	0.0004	0.50	0.0001	0.68	0.48	0.0001	0.0098	-0.0791
24010	21-6-06	-0.0001	0.54	-0.0009	0.87	0.50	0.0001	0.0093	0.0212
21776	21-9-06	0.0005	0.50	0.0002	0.92	0.48	0.0002	0.0120	0.0515
21776	25-5-05	0.0014	0.55	0.0011	0.6	0.53	0.0001	0.0103	-0.0641
21776	9-4-07	0.0003	0.50	0.0000	0.43	0.52	0.0001	0.0107	-0.0319
21776	11-12-07	0.0012	0.55	0.0002	1.41	0.44	0.0003	0.0135	0.0651
25785	25-9-06	-0.0019	0.45	-0.0023	1.08	0.49	0.0004	0.0184	-0.0709
24205	13-2-06	0.0009	0.54	0.0004	1.02	0.50	0.0001	0.0089	0.0517
27828	23-5-07	0.0009	0.52	0.0004	0.94	0.51	0.0002	0.0130	-0.0693
21573	28-3-06	-0.0007	0.46	-0.0014	1.18	0.49	0.0002	0.0116	-0.0056
21573	20-6-06	-0.0001	0.49	-0.0011	1.05	0.47	0.0002	0.0112	-0.0115
21573	20-2-07	0.0003	0.50	-0.0006	1.12	0.51	0.0002	0.0107	-0.0110
21573	15-10-07	0.0001	0.53	-0.0005	1.13	0.55	0.0002	0.0104	-0.0584
42534	10-8-05	0.0003	0.45	-0.0002	0.9	0.47	0.0001	0.0103	0.0224
42534	27-4-06	0.0008	0.50	0.0001	1.02	0.46	0.0002	0.0120	-0.1079
42534	10-4-07	0.0013	0.54	0.0006	1.18	0.48	0.0003	0.0161	-0.2842

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation (Continued)

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residuals proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
39917	5-10-05	0.0005	0.49	-0.0006	1.08	0.46	0.0002	0.0105	0.0494
39917	31-7-06	0.0000	0.49	-0.0009	1.1	0.47	0.0001	0.0091	0.1780
39917	15-8-07	0.0013	0.50	0.0004	1.17	0.41	0.0002	0.0124	0.0659
23931	10-10-05	0.0007	0.56	0.0000	0.7	0.49	0.0001	0.0075	-0.0636
23931	10-12-07	0.0004	0.54	-0.0003	1.05	0.45	0.0002	0.0098	-0.0566
11703	7-2-06	0.0000	0.48	-0.0005	1.08	0.47	0.0002	0.0102	0.0485
11703	3-8-06	-0.0002	0.48	-0.0008	0.71	0.47	0.0001	0.0101	0.0909
11703	29-3-07	0.0010	0.53	0.0005	0.81	0.47	0.0001	0.0087	0.0798
11762	22-8-07	0.0013	0.57	0.0003	1.17	0.49	0.0002	0.0109	-0.1788
13688	15-2-06	0.0007	0.53	0.0002	1	0.49	0.0001	0.0090	-0.0943
13688	15-5-06	0.0005	0.54	0.0000	0.91	0.51	0.0001	0.0095	-0.1055
13688	6-2-07	0.0011	0.52	0.0008	0.39	0.54	0.0001	0.0103	-0.1462
13688	19-6-07	0.0011	0.53	0.0008	0.53	0.51	0.0001	0.0094	-0.1578
13928	20-3-07	0.0004	0.52	-0.0004	1.11	0.52	0.0003	0.0149	0.1018
13928	10-4-07	0.0004	0.53	-0.0003	1.21	0.53	0.0003	0.0146	0.0746
13928	16-4-07	0.0003	0.52	-0.0004	1.2	0.53	0.0003	0.0146	0.0761
13928	28-9-07	0.0012	0.52	0.0003	1.15	0.50	0.0002	0.0135	0.0745
14541	31-3-05	0.0010	0.57	0.0007	0.63	0.52	0.0001	0.0102	0.0048
14541	5-1-06	0.0005	0.54	-0.0003	1.17	0.51	0.0002	0.0125	-0.0490
14541	11-5-06	-0.0002	0.51	-0.0010	1.26	0.51	0.0002	0.0125	-0.1053
14541	15-6-06	0.0004	0.52	-0.0008	1.26	0.51	0.0002	0.0121	-0.1170
14541	3-8-06	0.0006	0.51	-0.0003	1.22	0.48	0.0002	0.0117	-0.1006
14541	19-9-06	0.0008	0.52	0.0004	1.06	0.48	0.0002	0.0119	-0.0754
14541	29-5-07	0.0011	0.53	0.0007	0.85	0.49	0.0002	0.0116	0.0034
14541	6-9-07	0.0016	0.55	0.0009	0.82	0.52	0.0002	0.0112	-0.0011
14541	5-10-07	0.0011	0.54	0.0004	1.01	0.52	0.0002	0.0111	0.0021
16432	27-7-07	0.0038	0.53	0.0030	1.22	0.43	0.0005	0.0210	0.1262
17830	4-4-06	0.0008	0.53	0.0001	0.94	0.49	0.0001	0.0092	0.0445
17830	18-7-06	0.0011	0.53	0.0002	0.9	0.47	0.0001	0.0095	0.1489

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day, Market Model Estimation (Continued)

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residual proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
17830	26-10-06	0.0008	0.51	0.0004	0.95	0.46	0.0001	0.0095	0.1766
17830	5-9-07	0.0006	0.53	-0.0003	1.05	0.49	0.0001	0.0079	-0.0131
17830	31-10-07	0.0008	0.54	0.0003	0.88	0.49	0.0001	0.0083	-0.0692
18411	25-5-05	0.0004	0.52	0.0002	0.48	0.50	0.0001	0.0086	-0.1131
18411	6-9-05	0.0009	0.51	0.0006	0.51	0.47	0.0001	0.0085	-0.0835
18411	6-12-05	0.0009	0.50	0.0002	0.77	0.49	0.0001	0.0080	-0.0668
18411	22-2-06	0.0005	0.49	0.0001	0.84	0.48	0.0001	0.0073	-0.1257
18411	15-9-06	0.0000	0.52	-0.0004	0.72	0.47	0.0001	0.0077	-0.0694
19561	22-1-07	0.0012	0.54	0.0005	1	0.50	0.0002	0.0128	0.0351
20626	16-1-07	-0.0002	0.50	-0.0010	1.06	0.49	0.0002	0.0110	-0.0022
21178	4-4-05	0.0004	0.53	0.0002	0.48	0.51	0.0001	0.0112	-0.0258
21178	18-10-05	0.0007	0.51	0.0001	0.61	0.51	0.0001	0.0097	0.0627
21573	20-12-06	0.0011	0.52	0.0002	1.11	0.50	0.0002	0.0112	-0.0033
21936	10-4-07	0.0005	0.51	0.0001	0.56	0.49	0.0002	0.0125	0.0458
22517	23-5-06	0.0008	0.55	0.0000	1.08	0.49	0.0001	0.0101	0.0396
23114	18-2-05	0.0003	0.53	-0.0002	0.5	0.50	0.0001	0.0086	0.0010
23114	22-2-07	0.0007	0.57	0.0005	0.36	0.52	0.0001	0.0085	-0.0285
23931	29-9-05	0.0008	0.56	0.0001	0.69	0.48	0.0001	0.0078	-0.0570
23931	8-5-06	0.0003	0.52	-0.0003	0.8	0.50	0.0001	0.0080	-0.0498
23990	5-1-05	0.0010	0.50	0.0001	1.03	0.47	0.0002	0.0106	0.1127
23990	13-4-05	0.0010	0.52	0.0004	1.14	0.45	0.0002	0.0102	0.0100
23990	23-6-05	0.0005	0.52	0.0002	1.21	0.47	0.0002	0.0096	0.0163
24010	17-8-06	0.0001	0.55	-0.0003	0.79	0.52	0.0001	0.0097	0.0177
24109	4-10-07	0.0010	0.54	0.0004	0.85	0.50	0.0001	0.0095	-0.0615
24109	16-10-07	0.0012	0.54	0.0007	0.89	0.48	0.0002	0.0107	-0.0552
24221	9-2-05	0.0007	0.50	0.0002	0.57	0.46	0.0001	0.0091	0.0888
24221	23-8-05	0.0016	0.55	0.0012	0.72	0.47	0.0001	0.0102	0.1228
24643	14-8-06	0.0006	0.51	-0.0004	1.43	0.47	0.0003	0.0136	0.0791
24643	16-1-07	0.0009	0.55	-0.0002	1.4	0.51	0.0003	0.0140	0.0086

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation (Continued)

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residuals proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
24643	21-9-07	0.0017	0.53	0.0005	1.36	0.44	0.0003	0.0149	0.1478
25013	21-3-06	0.0000	0.50	-0.0003	0.47	0.46	0.0002	0.0137	0.1021
25785	28-1-05	0.0007	0.48	-0.0003	1.13	0.46	0.0004	0.0170	0.0364
25785	1-2-06	-0.0017	0.43	-0.0025	1.47	0.49	0.0003	0.0158	-0.0532
25785	9-7-07	0.0008	0.49	0.0003	0.84	0.47	0.0005	0.0208	0.0352
27828	27-1-06	0.0018	0.49	0.0014	0.72	0.42	0.0003	0.0166	-0.0105
27959	15-10-07	0.0006	0.51	0.0001	0.84	0.47	0.0001	0.0105	0.0460
27959	12-11-07	0.0006	0.52	0.0002	0.89	0.47	0.0002	0.0109	0.0423
27983	9-8-07	0.0014	0.54	0.0007	0.94	0.45	0.0001	0.0102	-0.2535
39917	12-4-07	0.0007	0.49	-0.0001	1.25	0.44	0.0002	0.0111	0.1131
42534	14-8-06	0.0018	0.54	0.0010	1.05	0.46	0.0002	0.0135	-0.1233
48725	16-1-07	0.0012	0.50	0.0003	1.24	0.47	0.0002	0.0119	0.0313
59328	21-6-06	-0.0006	0.49	-0.0015	1.06	0.53	0.0002	0.0132	0.1426
65875	6-3-07	0.0011	0.54	0.0005	0.77	0.51	0.0001	0.0089	0.0679
70578	16-2-05	0.0011	0.50	0.0004	0.79	0.49	0.0001	0.0098	-0.1567
70923	10-3-06	0.0001	0.46	-0.0002	0.82	0.48	0.0002	0.0126	-0.0484
70923	21-2-07	-0.0005	0.49	-0.0007	0.29	0.52	0.0002	0.0128	-0.0618
77730	8-3-05	0.0016	0.52	0.0008	0.82	0.48	0.0003	0.0174	0.0351
77730	16-4-07	0.0011	0.49	0.0007	0.73	0.47	0.0003	0.0174	-0.0236
77768	27-11-06	0.0009	0.54	0.0004	1.15	0.49	0.0002	0.0103	-0.1250
77768	17-12-07	0.0015	0.57	0.0007	1.18	0.45	0.0002	0.0100	0.0234
87447	21-6-06	0.0006	0.49	-0.0003	0.91	0.45	0.0001	0.0096	-0.0201
11308	5-9-07	0.0009	0.54	0.0005	0.51	0.45	0.0001	0.0069	0.1706
11308	23-10-07	0.0010	0.54	0.0007	0.55	0.46	0.0001	0.0073	0.1551
11955	11-5-05	0.0004	0.50	0.0000	0.77	0.49	0.0001	0.0096	-0.0040
13688	10-4-06	0.0004	0.54	-0.0003	0.97	0.52	0.0001	0.0092	-0.1210
13688	5-1-07	0.0008	0.50	0.0005	0.41	0.52	0.0001	0.0104	-0.1365
13688	27-2-07	0.0011	0.54	0.0009	0.38	0.54	0.0001	0.0101	-0.1403
13856	2-12-05	0.0006	0.52	0.0001	0.68	0.47	0.0001	0.0073	0.0840

Table 5. Study 1. Green Strategic Partnerships, Normally Expected Returns over the Estimation Period of 255 days Ending 30 days Before the Event Day , Market Model Estimation (Continued)

PERMNO	Event Date	Mean Total Returns	% of Raw Returns >0	Alpha	Beta	MM Residual proportion >0	Total Return Variance	Residual Standard Deviation	Autocorrelation
14541	11-4-07	0.0010	0.52	0.0005	0.82	0.48	0.0002	0.0119	-0.0285
17750	4-4-05	0.0007	0.51	0.0005	0.45	0.46	0.0001	0.0108	-0.2683
17750	23-10-07	0.0006	0.53	0.0004	0.48	0.49	0.0001	0.0079	-0.0012
18411	12-9-06	-0.0001	0.52	-0.0005	0.72	0.49	0.0001	0.0078	-0.0809
20482	4-4-06	-0.0001	0.46	-0.0005	0.56	0.48	0.0002	0.0123	-0.0225
22517	27-3-06	0.0008	0.55	0.0001	1.08	0.48	0.0001	0.0099	-0.0255
23114	26-7-07	0.0011	0.59	0.0009	0.44	0.46	0.0001	0.0076	-0.0223
23114	19-12-07	0.0004	0.56	-0.0002	0.95	0.49	0.0001	0.0090	-0.0399
23931	12-4-06	0.0004	0.54	-0.0002	0.85	0.49	0.0001	0.0080	-0.0681
23931	2-11-06	0.0005	0.51	0.0003	0.58	0.47	0.0001	0.0092	-0.1156
24109	14-3-07	0.0007	0.52	0.0003	0.45	0.51	0.0001	0.0092	-0.0254
24109	9-10-07	0.0010	0.54	0.0005	0.87	0.50	0.0001	0.0102	-0.0663
24643	30-10-06	0.0003	0.52	-0.0003	1.37	0.50	0.0003	0.0138	0.0259
25320	10-3-05	0.0006	0.50	0.0002	0.49	0.47	0.0001	0.0108	-0.1242
25419	25-1-07	0.0007	0.48	-0.0002	1.12	0.45	0.0003	0.0143	-0.1441
25785	11-1-05	0.0008	0.49	-0.0001	1.16	0.47	0.0004	0.0172	0.0605
25785	12-12-06	-0.0002	0.49	-0.0007	1.02	0.49	0.0006	0.0226	0.0068
25785	30-8-07	0.0016	0.50	0.0009	0.76	0.47	0.0005	0.0208	0.0450
39917	28-6-05	0.0000	0.50	-0.0003	1.11	0.47	0.0002	0.0104	0.0410
48725	24-6-05	0.0005	0.46	0.0004	0.84	0.44	0.0001	0.0105	0.0334
50227	16-6-05	0.0021	0.55	0.0018	0.94	0.45	0.0002	0.0114	-0.1925
50227	24-6-05	0.0017	0.56	0.0015	1.06	0.47	0.0002	0.0118	-0.1294
64936	18-12-07	0.0007	0.51	0.0002	0.78	0.46	0.0001	0.0090	0.1437
70923	30-5-06	-0.0003	0.47	-0.0009	0.76	0.49	0.0002	0.0123	-0.0579
90562	24-10-05	-0.0006	0.44	-0.0008	0.51	0.55	0.0005	0.0233	-0.2356
	Mean	0.0006	0.52	0.0001	0.89	0.49	0.0002	0.0113	-0.0175
	Median	0.0007	0.52	0.0001	0.89	0.49	0.0002	0.0105	-0.0164

Table 6. Study 1. Green Strategic Partnerships, Cumulative Abnormal Returns over Different Event Windows ($-t_1$; $+ t_2$), Market Model Estimations

	Green Marketing Partnerships				Green Technology Partnerships			
Event Window	N	Mean CAR	Patell Z	Gen. Sign Z	N	Mean CAR	Patell Z	Gen. Sign Z
(-7,+7)	235	.18%	.53	.34	107	-.25%	.070	-.01
(-6,+6)	235	.15%	.37	.47	107	-.29%	-.18	.18
(-5,+5)	235	.17%	.48	1.12	107	-.27%	-.25	.18
(-4,+4)	235	.30%	1.13	1.65*	107	-.41%	-.64	.18
(-3,+3)	235	.38%	1.62	2.30*	107	-.25%	-.35	-.59
(-3,+2)	235	.39%	1.87*	1.52	107	-.25%	-.48	-.40
(-2,+3)	235	.36%	1.64	.99	107	-.33%	-.75	.18
(-2,+2)	235	.37%	1.93*	2.30*	107	-.33%	-.94	-.98
(-1,+2)	235	.29%	1.88*	.99	107	-.15%	-.20	.38
(-2,+1)	235	.34%	1.90*	2.30*	107	-.48%	-1.81*	-1.75*
(-1,+1)	235	.27%	1.88*	1.25	107	-.29%	-1.10	-.40
(-1,0)	235	.16%	1.40	.60	107	-.22%	-.84	.18
(0,0)	***235***	***.21%***	***2.72*****	***1.91****	***107***	***-.28%***	***-2.46*****	***-2.14****
(0,+1)	***235***	***.32%***	***2.82*****	***1.78****	***107***	***-.35%***	***-2.25****	***-2.53*****
(0,+2)	235	.34%	2.61**	.86	107	-.21%	-.97	-1.37

***p<.01, *p<.05*

Figures 2 and 3 show the daily and cumulative abnormal returns following announcements of green marketing partnerships and green technology partnerships, respectively, for the event window (-10, +10). The highest daily average abnormal return following announcements of green marketing partnerships occurred on the day of announcement t=0 (Figure 1, Mean Abnormal Returns MAR% line), the cumulative positive effect reached its maximum of .8% on day t= +2 (Figure 1, Mean Cumulative Abnormal Returns MCAR% line). In the case of green technology partnerships, the lowest daily abnormal returns occurred on the day of an announcement t=0 (Figure 2, Mean Abnormal Returns MAR% line). The cumulative average abnormal returns showed a consistent negative trend, reaching its minimum of .55% on day t=+1 (Figure 2, Mean Cumulative Abnormal Returns MCAR% line).

Figure 2. Study 1. Daily Average Abnormal Returns (MAR) and Cumulative Abnormal Returns (MCAR), Green Marketing Partnerships

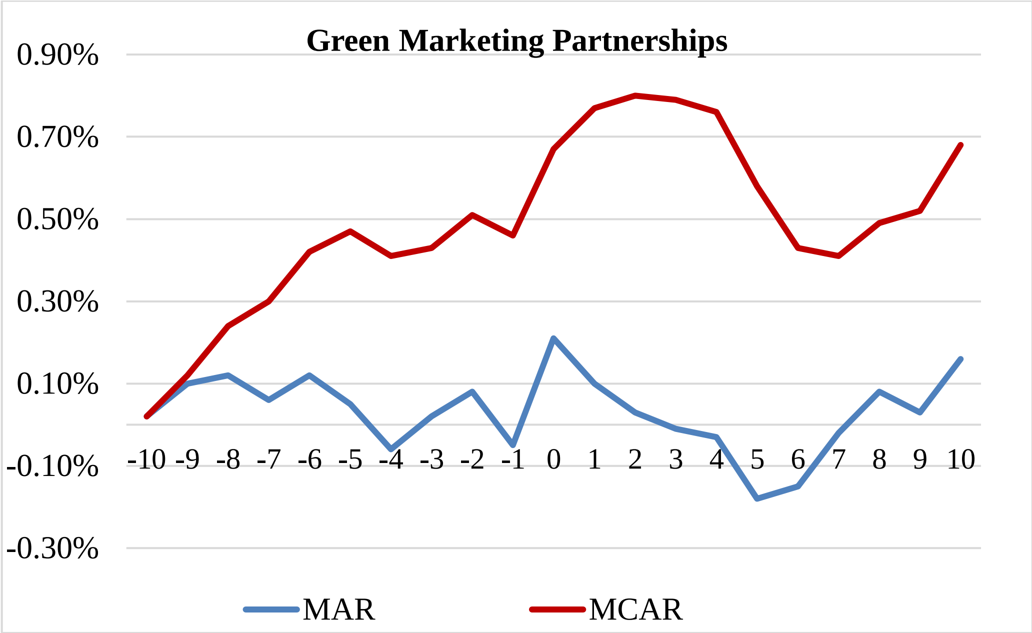
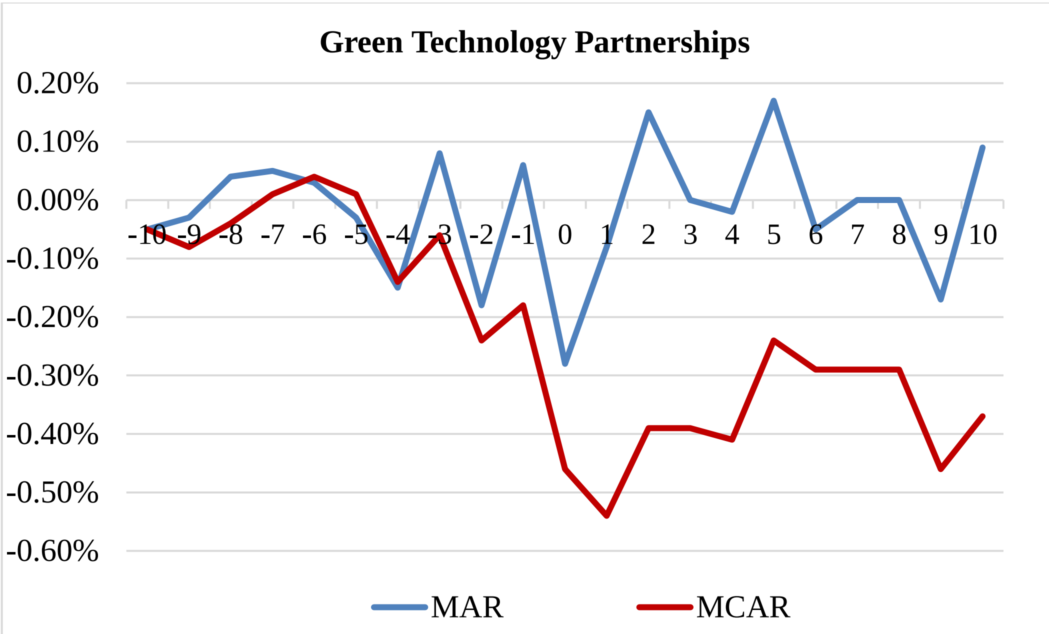


Figure 3. Study 1. Daily Average Abnormal Return (MAR) and Cumulative Abnormal Returns (MCAR), Green Technology Partnerships



As an additional robustness check, I do mean difference tests across the partnership types for the day of an announcement t=0 and for the event window (0; +1). The results (Table 7) show that abnormal returns do differ across the partnership categories at a $p<.01$ significance level, with the marketing partnership sample reporting positive means, and the technology partnership sample reporting negative means, which confirms the findings of the market models discussed above. The mean difference test across the partnership types for the event window (0; +1) generates similar results. Thus, Hypothesis 2 is supported.

Table 7. Study 1. Mean Difference Test, Green Technology vs. Green Marketing Partnerships

Group	N	Mean	STD Err.	Std. Dev.	[95% Con. Int.]	
Technology partnerships (0)	107	-2.44	1.20	12.40	-4.81	-0.06
Marketing partnerships (1)	235	2.12	0.97	12.06	.57	3.67
combined	342	0.70	0.69	12.33	-.62	2.01
diff		-4.56	1.42		-7.35	-1.77
diff = mean (0) – mean (1)					t = -3.21	
Ho: diff = 0		degrees of freedom =		340		
Ha: diff < 0		Ha: diff = 0		Ha: diff > 0		
Pr(T < t) = 0.001		Pr(|T| >|t|)= 0.001		Pr(T > t) = 0.99		

To further explore the effects of green marketing and green technology partnerships on firm's market value, the mean difference test of abnormal returns for the firms engaging in only 1 type (green marketing or green technology) of partnership versus firms practicing both types of partnership (not simultaneously though) was done. After removing 27 observations where firms had 1 announcement only, the results show that those firms announcing both green marketing and green technology partnerships (one type at a time) outperform the firms that engage in 1 type of green partnerships only. Remarkably, majority of those firms in the second group choose to announce green marketing partnerships. This finding is consistent with marketing literature suggesting complementarity of firm marketing and technology capabilities (Dierickx & Coll 1989, Moorman &

Slotegraaf 1999). The results hold for both the announcement day t=0 and the event window (0; +1). The results are provided in Table 8.

Table 8. Study 1. Mean Difference Test for 1 Partnership Type Used versus Both Partnership Types Used (not simultaneously)

Group	Obs	Mean	Std Err.	Std. Dev.	[95% CI]	
One Partnership Type Used (0)	50	-2.73	1.56	11.00	-5.85	0.40
Both Partnership Types Used (1)	265	1.14	0.70	11.45	-0.25	2.53
combined	315	0.53	0.65	11.42	-0.74	1.80
diff		-3.87	1.71		-7.27	-0.46
diff = mean (0) -mean (1)					t = -2.26	
Ho: diff = 0		degrees of freedom =		313		
Ha: diff < 0		Ha: diff =0		Ha: diff > 0		
Pr(T < t) = 0.013		Pr(|T| > |t|) = 0.02		Pr(T > t) = 0.99		

Finally, I checked if the stock market reaction towards announcements of green partnerships can be driven by other industry attributes, like technological turbulence. Strategic management literature traditionally explains variations in the stock market valuation of various types of strategic partnerships in reference to industry dynamism (Park *et al*., 2004; Song, Droge, Hanvanich, & Calantone, 2005). In volatile, rapidly changing high-tech industries, technology partnerships are more rewarded by investors, whereas marketing partnerships are more valuable in mature, slow-growth industries (Park *et al*., 2004).

The data set utilized in this dissertation includes a good mix of high and low-tech industries, as defined by the Bureau of Labour Statistics (Heckler, 2005). The green marketing sample includes of 152 partnerships announced by firms in operating low-tech industries and 83 partnerships announced by companies in high-tech economy sectors. The green technology sample comprises of 62 partnerships established by firms in low-tech and 45 by firms in high-tech industries.

Table 9. Study 1. Mean Difference Test for High-tech versus Low-tech Industries

Group	Obs	Mean	Std. Err.	Std.dev.	[95% CI]	
Low-Tech Industry (0)	196	0.0002	0.0008	0.0116	-0.0014	0.0018
High-Tech Industry (1)	146	0.0014	0.0011	0.0133	-0.0008	0.0035
combined	342	0.0007	0.0007	0.0123	-0.0006	0.0020
diff		0.0007	0.0007	0.0123	-0.0006	0.0020
diff = mean(0) -mean(1)		-0.0011	0.0013		-0.0038	0.0015
Ho: diff = 0		degrees of freedom=		340		
Ha: diff < 0		Ha: diff = 0		Ha: diff > 0		
Pr(T < t) = 0.1987		Pr(|T| > |t|) = 0.397		Pr(T > t) = 0.8013		

The mean difference tests conducted on the aggregate sample, as well as separately on the green marketing and green technology subsamples, show no statistically significant difference in mean abnormal returns for the low-tech versus high-tech industries for any of the event windows. The results for the aggregate sample are provided in Table 9. In the short-term perspective, irrespective of the industry's technological turbulence, announcements regarding green marketing partnerships consistently generate higher short-term abnormal stock returns than announcements about green technology partnerships do.

Next, I estimated the long-term abnormal returns on announcements of green partnerships, using a long horizon event study method. Due to the relatively small sample size, a one-year horizon was utilized (Kolari & Pynnonen, 2010). In line with literature and following the recommendations in a recent review of the methodological issues in long-horizon event studies (Ang & Zhang, 2011), I used both the buy-and-hold abnormal returns on a Fama-French benchmark and the calendar-time portfolio returns on a Fama-French benchmark, as discussed in the Chapter 3, Study 1 Research Methodology.

Table 10 shows the results of the analysis. No long-term abnormal returns were reported following the news of green marketing partnerships, using either of the estimation approaches. By contrast, the results for green technology partnerships show positive and statistically significant abnormal returns of 8.6% of a firm's market value if estimated with BHAR model, and 4% if estimated using a more conservative calendar-time portfolio with Fama-French benchmark model, within 1 year after the announcement. Despite the initial negative reactions of investors, those firms were still able to accrue financial returns following the green technology partnership announcements, but over a longer period of time. Thus, based on the results of short-term and long-term event studies, support for Hypothesis 1 is found.

Table 10. Study 1. Long-term Abnormal Returns 1 year after announcement

Partnership type	Post event Fama-French Calendar Time Portfolio approach, 1 year Returns (%)	Buy-And-Hold Benchmark approach, 1 year Returns (%)
Green technology partnerships	4.0*	8.6**
Green marketing partnerships	1.0	1.0

*n=342 **p<.05, *p<.1*

H3a (b): Firm's prior positive (negative) green performance will be positively (negatively) associated with a change in firm's stock market value in response to announcements of strategic green partnerships.

H4a: All other things being equal, industry pollution intensity is negatively related to the change in firm's stock market value in response to announcements of strategic green partnerships.

H4 b, (c): As the level of industry pollution intensity increases, a firm with more positive (negative) green performance in the past will experience lower (higher) returns to announcements of green strategic partnerships.

To test the hypotheses H3a, b and H4a, b, c, cross-sectional analysis is applied. In the observed data set, some firms announce once, while other do multiple announcements over the observed period 2005-2007. Thus, the data set includes a sample of multiple units (firms) and multiple observations (announcements) clustered with a unit. In this case, statistical approach must account for the inter-cluster correlation to avoid misleading statistical inferences. To address these issues, the regression with robust standard errors and clustered events deems appropriate.

The dependent variable is firm's abnormal returns on the day of announcement t=0. The explanatory variables are the Partnership type (green marketing vs. green technology), Industry Pollution Intensity, Firm's Past Positive Green Performance, Firm's Past Negative Green Performance, the interaction terms of Industry Pollution Intensity with the Past Green Positive and Past Green Negative Performance respectively, Firm Size (as estimated by firm sales), Firm Financial Leverage, Firm Reputation, Firm's Partnership Experience, Firm Book-to-market Ratio, Stock Market Beta, Mills Lambda, Dummy for a Partner Type (for profit vs. not-for profit), Dummy for a First Green Partnership, Dummy for Multi-firm Partnerships, Dummy for Partnerships with Regulators, Time, and Industry Effects. First, the model with the control variables only was used (Model 1), then the independent variables were added (Model 2, main effects), and finally a full model including the independent variables, the interaction term and the control variables was implemented (Model 3). Examination of the Pearson correlations (all below .5 as reported in Table 4) as well as multicollinearity diagnostics (variance inflation factors all below 6) suggests that multicollinearity should not be a problem (Meyers, Gamst, & Guarino 2006).

Table 11. Study 1. Stage 1 Heckman Selection Model

Dependent variable: Decision to engage in a green partnership	Coef.	Robust SE
Firm Age	0.01	0.00
Firm Financial Leverage	-0.10	1.83
Firm Market Share	2.26*	1.27
Industry Competitiveness	7.19***	2.72
Partnership Experience	-.40**	0.21
Environmentally Sensitive Industries	0.04	0.52
Industry Growth	-0.18	0.22
Firm Sales	1.76***	0.40
Firm Market Capitalization	-0.59**	0.26
Industry Dummies included		
Year Dummies included		
Constant	-10.45***	2.52
Pseudo R2	0.43	
Wald chi2(13)	46.66***	

****p<.01**p<.05, *p<.1*

Table 12. Study 1. The Effect of Firm Past Green Performance, Positive and Negative, and Industry Pollution Intensity on Stock Market Valuation of Green Strategic Partnerships

	Model 1		Model 2		Model 3	
DV: AR (day 0)	Coef.	Robust Std. Err	Coef.	Robust Std. Err	Coef.	Robust Std. Err
Partnership Type (Marketing=1)			4.54***	1.74	5.53***	1.73
Firm Sales	-1.87	1.90	-1.99	1.84	-4.33**	2.29
Firm Reputation	-0.95	1.15	-2.18**	1.13	-3.65**	1.19
Firm Partnership Experience	0.02	0.16	0.04	0.13	0.26**	0.15
Firm First Green Partnership	-5.77**	2.34	-7.13**	2.56	-6.59**	2.18
Firm Financial Leverage	-40.46**	16.77	-31.87**	15.17	-33.96**	14.43
Inverse Mills Ratio	2.31	4.68	5.05	4.42	2.78	4.27
Stock-market Betas	3.58	3.89	1.11	3.75	1.18	3.74
Firm Book-to-Market Value	12.20**	5.43	3.78	5.71	-1.11	4.67
For-Profit Partner dummy	4.98***	1.80	5.81***	1.87	6.36***	1.91
Partnership w/Regulators dummy	5.17**	2.45	5.09**	2.31	5.27**	2.27
Multi-firm Partnership dummy	-5.24**	2.52	-5.01**	2.36	-5.84***	2.19
Industry Pollution Intensity			-8.95***	2.44	-7.40***	2.85

Table 12 (continued). Study 1. The Effect of Firm's Past Green Performance, Positive and Negative, and Industry Pollution Intensity on Stock Market Valuation of Green Strategic Partnerships

	Model 1		Model 2		Model 3	
DV: AR (day 0)	Coef.	Robust Std. Err	Coef.	Robust Std. Err	Coef.	Robust Std. Err
Firm' Past Negative Green Performance			-0.10***	0.03	-0.20***	0.05
Firm' Past Positive Green Performance			0.00	0.04	-0.03	0.04
[Ind. Pollution Intensity] *[Firm Negative Green Performance]					0.02	0.08
[Ind. Pollution Intensity] *[Firm Positive Green Performance]					-0.39***	0.11
Year Dummies	included		included		included	
Industry Dummies	included		included		included	
intercept	19.46	20.83	27.56	22.79	63.80***	30.88
Observations	208		201		201	
R-square	0.12		0.16		0.19	
F	2.23***		11.01***		11.90***	

****p<.01**p<.05, *p<.1*

Analysis of the results (Table 11) shows that the full model performed best explaining 19 % of variance in stock market abnormal returns in response to green partnership news. The Partnership Type variable (1 if a marketing partnership category) was a positive and significant determinant of AARs ($p<.05$), which supports hypothesis H2. Consistent with the results of the event study, in the short run, on average, green marketing partnerships generated higher abnormal returns than green technology partnerships. Similarly, a Firm's Past Negative Performance variable was negative and significant ($p<.01$), which supports Hypothesis H3b. The impact of an announcement of a green strategic partnership on a firm stock market value was lower if a firm had a history of poor environmental performance. Contrary to expectations, I did not observe significant effects of a Firm's Past Positive Performance variable on stock market valuation of green partnership. Thus, Hypothesis H3a was not supported. The potential reason for not observing the significant effects might be that stock market does not consider those announcement as novel information. A firm's prior positive green performance indicates that it has been consistently working on improving environmental performance. A firm's proactive environmental position has already been ingrained in investors' minds and built into their expectations of a firm's future cash flow. Announcement of one more environmentally positive action is consistent with the status quo and does not change the stock market valuation of a firm.

The Industry Pollution Intensity variable was negative and significant determinant of AARs (*p<.05*), supporting Hypothesis 4a which stated that as industry pollution intensity increases, firms experience lower abnormal returns. Furthermore, I found the interaction term of the Industry Pollution Intensity and Firm's Past Positive Green Performance negative and significant *(p<.05)*, confirming that the negative impact of the industry pollution intensity on AARs would be stronger for the firms with a history of positive environmental performance in the past. Thus, Hypotheses 4b was supported. Finally, the interaction term of the Industry Pollution Intensity and Firm's Past Negative Green Performance was not significant, although the direction was as predicted. Hypothesis H4c was not supported. The potential explanation for not observing the significant positive effects might be that although stock markets can interpret those announcements as promises of higher revenues and lower fines and liabilities in the future, the costs of environmental improvements in the presence of high pollution levels escalate so fast that cancel out all the positive effects.

In addition to the predicted effects, I also obtained insights regarding the additional factors that affect stock market valuation of green partnerships. Thus, the Firm Sales variable was negative and significant *(p<.01*), suggesting that bigger firms gain less from announcements of green partnerships. Surprisingly, the Firm Reputation variable was negative and significant (*p<.05*), indicating that firms with strong reputations might not benefit as much from green CSR. The Partnership Experience variable was positive and significant (*p<.05),* which is consistent with the established view in the strategy literature that firms with stronger partnership capabilities are able to select most attractive partners and engage in partnerships with higher value creation potential. The dummy First Green Partnership was negative and significant ($p<.05$), suggesting that stock markets remain conservative about green collaborations and might penalize firms that are unexperienced specifically with green partnerships, even though those firms might have a history of partnership management in the past. The Firm Financial Leverage variable was negative and significant ($p<.05$), indicating that as firm debt increases, investors become more wary about firm investments into environmental sustainability. The dummy For-profit Partner was positive and significant ($p<0.01$), suggesting that investors more favor partnerships with for-profit organizations rather than with NGOs, activist groups and local communities. The dummy Partnership with Regulators was positive and significant ($p<0.05$), which might be interpreted in a way that investors perceive those partnerships as government-endorsed arrangements with more legitimacy and lower investment risks, implying increased cash flow in future. The dummy Multi-firm Partnership was negative and significant (($p<0.05$), indicative of investors becoming more skeptical about green partnerships with more than two partners.

I also re-estimated the model in Table 12 for the event window (0; +1). Six out of seven parameters relating to the hypotheses remained stable in terms of direction and significance. The effect of industry pollution intensity became non-significant, but the sign preserved as hypothesized.

4.3. Additional Robustness Tests

To further increase confidence in the results, I did various robustness checks.

1. Robustness to the alternative estimation periods, event study

I estimated abnormal returns with Market Index model over alternative estimation periods, from 300 to 46 days and 260 to 10 days before the event day. The results of the event study replicate those given in Table 6.

2. Robustness to the alternative estimation model, event study

I estimated firm’s abnormal returns with the alternative Fama-French-Carhart four-factor model which adds three additional risk factors (return differential between portfolios of small and big capitalization stocks, return differential between portfolios with high and low book-to-market ratio stocks, and return differential between portfolios with high and low prior-return stocks) to the market model (Carhart, 1997; Fama & French, 1993). The results (Table 13) were similar to those of the Market Index model (Table 6), confirming that on the announcement day t=0, in both partnership categories, stock markets report statistically significant abnormal returns towards announcements of green partnerships. However, when the event window (0: +1) is chosen, green technology partnerships report non-significant non-parametric rank test, which suggests that the results might be driven by some influential outliers. This confirms that the average abnormal returns AARs observed on the day of an announcement t=0 are most appropriate to be used as a dependent variable in cross-sectional analysis.

Table 13. Study 1. Green Strategic Partnerships, Cumulative Abnormal Returns over Different Event Windows ($-t_1;+t_2$), Fama-French-Carhart four-factor model

	Green Marketing Partnerships				Green Technology Partnerships			
Event Window	N	Mean CAR, %	Portfolio Time-Series CDA t	Rank test	N	Mean CAR, %	Portfolio Time-Series CDA t	Rank test
(-1,+1)	235	0.2	1.63*	0.79	107	-0.16	-0.86	-0.39
(0,+2)	235	0.30	2.45***	1.69**	107	-0.05	-0.28	-0.97
(-1,0)	235	0.13	1.29*	0.67	107	-0.16	-1.01	0.58
(0,0)	***235***	***0.20***	***2.85****	***1.75***	***107***	**-0.22**	**-1.98**	**-2.52***
(0,+1)	***235***	***0.28***	***2.72****	***1.53**	***107***	**-0.22**	**-1.44**	**-0.78**

3. Robustness to the alternative estimation model, cross-sectional analysis

I also checked the regression results for hypotheses H3a, b and H4 a, b, c, with a mixed linear model with random effects. A mixed linear model design deems appropriate in this case as it allows to account for unobserved heterogeneity in the effects of explanatory variables on the dependent variable and to control for the correlated errors among multiple observations nested within firms over time. The additional advantage of the mixed model design is that it allows for partitioning the variance to explore what its sources are.

I specified a mixed model with random intercepts and random slopes reflective of the individual firm and time effects and a set of covariates, similar to the model in Table 10. I estimated it with Restricted Maximum Likelihood (REML) estimation procedure (Muller, Sceally, & Welsh 2013). To examine goodness of fit and identify the best model specification, I tested the baseline Model 1 including only control variables vs. Model 2 with controls and main effects only vs. full Model 3 with the controls, the main effects and the interaction terms. To compare the models, I used traditional log-likelihood estimator and Bayes Information Criterion (BIC) (Schwarz, 1978) estimator. The additional advantage of BIC is that it takes into account the number of estimated parameters and penalizes more complex models, leading to the optimal parsimonious model design. The model specification that minimizes the log-likelihood and BIC estimators indicates the model that best fits the observed data.

The results indicated that Model 3 which included the controls, main effects and the interaction terms and allowed to decompose the direct effects of the industry pollution intensity levels and a firm's past environmental performance, positive and negative, performed best, reporting the lowest log-likelihood and BIC estimators. The results of the mixed linear model (Table 14) replicated those of the regression with robust standard errors and clustered events (Table 12).

Table 14. Study 1. The Effect of Firm's Past Green Performance, Positive and Negative, and Industry Pollution Intensity on Stock Market Valuation of Green Strategic Partnerships. Mixed Linear Model

Estimates of Fixed Effects

DV: AR (day 0)	Estimate	Std. Error
Intercept	56.81*	28.59
Green Marketing Partnership	5.94***	1.92
Firm Sales	-3.39*	2.41
Firm Reputation	-3.77**	1.39
Firm Partnership Experience	1.09	1.94
Firm's First Green Partnership	-5.99**	3.34
Firm's Financial Leverage	-29.63**	15.73
Inverse Mills Ratio	4.38	5.61
Partner (for-profit =1)	3.67**	1.83
Partnership with Regulators		
Multi-firm partnership	-5.23*	3.27
Betas	-0.46	3.46
Firm book-to-market value	-0.52	7.41
Industry Pollution Intensity	-6.28*	5.13
Firm's Past Negative Green Performance	-0.18***	0.06
Firm's Past Positive. Green Performance	-0.04	0.06
[Industry Pollution Intensity] *[Firm' Past Negative Green Performance]	0.00	0.11
[Industry Pollution Intensity] *[Firm's Past Positive Green Performance]	-0.37***	0.15
Random Effects		
Residual	1.44	0.17***
Variance σ2	1.30	4.68

****p<.01**p<.05, *p<.1*

4. Robustness to a more conservative coding approach with respect to the marketing partnerships.

The definition of marketing partnerships used in the study describes those as agreements focusing on the value chain activities related to promotion of products and services, brand building, penetration of new markets, customer acquisition and retention (i.e. Park, Mezias & Song 2004; Moorman & Swaminathan, 2009). Based on this definition, the data set includes a substantial portion of partnerships that can be characterised as green philanthropy partnerships, where organizations partner with local communities for environmental benefits of the latter. The example would be a partnership of a manufacturer and a local municipality to convert an old manufacturing site into a city park with financial support of the former or a partnership of the oil company and a local schoolboard to help the city to refurbish school busses with pollution control equipment. Although it can be argued that those partnerships contribute to a "greener" firm image among stakeholder community and can lead to greater firm revenues and profits, those partnerships do not satisfy more conservative definitions of marketing partnerships adopted in marketing literature and focusing primarily on the down-stream value chain activities (i.e. Bucklin & Sengupta, 1993). To check if the study results are sensitive to these definitional nuances, I removed the green philanthropy partnerships from the marketing sample and re-estimated the model. The reduced sample comprised 190 green partnerships, including 83 marketing and 107 technology partnerships. The results of the event study replicated those of the full sample (Table 15). With regards to cross-sectional analysis, all the model parameters relating to the hypotheses also remained stable in terms of direction and significance (Table 16).

Table 15. Study 1. Green Partnerships, Cumulative Abnormal Returns over Different Event Windows ($-t_1$, t_2), Market Index Model. Reduced Sample due to a more conservative coding approach.

	Green Marketing Partnerships				Green Technology Partnerships			
Event Window	N	Mean CAR,%	Patell Z	Generalized Sign Z	N	Mean CAR, %	Patell Z	Generalized Sign Z
(-7, +7)	83	0.84	1.63	0.96	107	0.04	0.79	0.93
(-6, +6)	83	0.55	1.05	0.96	107	-0.09	0.34	0.55
(-5, +5)	83	0.50	1.08	1.62	107	-0.09	0.28	0.74
(-4, +4)	83	0.39	0.98	1.40	107	-0.25	-0.18	0.16
(-3, +3)	83	0.69	1.84*	2.94**	107	-0.12	0.14	-0.03
(-3, +2)	83	0.75	2.40**	2.06*	107	-0.16	-0.11	0.35
(-2, +3)	83	0.71	2.01*	2.28*	107	-0.20	-0.21	0.35
(-2, +2)	83	0.77	2.64**	2.50**	107	-0.24	-0.52	0.16
(-1, +2)	83	0.54	2.19*	1.84*	107	-0.09	0.14	1.13
(-2, +1)	83	0.62	2.43**	3.16***	107	-0.39	-1.37	-1.774*
(-1, +1)	83	0.40	1.93*	2.28*	107	-0.24	-0.76	-0.23
(-1,0)	83	0.6	3.07**	2.06*	107	-0.16	-0.66	-1.774*
(0)	***83***	***0.31***	***2.68******	***3.38*******	***107***	***-0.25***	***-2.03****	***-1.97****
(0, +1)	**83**	**0.49**	**3.01***	**2.50****	**107**	**-0.32**	**-1.94***	**-1.77***
(0, +2)	83	0.63	3.07*	2.06**	107	-0.16	-0.66	-1.774*

******p<.01**p<.05, *p<.1*

Table 16. Study 1. The Effect of Firm's Past Green Performance, Positive and Negative, and Industry Pollution Intensity on Stock Market Valuation of Green Strategic Partnerships

Reduced sample due to a more conservative coding approach

	Model 3 (Full Model)	
DV: AR (day 0)	Coef.	Robust Std. Err
Partnership Type (Marketing=1)	4.95**	2.60
Firm Sales	-10.23***	2.50
Firm Reputation	-1.88	1.45
Firm Partnership Experience	0.70***	0.21
Firm's First Green Partnership	-5.69**	2.39
Firm's Financial Leverage	-47.34***	17.62
Inverse Mills Ratio	-7.09	4.91
Betas	11.49**	4.77
Firm Book-to-Market Value	5.26	6.16
Partner (for-profit =1)	7.06***	2.70
Government Endorsement (yes=1)	5.97**	3.33
Multi-firm partnership	-8.19*	5.17
Industry' Pollution Intensity	-19.17***	3.92
Firm' Past Negative Green Performance	-0.25***	0.06
Firm' Past Positive Green Performance	0.01	0.06
[Ind. Pollution Intensity] *[Firm' Negative Green Performance]	0.11	0.09
[Ind. Pollution Intensity] *[Firm Positive Green Performance]	-0.42***	0.14
Year Dummies	included	
Industry Dummies	included	
intercept	93.96***	34.41
Observations	120	
R-square	0.378	
F	15.48***	

****p<.01**p<.05, *p<.1,*

Chapter 5

Study 1 Discussion

In Study 1, I explore the effects of public announcements of green strategic partnership on a firm's stock market value. Firms today face mounting pressure from multiple stakeholder groups to give consideration to environmental concerns. However, whether environmental initiatives are beneficial for a firm's financial performance remains unclear (Margolis et al 2009).

The results of Study 1 provide empirical support for the importance of investing in green inter-organizational strategies. Green collaborations can be instrumental in addressing the environmental objectives of a firm, and have a positive effect on firm stock market valuation. However, not all green strategic partnerships have an immediate positive economic impact. A major insight of this study is that stock markets are selective in reacting to announcements of green strategic partnerships and some of those initiatives can, in fact, destroy shareholder value.

Further examination of variation in investor reactions reveals that the ultimate effect is contingent on the partnership type (green marketing versus green technology), environmental profile of a firm - past positive and negative environmental performance- and environmental characteristics of the industry, such as pollution intensity levels. The results demonstrate that announcements of green marketing partnerships have an immediate positive impact on firm market value. The stock market appears optimistic about environmental trends in the market and rewards the firms that deliver green value to consumers. These results are similar to those observed in another event study analyzing the effect of environmental excellence on the firms' bottom lines, reporting comparable cumulative abnormal returns (+.63%) for a 3-day event window (Klassen & McLaughlin, 1996).

By contrast, announcements of green technology partnerships have an immediate negative impact on a firm's stock market value. Investors seem conservative about the potential of green technology partnerships to create environmentally-friendly technologies that would be superior to the conventional, often cheaper alternatives in the market (Horbach, Rammer, & Rennings, 2012). This finding is consistent with prior studies suggesting that stock markets might be unable to immediately recognize value of innovation and incorporate it into firm market price gradually, as more information related to it becomes available (Sorescu, Shankar & Kushwaha 2007; Soresku & Spanjol 2008).

Despite the initial negative stock market reaction to green technology partnerships, after a one-year period those firms experience an increase in stock market value. Empirical studies in inter-organizational literature contend that it typically takes approximately one year for technology partnerships to develop a technology and patent it (see, for example, Ahuja, 2000; Phelps, 2010). Once a novel technology is created, a firm leverages marketing capabilities to commercialize and bring green innovation to market, which is recognized and rewarded by investors. This is also supported by the observed complementary effects - greater joint returns relating to joint exercising marketing and technology capabilities for eco-based competitive advantage, in terms of their impact on a firm's market value (Christmann, 2000; Moorman & Slotegraaf, 1999). The firms that announce both green marketing and green technology partnerships consistently outperform the firms engaging in one or another type of green partnership only. To the extent that technology capabilities originate in attending and responding to consumer needs, marketing capabilities facilitate the development and exploitation of technology capabilities, together creating a synergy and enhancing a firm's green performance (von Hippel, 1978).

Industry's environmental profile is an important determinant of investors' valuation of green strategic partnerships. As level of industry pollution intensity increases, stock markets get more pessimistic regarding the prospects of a partnership to generate positive returns for a firm. Furthermore, firms' past environmental performance, positive and negative, also plays a role in shaping investor sentiment towards strategic green partnerships. Stock markets are very sensitive to information about firms' past green misdeeds, but, surprisingly, remain irresponsive to information about firms' positive green behavior. Investors keep reservations about firms' voluntary environmental efforts beyond mere compliance and even penalize those environmentally responsible firms performing in excessively polluting industries. This finding runs counter some earlier studies suggesting that firm reputation for positive environmental performance can serve as 'reservoir of goodwill', reduce firm-specific risks and volatility and protect an organization in times of financial crisis (Schnietz & Epstein, 2005). Contrary to that, this study highlights the fact that 'doing bad' might hurt an organization more than 'doing good' helps it. To minimize financial losses, firms need to pursue positive environmental performance across all business domains and avoid negative environmental approaches altogether.

Green partnerships with for-profit organizations, including suppliers, distributors, competitors and buyers, generate higher abnormal returns than the partnerships with not-for-profit organizations such as government agencies, local municipalities, NGOs, or universities. In general management literature, the argument regarding the distinction between profit-oriented and nonprofit-oriented organizations is that the former are generally funded through commercial operations in the markets and, thus, are more influenced by competitive dynamics, whereas the latter are funded via public sources and, thus, are heavily driven by political and institutional considerations (Fottler, 1981; Boyatzis, 1982). The findings of Study 1 are in line with this argument. In comparison to nonprofit-oriented organizations, for-profit firms are more likely to develop organizational capabilities creating long-term competitive advantage. For-profit firms leverage those capabilities in green strategic partnerships, which is recognized by investors, leading to an increase in a firm's stock market value.

Summary of the key results are provided in Table 17.

Table 17. Study 1. Predicted Effects and Findings

Independent Variable	Hypothesis	Sign	Findings
Announcement of green partnership	H1	+	+
Returns to green marketing partnerships > Returns to green technology partnerships	H2	+	+
Firm Prior Positive Environmental Performance	H3a	+	n.s.
Firm Prior Negative Environmental Performance	H3b	-	-
Industry Pollution Intensity	H4a	-	-
Industry Pollution Intensity * Firm Prior Positive Environmental Performance	H4b	-	-
Industry Pollution Intensity * Firm Prior Negative Environmental Performance	H4c	+	n.s.

One of the interesting findings of Study 1 relates to a shift in investor sentiment regarding the green technology partnerships over time. Why does initial investor skepticism materializing in immediate average 0.28% drop in a firm's stock market price, later turn into positive expectations manifested in dramatic 4% increase in firm stock market value over 1-year period? One possible explanation could be that stock markets re-adjust valuation of those partnerships, based on new information signaling that firms were able to achieve their goals and create a new green technology. Information indicative of a firm's technological success might be news about green technology patents a firm has applied for.

So, what are the drivers behind firm green innovation in strategic partnerships? Do green partnerships help firms create more green innovation?

Some firms actively engage in green technology partnerships. Other prefer to create green innovation in-house, while maintaining network of non-green technology partnerships. Do firms create green innovation because they engage in green-focused partnerships? Because they get connected to a global industry-level network of relationships, where environmental knowledge circulates? How is the propensity of a firm to create green innovation affected by the properties of a firm's network of partnerships (i.e. green/non-green) and the properties of global network of partnerships existing in the industry?

I explore those issues by examining green patenting activities of firms involved in complex networks of technology collaborations, both green and non-green, in the chemical industry. The choice this economy sector was conditioned by the high-tech nature of the chemical industry and the fact that chemical firms actively patent their inventions and engage in technology partnerships (Ahuja 2000). Chemical firms were a part of the data set in Study 1, and stock market reaction towards announcements of those green technology partnerships was similar to the one in the other industry sectors examined, as confirmed by non-significant mean difference test.

Chapter 6

Study 2

Green Innovation in Technology Networks in the Chemical Industry

Building on the social networks and environmental corporate social responsibility (CSR) literatures[1], I propose a model that links firm propensity to create green innovation to the attributes of networks of technology partnerships. The patterns and predictors of firm green patenting activities are explained, based on the knowledge resource attributes and the structural properties of networks of technology partnerships at the firm and industry level. I also propose a novel multidimensional conceptualization of the construct of knowledge heterogeneity in a firm network to explain conflicting results in the empirical literature regarding the impact of knowledge heterogeneity on firm innovation.

The hypothesized models are provided in Figures 4 and 5.

[1] Environmental CSR literature here refers to the stream of research that focuses on the environmental aspects of corporate social responsibility practices, as opposed to the diversity, governance, employees, community, and product-related issues also explored within the CSR domain (Cronin et al 2011, Mishra & Modi, 2015).

Figure 4. Study 2 Theoretical Model. Firm Network Level

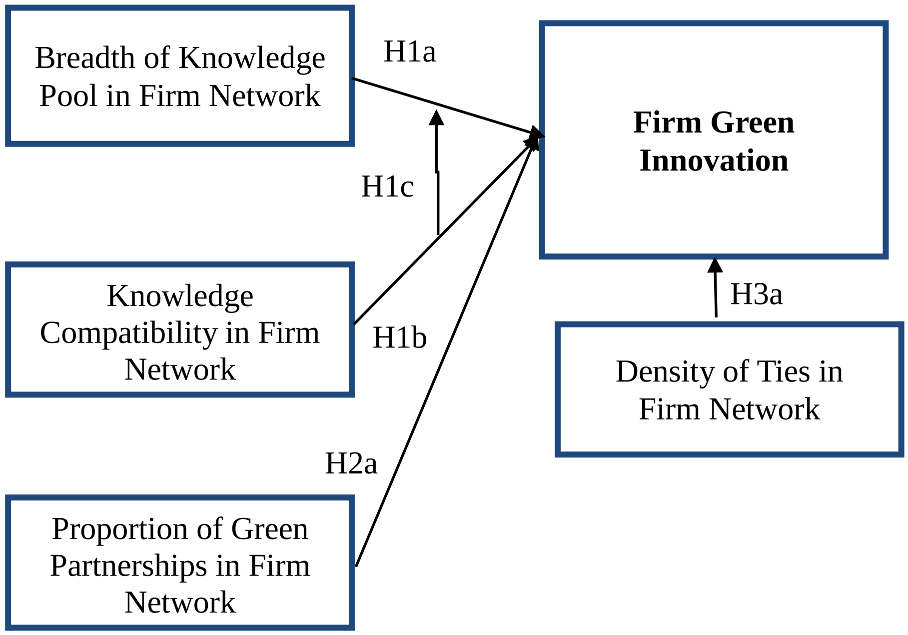
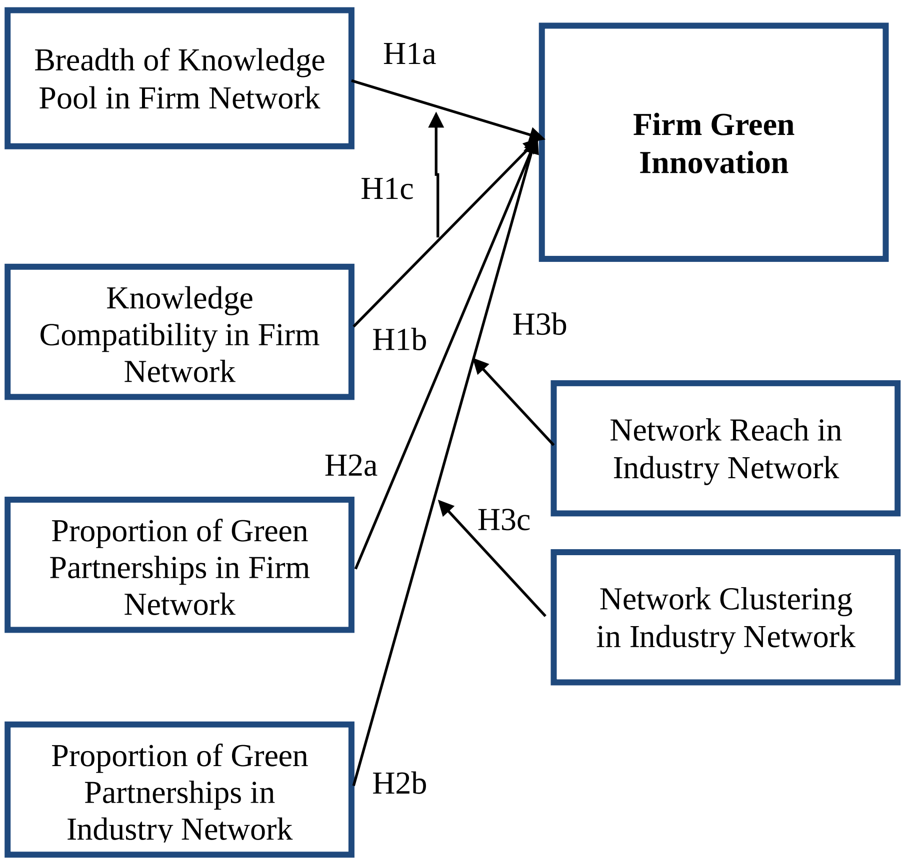


Figure 5. Study 2 Theoretical Model. Industry Network Level



Theory Development

6.1. Firm innovation in inter-organizational networks

The importance of environmental agendas for businesses has been rising exponentially for the last decades. One of the ways organizations incorporate green considerations in their strategies, while building eco-based competitive advantage, is through environmental innovation (Popp, Newell & Jaffe, 2009).

In general management literature, innovation is often defined as a process of knowledge creation based on a search and discovery of novel opportunities (March, 1991). Environmental innovation specifically is innovation that allows to avoid or reduce environmental impact (Horbach 2008; Rio et al 2015).

Knowledge creation takes place, when social actors refine existing knowledge resources or when they explore distant and unrelated knowledge domains (Ahuja, Lampert, & Tandon, 2008; Lavie & Rosenkopf 2006). A long line of research in strategy and general management literature suggests that organizational innovation is a result of novel re-combinations and re-configurations of organizational knowledge for a purpose of solving organizational problems (Schumpeter, 1934).

No firm has all the resources necessary to survival and growth, and companies undertake external search to get the required inputs (Penrose, 1959). When those inputs are not easily transferable in pure market transactions, i.e. because they are mingled with other firm resources, strategic partnerships may be an avenue to pursue (McEvily & Marcus, 2005). In the context of firm innovation, inter-firm collaborations have been traditionally used to access knowledge that firms do not possess (Cui & O'Connor, 2012; Rindfleisch & Moorman, 2001). In partnerships, partners get access to heterogeneous knowledge resources of each other, which effectively increases the scope and diversity of information elements available for further re-combinations and search (Hoffman, 2007). Benefits of collaborative knowledge creation further propagate as firms engage in multiple partnerships (Gulati, 1999). As their portfolios of partnerships expand, firms get access to an increasingly diverse knowledge pool, become more flexible in learning strategies and more receptive to novel, "unconventional" information, a source of innovative ideas (Inkpen, 1998; Jensen & Nybakk, 2013; Swaminathan & Moorman, 2009).

As environmental innovation becomes more prominent in the marketplace, organizations increasingly use inter-firm partnerships to manage green innovation projects (Horbach, 2008). According to recent research, technology collaborations become more popular in the green than in the other technological domains (Belin et al 2012; De Marchi, 2012; Rio et al 2015). Recently a number of studies on firm green strategies have shown that partnerships with stakeholders for environmental and social benefits can foster organizational learning and lead to a better firm performance (Arya & Salk 2006; Cuerva, Triguero-Cano & Córcoles 2014; Rome & Wijen 2006). Yet, most of those publications are case studies that analyze green partnerships at the firm level and "often do not explicitly address the mechanisms through which influencing factors affect innovative capacities" (Boons & Lüdeke-Freund, 2013).

An emerging stream in environmental management literature advocates the relevance of the social networks perspective for analysis of firm environmental performance. Complex and far-reaching consequences of environmental concerns have provoked the need for more frequent and meaningful interactions between businesses and stakeholder communities (Roome, 2001). Networks are envisioned as structures enabling diverse social agents like firms, stakeholders, government agencies, local communities to collaborate and coordinate efforts to achieve sustainability objectives and create environmental and social value (Bodin, Crona, & Ernstson, 2006; Öberg, Huge-Brodin, & Björklund, 2012).

However, involvement into networks is not a guarantee of success. The concept of inclusiveness of sustainable development and, as follows, diversity in the networks working towards sustainability goals may lead to lack of clarity of purpose, not completely aligned goals of participants, and poor selection of key actors (Del Rio et al, 2011). Firms need a better understanding of how to leverage inter-organizational networks to maximize green innovation and enhance environmental and social benefits.

Social networks analysis offers a robust framework for analysis of an innovation phenomenon, and green innovation in particular, in complex inter-organizational relationships. The theory builds on the notion that firm performance is influenced by the context and structure of its relationships (Dyer

& Singh 1998; Powell & Smith-Doerr, 1994). It assumes that the prime function of networks is to channel information among network members (Ahuja, Lampert & Tandon, 2008; Gulati 1998) and identifies network properties that influence firm innovation (Stinchcombe, 1990). In the context of innovation literature, diversity of knowledge resources accumulated in a network (Reagans & McEvily 2003, Rodan & Galunic, 2004; Sampson, 2007) and network structure attributes (Ahuja 2000; Burt 1992; Owen-Smith & Powell, 2004) were shown to be important determinants of firm innovation. For clarity of the discussion, hereafter the firm network relates to the focal firm and its partners; the industry network relates to the global network of partnerships in the industry.

6.2. Knowledge attributes and green innovation in inter-organizational networks.

Knowledge diversity or else knowledge heterogeneity has been identified as one of the driving factors of firm innovation in inter-organizational relationships (Rodan & Galunic, 2004; Shilling & Phelps, 2007). I propose that in the green innovation context, knowledge heterogeneity, as well as knowledge specificity, green versus non-green, are the important determinants of firm green innovation.

6.2.1. Knowledge heterogeneity

Inter-organizational networks bring together a variety of firms with diverse sets of skills and competencies. A degree to which a network involves partners with non-redundant knowledge resources is defined as knowledge heterogeneity in social networks literature (Burt, 1992, Corsaro et al., 2012). Heterogeneity of knowledge in a network increases firm exposure to novel information and enables it to identify and discover emerging opportunities faster and more efficiently through new transformations and re-combinations of knowledge elements (Fleming 2001, Uzzi et al, 2013).

Despite the decades of research, empirical literature provides mixed results about the role and impact of knowledge heterogeneity on firm innovation. Some studies show that organizational ability to create innovation is positively related to a variety of knowledge stocks accumulated in a firm network (Phelps 2010; Rodan, 2002; Rodan & Galunic 2004; Wuyts et al, 2004). Other studies report a curvilinear relationship between the two (Gilsing et al 2008; Sampson 2007; Swaminathan & Moorman 2009). Some advocate a negative relationship on the grounds that knowledge heterogeneity in a network can lead to information asymmetries and increased transaction costs, thus restraining organizational innovation (Goerzin & Beamish 2005, Jiang, Tao, Santoro (2010); Kaplan & Tripsas, 2008).

A review of theoretical developments in social networks literature also reveals some ambiguity in the conceptualization of knowledge heterogeneity. Some authors define it as a function of diversity or 'non-overlap' - how many distinctive knowledge elements are accumulated in a network and available for further re-combination and transformations (e.g. Swaminathan & Moorman 2009, Wuyts, Dutta & Stremerch 2004, Oerlemans et al. 2013). Other scholars emphasize a relatedness of partner knowledge bases and their ‘combinatorial potential’- synergies arising from combining related, but not identical knowledge resources of partners (e.g. Dyer & Singh 1998; Gilsing et al 2008, Makri, Hit & Lane, 2010).

Definitional ambiguity along with inconsistencies in empirical findings might be attributed to a limited perspective on the phenomenon of knowledge heterogeneity and neglecting its multidimensional nature. Wassmer (2008, p.163) notes that “the ongoing issue with existing research on partnership portfolio configurations is that the operationalization of key constructs …is mainly one dimensional … and is of limited use”. A recent meta-analytical review on the diversity in alliance portfolios and firm performance by Lee, Kirkpatrick-Husk, & Madhavan (2014) also points to a lack of clarity about what diversity exactly is and suggests there might be many aspects of diversity. The idea of multiple dimensions of knowledge heterogeneity represents a promising research opportunity. In this dissertation, I propose a two-dimensional conceptualization of knowledge heterogeneity. Analysis of different configurations of the dimensions can shed new light on the role and contributions of the phenomenon of knowledge heterogeneity to firm innovation.

Although diversity and relatedness of knowledge resources represent closely connected ideas, they are theoretically distinct. The dimension of knowledge diversity (or breadth of knowledge pool) reflects the array of unique knowledge elements accumulated in the network, but it does not account for the “distances” between them (Sampson 2007). It rather assumes all knowledge stocks equally distant. The dimension of knowledge relatedness (or knowledge compatibility) reflects how distant firms’ knowledge bases, but does not capture the whole spectrum of knowledge stocks available in a network. The two dimensions play distinct, although complementary roles and both should be included into analysis for a more nuanced understanding of the effects of knowledge heterogeneity on firm innovation.

Dimension 1: Breadth of knowledge pool in the firm network reflects to what extent a system consists of uniquely different elements. Effectively, it captures a total ‘combinatorial space’ in a network (Fleming, 2001). The broader the array of alternative knowledge stocks available in a network, the greater the variability of search and the more opportunities for novel re-combinations and transformations exist and the greater the firm capacity to generate novel knowledge (Ahuja & Katila, 2001, Singh & Fleming, 2010).

Dimension 2: Knowledge compatibility relates to how well the distinctive knowledge elements can be combined (Quintana-Garcia & Benavides-Velasco 2010). Combined, partners’ knowledge bases create synergistic effects of greater learning rents than the sum of learning rents obtained by the firms, if utilized individually (Dyer & Singh, 1998). Compatibility of knowledge resources can vary on the continuum from zero to an absolute value and depends on the cognitive distances among knowledge stocks. In the organizational context, a cognitive distance relates to the differences in organizational focus, interpretation systems and values firms hold (Nooteboom, 2000). Similar knowledge resources are characterized by small cognitive distances and can be easily combined. But they have little to no new combinatorial value and cannot be a source of novelty. Perfectly dissimilar knowledge resources bring in a lot of novelty, but they are cognitively distant, with low chances for new re-combinations because partners suffer from information overload, confusion and diseconomies of scale associated with management of multiple unfamiliar and disconnected streams of knowledge (Ahuja & Lampert 2001; Schildt, Maula & Keil, 2005). Thus, perfectly similar and cognitively close knowledge resources, as well as highly distinct and cognitively distant knowledge bases of partners have an adverse effect on firm innovation. Partial (dis)similarity is desirable and ensures that knowledge elements are different enough to enable free experimentations and re-combinations and, at the same time, share some commonalities to facilitate inter-partner knowledge integration.

The attribute of breadth of knowledge pool in firm network reflects all theoretically possible combinations of firms' resources. The attribute of knowledge compatibility reflects a potential of each of those combinations to generate novel meaningful insight. Both attributes are important for understanding the effects of network knowledge heterogeneity on firm innovation. A deficit of breadth of knowledge pool reduces the total spectrum of potential re-combinations. Too low or too high knowledge compatibility limits partner chances for effective detecting, evaluating, and synthesizing each other's knowledge resources. Furthermore, the effect of the breadth of knowledge pool on firm innovation is conditional on the degree of compatibility of partners' knowledge resources. As cognitive distances among knowledge stocks increase and compatibility decreases, the combinatorial potential of a broad knowledge pool in a network will diminish because of increasing complexity and costs associated with recombination of multiple distant knowledge elements. Based on that,

H1a: Breadth of knowledge pool accumulated in a firm network positively relates to firm green innovation.

H1b: Compatibility of knowledge resources accumulated in a firm network has an inverse U-shaped relationship with the green innovation of the firm.

H1c: The positive effect of the breadth of a knowledge pool on firm green innovation decreases as compatibility of knowledge resources in a network decreases.

6.2.2 Knowledge specificity as a 'greening' factor in a network

The degree to which knowledge is tailored to the requirements of a specific functional domain, refers as knowledge specificity (Galunic & Rodan, 1998). Knowledge is domain-specific if it is maximally effective within the domain, but might lose in value outside the domain boundaries (Luca & Atuahene-Gima, 2007). Simple examples of a domain-specific knowledge would be knowledge related to firm R&D versus knowledge related to consumer characteristics versus knowledge related to idiosincrases of the industry environment (Simonin, 1999).

Extant literature provides evidence that knowledge specificity can affect organizational innovation in a variety of ways and at multiple levels. At the individual level, it drives searching behavior and affects the way how people process information, i.e. art versus technology-related information (Rouet, 2002). At the firm level, the content and specificity of knowledge influence the quality of knowledge-sharing routines among organizational units and affect firm innovation outcomes (Haas & Hansen, 2005; Luca & Atuahene-Gima, 2007). At the dyadic level, domain-specific knowledge of partners helps reduce costs of information processing, improving joint product development (Sun, 2008).

The role of knowledge specificity remains mostly unexplored at the network level. Both Brenner (2007) and Phelps, Heidl, & Wadhwa (2012) note that networks literature tends to ignore the issue of how different types of knowledge are transferred in inter-organizational knowledge exchanges and urge for more research into the issue. Recently, scholars started examining the role knowledge specificity plays in inter-organizational networks. For example, Sammarra & Biggiero (2008), in a small-scale study, explore how domain-specific knowledge, technological versus market versus managerial, is transferred in high-tech networks in the aerospace industry. They found that partners often bundle various types of knowledge, which points to the interconnectedness of the technological and administrative dimensions of knowledge creation. The authors conclude that knowledge specificity can be an important factor in explaining a variance in performance outcomes in complex inter-organizational relationships.

I further build on the notion of knowledge specificity in the context of inter-organizational networks and propose that knowledge specificity, i.e. green vs. non-green knowledge, can be an important determinant of firm green innovation.

Recent studies in the environmental CSR literature suggest that green innovations might be different from other, non-green, innovations in several aspects (Cainelli et al, 2015; De Marchi 2012, Horbach 2008). Green innovations tend to be more complex and require inputs from a diverse set of sources (Rennings & Rammer, 2009). They often need external knowledge and expertise linked to the alternative materials, inputs, and production processes and involve more basic scientific research (De Marchi, 2012). Finally and most important, green innovations, more than many other technological domains, are influenced by government policies (Belin et al 2011; Horbach 2008; Porter & van der Linde, 1995).

Green industries represent a unique sector of the economy that faces substantial regulatory and normative pressures (Jaffe, Newell, Stavins 2002; Norberg-Bohm, 1999). At a minimum level, a green technology must comply with environmental policies imposed by governments. The objective of environmental policies is to raise incentives for firms to minimize the external costs of harmful consequences of economic activities on the environment (Popp, Newell & Jaffe, 2009).

Green regulations are very complex, detailed and define both the goals of regulations and also the processes of achieving those goals (Jaffe & Palmer, 1997). Furthermore, environmental policies are increasingly stringent. As overall level of environmental performance in the industry improves, regulations are periodically reviewed and revised to incentivise companies for even more sustainable efforts. A recent study conducted by the Economic Department of OECD shows that stringency of environmental policies has been steadily increasing across countries over the last two decades (Abruzzo et al 2014). Ever changing policies and regulations make environmental standards a moving target that requires ongoing monitoring and continuous learning.

In addition to formal policy instruments, there are normative pressures for firms to become more environmentally sustainable, as well. To be qualified as eco-friendly and get endorsement from reputable environmental organizations, a technology must exceed the mandatory standards and satisfy even tougher environmental benchmarks promoted by environmental activist groups and NGOs (Popp, Newell & Jaffe, 2009).

In this context, knowledge of institutional and normative mechanisms pertinent to the environmental domain becomes an important determinant of organizational survival (Porter & van der Linde, 1995). Firms operating in the green sectors must develop unique frames of reference helping them navigate through institutional pressures and acquire knowledge expertise in two distinct domains, technological and regulatory ones. Even more important, firms need to develop knowledge integration mechanisms enabling synthesis of technological and regulation-related knowledge.

The process of integration of knowledge elements from functionally distinct and distant domains depends on how easily knowledge can be interpreted (Hamel, 1989; Stuart 1998; Kogut & Zander 1993; Simonin, 1999). Integration of knowledge from the functionally distinct domains features higher levels of complexity and causal ambiguity (Reed & DeFillippi, 1990) and requires development of specific routines and heuristics to facilitate transfer and synthesis of distant knowledge (Winkelbach & Walker, 2015).

Organizations are more effective in developing specific knowledge transfer mechanisms if participate in the related types of business activities or engage in a relationship with a relevant strategic orientation (Phelps 2010; Powell & DiMaggio, 2012). All other things equal, green technology partnerships will be more effective in developing green knowledge-specific integration mechanisms than non-green technology partnerships. Furthermore, with increasing number of green partnerships in their portfolio of inter-firm relationships, firms develop and master a more comprehensive view of the green technology domain, better understand nuances and interdependencies among the knowledge elements, more effectively manage resource flows among the partnerships and faster identify emerging opportunities (Cui & Connor, 2012, Hoffman, 2007). Based on that,

H2a: The proportion of green partnerships in a firm network is positively related to firm green innovation.

Environmental policies and regulations motivate firms to allocate more R&D resources to green innovation (Hottenrott & Rexhäuser, 2015). In green industries, multiple firms share interest in environmental technologies, creating what is called the effect of technological crowding – specializing in the technological domain populated with many other firms (Stuart & Podolny, 1996). Prior research has shown that focusing on the technological areas concurrently pursued by many competitors motivates firms to differentiate themselves from other technologically adjacent organizations by increasing investments in R&D activities (Stuart 1999). Competitive crowding intensifies learning race and promotes organizational search for novel knowledge.

Organizational search is strongly influenced by the structure of relationships in the technological arena (Merton 1973, Stuart 1998; Stuart & Podolny , 1996). Racing for a new technology, many firms simultaneously conduct R&D projects exploring the related technological ideas and actively searching for knowledge in the external environment. Organizations that work in similar niches tend to develop some similarities in knowledge bases (Powell & DiMaggio, 2012). Shared understanding facilitates knowledge transfer and stimulates inter-firm information exchange on a large scale (Stuart, 1998). The growing number of green partnerships in the industry fuels global circulation of green knowledge and makes it more available and in timelier manner to all interested parties. Based on that,

H2b: The proportion of green partnerships in the industry network is positively related to firm green innovation.

6.3. Network structure attributes and green innovation in inter-organizational networks

Presence of heterogeneous and specific knowledge resources in a network is necessary, but not a sufficient condition for novel knowledge to emerge. A structure of the network, connections among network members - “pipes and prisms of the market” through which information flows - is what makes knowledge disseminate (Podolny, 2001).

Social networks literature considers a network structure at the local firm level and the global industry one.

6.3.1 Firm Network

The quality of a network structure is captured by the density of ties in the network. Network density is defined as a degree of interconnectedness among economic agents in the network (Burt, 1992). Connectivity may vary from sparse to dense. At a maximum, each economic agent in a network is connected every other member of that network.

Extant literature argues that density of connections in a network can influence the informational value of knowledge resources accumulated and speed of knowledge transfers among network members (e.g. Gilsing et al. 2008; Gulati 1995, 1998; Karamanos, 2012).

Multiple benefits of densely connected networks can be identified.

In a dense network, firms share multiple ties through which valuable knowledge can disseminate fast. The process of knowledge diffusion speeds up because information travels not only through proximate connections, but spreads through the whole structure of the network (Bechman & Haunschild, 2002).

Getting access to novel knowledge in a timelier manner becomes critical, because domain specific knowledge (i.e. green versus non-green) is most valuable in the context for which it was generated, making its value time-sensitive (De Luka & Atuahene-Gima, 2007; Subramani & Venkatram, 2003). In dense networks with multiple connections among members specific knowledge disseminates fast, without loss in value, enabling firms to identify emerging opportunities more effectively.

As noted before, complex knowledge often requires idiosyncratic integration mechanisms. Densely interconnected firms can be in a more advantageous position to transfer complex and specific knowledge than isolates or weakly-connected counterparts (Hansen 1999, Kogut 2000). In dense networks, firms are connected to multiple contacts that can provide alternative interpretations of complex knowledge, thus expanding the focal firm's understanding of it. High interconnectivity of firms facilitates development of integration mechanisms as intense interactions among the network firms stimulate creation of partner-specific heuristics and ease knowledge transfer (Grant & Baden-Fuller 2002; Phelps 2010).

In dense networks, firms can create a broader set of expertise and capabilities to detect and evaluate unfamiliar knowledge. But even when networks connect firms with similar, not highly diverse knowledge bases, multiple connections among networks members may trigger refinement and elaboration of extant knowledge, leading to novel re-combinations of well-understood knowledge resources (Ahuja & Lampert 2001; Fleming, 2001).

Dense networks can also serve as collective monitoring mechanisms reducing risks of partner opportunism and breeding trust (Coleman 1988, Vanhaverbeke, 2006). Dense networks increase transparency of inter-firm relationships, as every firm engages in many relationships and being observed by many other network members, also interconnected. Transparency with respect to firm behavior deters firms from behaving opportunistically and increases confidence in each other. Greater trust in partners stimulates knowledge-sharing behavior and creates greater learning opportunities (Norman 2004, Rindfleisch & Moorman 2001). Finally, densely connected firms often provide referral services for each other and promote cooperation and knowledge sharing among previously disconnected firms. Based on that,

H3a: Density of ties in a firm network is positively related to a firm's green innovation.

The alternative perspective in the networks literature is that densely connected networks have their own drawbacks and, in fact, are inferior to the networks rich in structural holes. For example, Burt (1992) argues that increasing number of ties in a network leads to the situation when everyone gets connected to everyone, with many ties being redundant. Establishment and maintenance of connections entail costs (Rowley et al 2000). Firms with excessive number of ties have to spread limited organizational resources thinly across many linkages, leading to suboptimal quality of each connection. Due to the limited information-processing capacity, firms may spend more resources on sorting out diverse information, than on integration and transformation.

Relatedly, densely connected networks might lock-in firms in the established partnerships with a low novelty potential. Firms with multiple mutual connections tend to develop shared values and behavioral norms (Rowley et al 2000). This creates a sense of intimacy and inter-partner trust, but along with that, prompts the development of certain expectations of reciprocity and loyalty to the existing partners (Duyster & Lemmens, 2003). This breeds relational inertia, preventing firms from entering new, more innovative relationships (Gilsing et al. 2008).

Finally, being connected to too many others, an organization might be less willing to share sensitive information because of fears of leakages to undesirable recipients. Risks of unplanned diffusion of valuable knowledge to competitors threaten firm positions in the marketplace and limit their willingness to share, inhibiting inter-firm learning (Swaminathan & Moorman 2009).

Those contrasting arguments about positive and negative effects of network density on firm learning suggest there might be some optimal network density which maximizes a firm's ability to generate novel knowledge. The recently emerged stream of research in the networks literature proposes the contingency perspective on the role of a network density on firm innovation (Burt 2000, Mariotti & Delbridge, 2012; Nooteboom, 2000). It argues that various network configurations might be more beneficial under different contingency factors, i.e. nature of exchange among network partners, different forms of searches or content of knowledge transferred.

Based on the argument above I retain the main hypothesis H3a proposing the linear positive relationship between the network density and a firm's green innovation, but I also test for the curvilinear relationship between the two to check for a presence of the optimal network structure in the context of green innovation.

6.3.2. Industry Network

At the industry level, local networks of firms connect to form a global industry network. Two the most important properties of a global network are network reach and network clustering (Karamanos, 2011; Shilling & Phelps, 2007).

The network reach relates to an average distance that separates any two firms in a network (Borgatti et al, 2013). Networks with short average path length are said to have higher network reach.

In large industry networks, the average distance between every two firms, or a numbers of steps necessary to reach the partner, tend to be large. With that, the quality and speed of knowledge transfers decrease (Watts, 1999). However, as density of connections among the network members increases, the average path length decreases and diffusion and exchange of information happens much faster and with more intensity (Schilling & Phelps, 2007). In the context of green partnerships, high industry network reach facilitates access to specialized green knowledge generated in remote and not directly connected firms.

In a network, some firms tend to be more interconnected than other, forming so-called network clusters. Clusters emerge because firms tend to connect and interact more intensively with firms which share some similarity i.e. being involved in similar type of business activity, or located in geographical proximity, or working in the same technological domain, for example, a high-tech cluster in Sillicon Valley. Clustered networks are characterized by multiple, dense ties within clusters and limited, relatively sparse connections outside of those (Tracey & Clark 2003). Networks literature provides evidence of positive effects of clustering on organizational innovation for firms located within the clusters (Capaldo 2007; Powell & Smith-Doerr, 1994). Dense connections among firms in a cluster increase the transmission capacity of a network and speed up knowledge diffusion. Firms can get alternative interpretations of the same technological problems from multiple sources, which enhances collective inter-firm learning and stimulates joint search for solutions (Shilling & Phelps, 2007).

Limited connections between clusters in a global network might constrain organizational innovation. As local clusters become denser, firms get sealed in those and isolated from a broader industry network, effectively limiting their access to diverse information residing outside the clusters (Burt 1992, Uzzi 1996). With respect to the green partnership argument, high clustering property of an industry network reduces firm's chances to access specialized green knowledge generated in remote, far-flung and not directly connected firms. Based on that,

H3b: The relationship between the proportion of green partnerships in the industry network and firm green innovation is positively moderated by the industry network reach.

H3c: The relationship between the proportion of green partnerships in the industry network and firm green innovation is negatively moderated by the industry network clustering.

Chapter 7

Study 2. Research Methodology

In this chapter I discuss the methodology-related issues pertinent to Study 2. First, I provide details on data sources and data collection process. Then I present definitions and operationalization of the model constructs. Finally, I discuss the model and statistical estimation procedure details.

7.1. Empirical Context

The empirical context of Study 2 is the U.S. chemical and petroleum production industry (SIC 28, 29). The industry consists of a wide array of organizations involved in business activities related to production and sales of chemicals and petrochemicals and defined by eleven 3-digit SIC codes (Table 18). The US chemical market was estimated at $801 billion in 2014 (not including petroleum refining sectors) and projected to grow in the coming years (American Chemistry Council, 2015).

Table 18. Study 2 SIC codes applied to classify the chemical industry

SIC Code	Description
280	Chemicals and Allied Products
281	Industrial Inorganic Chemicals
282	Plastics Materials and Resins
284*	Soap, Detergents, and Cleaning Preparations
285	Paints and Allied products
286	Industrial Organic Chemicals
287	Agricultural Chemicals
289	Miscellaneous Chemical Products
291	Petroleum refining
295	Asphalt and Roofing Materials
299	Miscellaneous Products of Petroleum and Coal

*Pharmaceuticals (SIC 283) were excluded from analysis as they represent quite distinct industrial subsector with very different patenting patterns.

The chemical industry fits well for testing the proposed research questions for several reasons. First, the chemical industry is a high-tech sector of the economy, where scientific knowledge plays a critical role. Innovation is a key determinant of long-term competitive advantage here and investments in R&D at chemicals are at the top positions of the list of all industries (Ahuja 2000, Landau & Rosenberg, 1991). For example, in 2014 US chemical companies invested $59 billion in research and development activities, which is higher than many other R&D intensive industries like electronics or health care (American Chemistry Council, 2015). Chemical companies actively engage in strategic partnerships to pursue innovation and systematically patent their inventions (Chesnais, 1988). The industry is among the most heavily polluting economy sectors with high pollution abatement costs and penalty rates (Environmental Protection Agency USA, 2005). The chemical industry releases more hazardous waste than the next eight most polluting industry sectors combined (Anastas & Warner, 2000). Chemicals are under scrutiny from regulators and environmental activists and are more motivated to pursue green technologies. Finally, the industry consists of a very heterogeneous population of firms that vary in terms of size, scope, and innovation strategies, which provides ample variation for testing the theory. Secondary data on inter-firm partnerships in the chemical industry is readily available and can be obtained from well-recognized and reliable sources (Schilling, 2009).

7.2. Data Collection

The nature of the proposed research questions requires a longitudinal research design. To test the hypotheses, a dataset consisting of the multi-year data on the firms, their partnerships and patenting activities has to be developed.

I limited the sample to the largest publicly traded companies operating in the US chemical industry. This was done for two reasons. First, for those firms, reliable financial data can be obtained from multiple sources. Second, largest companies get more coverage in press, thus ensuring validity of data regarding their partnership activities.

The time period for which data was collected was 8 years, from 2005 to 2012, with firms' partnering activities observed for the period 2005-2011 and firm patenting activities for the period 2006-2012. The chemical industry features high pace of innovation, and 8-year period should be sufficient for analysis of dynamics in technological networks. Other studies on firm innovation in the context of networks utilized similar time frames (i.e. Polidori et al 2011; Sampson 2007; Stuart 2000). Also, using a one-year lag between the partnership commencement and patenting activities is a common practice in this research stream (Ahuja, 2000, Phelps, 2010).

In order to identify organizations in the sample, following other studies in the field (i.e. Ahuja 2000; Polidoro et al 2011), I searched public sources such as trade journals in the chemical industry. I used 2005 Top 100 Chemicals Ranking (by sales) published by *Chemical Week* to identify firms in the US chemical markets with the largest volumes in sales. I utilized the above industry list at the beginning of the period of observations to minimize survivor bias (Ahuja, 2000). For some of the firms listed, reliable financial or patent data could not be obtained, and consequently I excluded them from analysis. Furthermore, subsidiaries of some of the firms were listed separately and also had to be removed. The finalized list of firms utilized in Study 2 comprised 55 leading companies operating in the US chemical industry and headquartered in North and South America, Europe, and Asia.

Only the sampled firms and the relations among them were analyzed. Partnerships between the sample firms and non-sample firms were not considered. I collected firm-related data like financials and industry affiliation from COMPUSTAT, annual reports and SEC filings for each year from 2005 to 2012.

I obtained information regarding technological partnerships of the firms identified above by merging data from multiple archival sources. For clarity of discussion, a technology partnership is defined as a voluntary arrangement between two or more organizations for purpose of sharing, exchange or co-creation of technological knowledge (Gulati, 1995).

I first obtained partnership data from SDC Platinum Joint Venture and Alliance database. SDC Platinum is a well-recognized source of relational data across many industries and provides advantage of the widest coverage and extensive searchability based on multiple sources including SEC files, trade publications and newswire services (Schilling, 2009). To ensure accuracy in data collection and triangulate data on each partnership, I also performed additional search of Lexus-Nexus and FACTIVA databases, companies' reports and websites, and industry-specific trade publications like *Chemical Week, Chemical Processing*, *Chemical and Engineering News*, *Plastic Technology Magazine*. That was done to address certain limitations in SDC database that were critical for the proposed research. More specifically, for some records in SDC Platinum database, duplicate entries were identified. Also, some records included partnerships that were announced, but never enacted, thus resulting in inflated partnership rates. Furthermore, some entries were missing important information like SIC code, types of partnership activities performed, or partnership tenure-related information.

SDC Platinum database provides data for different types of interfirm partnerships like marketing, manufacturing, technology, exploration and licensing agreements, etc. Conditioned by the nature of the proposed research questions, only technology-oriented partnerships and two-way technology licensing agreements were retained.

To correctly specify network structures in each year of observations, I checked all partnerships for continuity of operations. I established either the survival of each partnership beyond 2012 (the end of the observation period) or its termination date in a manner similar to the described above by searching multiple archival sources. In the cases, when it was impossible to identify the exact termination date, the year next after the last publication pertinent to that partnership was assumed a year of termination (Ahuja, 2000).

Maps of the networks were constructed representing firms' partnership relationships in each year of observations. To avoid a left censoring problem, information on partnerships in five years preceding the examined period, specifically from 2000 to 2004, was additionally collected and the networks of partnerships were built for each firm *i* and each year *t* in the panel. The example of a set of technology partnerships involving E. I. du Pont de Nemours & Company (DuPont) in the period from 2000 to 2012 is provided in Table 19.

I obtained information about firms' patenting activities from the U.S. Patent and Trademark Office (UPSTO) database. Large body of organizational research uses patents as a measure of a firm's innovative activity (Ahuja, 2000; Phelps, 2010; Polidori et al, 2011; Sampson, 2007; Schilling & Phelps, 2007; Silverman, 1999). Patent is a document issued by the government authority to grant the exclusive right to use a specific technology, process or a device for a certain number of years to the inventor, after examining its novelty and utility (Griliches 1990). Patents are assumed to be a good measure for firm innovation for several reasons. First, as past empirical research showed, there is a strong correlation between firm R&D activities and a number of patents granted to a firm (Pakes & Griliches, 1980). Second, patents are assigned only after novelty of an invention is attested by third-party independent examiners. Third, because patenting

Table 19. Study 2. Technology partnerships involving E. I. du Pont de Nemours and Company in the period 2000-2012

Focal Firm	Partner(s)	Year of commencement	Year of termination	Y00	Y01	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12
DuPont	Mitsui	1995	2005													
DuPont	Dow	1996	2005													
DuPont	Air Liquide	1997	2003													
DuPont	CIBA	1998	after 2012													
DuPont	Monsanto	1998	2003													
DuPont	ICI	1999	after 2012													
DuPont	Air Products	2000	2012													
DuPont	BP PLC	2000	2001													
DuPont	Monsanto	2002	2003													
DuPont	Reliance Ind.	2003	2008													
DuPont	BP PLC	2003	2011													
DuPont	Monsanto	2005	2007													
DuPont	Syngenta	2006	2010													

Table 19 (continued). Study 2. Technology partnerships involving E. I. du Pont de Nemours and Company in the period 2000-2012

Focal Firm	Partner(s)	Year of commencement	Year of termination	Y00	Y01	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12
DuPont	Bayer AG	2006	2007													
DuPont	BP PLC, undisclosed other	2007	2011													
DuPont	Sumitomo Chemicals	2007	after 2012													
DuPont	Honeywell Internat.	2007	2010													
DuPont	DIC	2008	2010													
DuPont	Eastman Chemicals	2008	2011													
DuPont	BP PLC	2009	after 2012													
DuPont	Dow	2009	2010													
DuPont	DSM	2011	after 2012													
DuPont	Exxon, GE	2011	after 2012													

activity is a costly and time-consuming process, firms patent only novel knowledge that has economic potential that is one of the major reasons of firm to innovate. Thus, patents can be assumed a reasonably good indicator of firm innovation activities.

USPTO database is traditionally used for examining firms' patenting behavior because of high reputation of UPSTO and rigorousness and consistency of information provided by the office (Griliches, 1990).

In order to maintain consistency, reliability, and comparability of patenting data, I used US patent data for all firms in the sample, including those headquartered abroad. The USA represents one of the largest markets for chemicals, and many foreign chemical firms patent their inventions with USPTO (Ahuja, 2000). Prior research followed a similar strategy of using USPTO patent data to measure innovation of international firms (i.e. Polidori et al. 2011; Phelps, 2010; Stuart, 1998).

In case of large corporations with many business units and divisions, patents might be assigned as to the parent firm, so to its subsidiaries and joint ventures. Organizational structure might change over time, firm subsidiaries can be renamed, restructured, dissolved, or spun off. Thus, patent data must be aggregated to the level of a parent firm (Griliches, 1990). To accomplish that, for every firm in the sample I prepared a list of the divisions, subsidiaries and joint ventures as of 2005, using *DB Who Owns Whom (North & South America, UK & Ireland, Continental Europe, and Asia editions*) and traced each firm's history throughout the period of observations to account for name or organizational structure changes. The final master list reflective of the sampled 55 firms and their subsidiaries was used to identify patents issued to the firms in the sample.

The final challenge related to the patent data was about industry classification of patents. Large chemical companies run operations across multiple industries and innovate as in the chemical, so in other unrelated fields. Given the focus of the research on firm patenting behavior within one specific industry, it was important to identify patents relevant to the chemical sectors.

USPTO office classifies patents by the functional fields, rather than SIC codes. This makes it difficult to map patent data to the relevant industries (Griliches, 1990). For purpose of matching patent classes and industrial classifications, several concordance systems are available. One is a concordance system developed by USPTO's Office of Technology Assessment and Forecast (OTAF), but criticized on many grounds (Phelps, 2010). The alternative system is Silverman's International Patent Classification - US SIC concordance system which overcomes many of the criticisms of the OTAF approach. Consequently, I utilized the Silverman's concordance system (Silverman, 1999).

The Silverman's system assigns probabilities associated with each patent class and each industry class, and maps a patent count for each patent class into a patent count for each industry class. Based on that, I first identified all the patent classes that were associated with chemicals' SIC codes. Then I limited the list by the top patent classes most commonly associated with chemicals. More specifically, I retained those patent classes, where the proportion of patents assigned to both SIC of use and SIC of manufacturer was at least 10% or more (Griliches, 1990). This approach yielded 26 primary patent classes most frequently associated with the chemical industry, similar to the number of patent classes (22) utilized in the other study on network effects on firm innovations (Phelps, 2010).

Following the established practice in the literature (i.e. Griliches 1990; Quintana-Garcia & Benavides-Velasco, 2010), I used patent application date, not a patent granting date, to assign patent to a firm-year. When a patent is issued, it includes the date of application. Because the date of application better captures the moment of knowledge creation, it is more suitable to assign patents to the particular year in the panel, based on the date of application.

The patents were sorted as green vs. non-green ones, based on the USPTO Environmentally Sound Technologies Concordance Matrix. The Matrix lists the patent classes across all the technology fields, which are identified as relevant for environmentally-friendly technologies by their function or application.

Variables

Dependent Variable

Firm Green innovation GIP_{it} – Firm green innovation is a dependent variable. I measured firm green innovation as a number of successful green patent applications of firm *i* in year *t*.

Independent Variables

For all the independent variables that were measured using patent data, I applied a rolling four-year window to establish firm and network's patent profiles. For example, a patent profile of firm *i* in year *t* included the patents firm *i* applied for in years *t, (t-1), (t-2), (t-3)*. Similarly, a patenting profile of a network of firm *i* in year *t* included patents of firm *i* and the patents of all its partners in years *t, (t-1), (t-2), (t-3)*. A four-year rolling window is a reasonable time frame for constructing patent profiles as technological knowledge is shown to depreciate sharply 4-5 years after its creation (Ahuja, 2000; Griliches 1990; Sampson, 2007).

Breadth of Knowledge Pool BKP_{it}*:* Breadth of knowledge pool in the network of firm *i* in year *t* was estimated with Palepu's entropy measure (1985). The entropy measure has been widely used to measure the degree of diversification in different organizational contexts (Hoskinsson et al, 1993; Khanna & Palepu, 2000). It is calculated as a weighted sum of shares of patent classes in a firm network. The advantage of using the entropy measure is that it allows not only to capture the number of patent classes, but also the relative importance of each class:

$$BKP_{it}= \sum_{i=1}^{N} P_{it}*\ln(1/P_{it})$$

where N is defined as the number of patent classes in a network, P_{it} is a proportion of a specific patent class in year *t*. The more patent classes are involved, the higher the entropy measure. If all the partners in a firm's network hold patents in the same class, the entropy measure is 0.

Knowledge Compatibility MD_{it}^{avg}: To assess compatibility of knowledge resources accumulated in a firm network, the average of Mahalanobis distances between the patent portfolios of each two firms in a firm network was calculated (Mukherji et al, 2011). The Mahalanobis distance between the patent portfolios of two firms show how close the technological bases of the firms are. The more they are similar and therefore compatible, the shorter Mahalanobis distance is.

The choice of Mahalanobis distance over another popular approach using Euclidian distance (see for example Vanhaverbeke et al., 2006) was driven by the fact that Mahalanobis distance was proved to be a more accurate instrument (Kumar, Mahalanobis, & Juday, 2006). More specifically, Mahalanobis distance not only measures how distant/close partners' knowledge resources are, but also captures the volume of patents in each class and, most importantly, allows to account for correlations between different patent classes. Unlike the Euclidian distance method, the Mahalanobis distance approach assumes patent classes are not completely independent from each other and different classes are not orthogonal. The firms with patents from two adjacent classes have more compatible knowledge bases, than those from the 'distant' classes (Kim & Finkelstein, 2009). By accounting for that, Mahalanobis distance provides a more accurate measure of knowledge compatibility.

The procedure of calculating the Mahalanobis distances between two patent portfolios was as follows. First, for each firm *j* in a firm *i*'s network the vector V_{jt} was constructed, capturing the composition of a firm *j*'s patent portfolio. Each patent class was represented by proportion of total number of patents in the aggregate patent portfolio accumulated in the firm *i*'s network.

$$V_{jt} = \begin{cases} \text{\% of patents in the patent class1} \\ \text{\% of patents in the patent class 2} \\ \ldots\ldots\ldots\ldots \\ \text{\% of patents in the patent class N} \end{cases}$$

Then the Mahalanobis distance between the vectors V_i and V_j for the firms *i* and *j* in year *t* was calculated as

$$MD_{ijt} = \sqrt{(Vit - Vjt)\ ^{T}W\ ^{-1}(Vit - Vjt)}$$

where W^{-1} is the inverse of the pooled covariance matrix (Kumar et al., 2006). Then, the average Mahalanobis distance in a firm *i*'s network in the year *t* was calculated as:

$$MD_{it}^{avg} = \sum MD_{ijt}/N,$$

where N is a total number of ties in the network.

Proportion of green partnerships in a firm network FGA $_{it}$ was operationalized as a ratio of a number of green technology partnerships to the total number of technology partnerships in the firm *i's* network in year *t*. The partnerships were sorted out as green vs. non-green by examining partnership abstracts in SDC database ('Deal text' field). A partnership was coded as green if the abstract included an explicit reference to the technological domains listed in the the USPTO Environmentally Sound Technologies Concordance Matrix. Additionally, content analysis of partnership abstracts was done based on the following key words: ‘environmentally friendly’, ‘sustainable’, ‘energy-saving’, ‘biofuel’, ‘fuel efficiency’, ‘carbon footprint’, ‘renewable’, ‘pollution prevention’, ‘pollution reduction’, ‘emission reduction’, ‘waste prevention’, ‘recycling’, to identify green partnerships. A similar key-word search approach was utilized in other studies examining trends in ecological patents in the USA (Marinova & McAleer, 2003; Wagner, 2007).

Proportion of green partnerships in industry IGA_t was operationalized as a ratio of a number of green technology partnerships to the total number of technology partnerships in the industry in year *t*, excluding green partnerships of the focal firm.

The independent variables reflective of the network properties at the firm and industry levels were estimated with UCINET 6.0 software (Borgatti et al 2013). To calculate those, I first constructed annual binary non-directed adjacency matrices capturing presence or absence of technology partnerships between all possible pairs of firms *i* and *j* in the sample at the end of year *t*, where 1 indicated a presence of a technology partnership between firms *i* and *j* and 0 otherwise.

It is important to note that the annual adjacency matrices should reflect not only the partnerships commenced in year *t*, but also the partnerships that were commenced in the previous years and stayed in operations in year *t*. To ensure that the adjacency matrices reflected all the active technology relationships among the firms in the sample, I constructed partnership sets for each firm in the sample, similar to the one shown in Table 16, capturing all technology partnerships announced starting 5 years before the observation period and maintained in year *t*. This approach allowed me to obtain annual adjacency matrices more accurately reflecting the true structure of the partnership networks.

The details of calculations of the variables reflective of the network properties are provided below.

Firm Network Density of ties ND_{it}: Density of ties in the network of firm *i* reflects the degree to which partners of firm *i* are directly connected. Following Burt (1992), a firm's network density was defined as a ratio of the number of unique ties among the partners of firm *i* to the difference between the square number of ties between firm *i* and its partners and the number of ties between firm *i* and its partners divided by 2, in year *t*

$$ND_t=\sum_{gt}\sum_{jt}x_{gjt}/(N^2-N)/2),$$

where x_{gjt} is a number of unique ties among the partners of firm *i* in year *t* and N is a number of ties between firm *i* and its partners. The index varies from zero to one. If firm *i* had no partnerships in year *t*, its firm network density for that year was set to 0.

Industry Network Reach NR_t: The industry network reach in year t was calculated based on the measure of average distance-weighted reach (Borgatti et al.,2013):

$$NR_t==(\sum_n\sum_j 1/d_{ijt})/n,$$

where n is a number of firms in the industry network and d_{ijt} is the minimum distance from the firm *i* to partner *j* in year *t*.

Industry Network Clustering NCl_t: The industry network clustering index was calculated as a weighted average of clustering coefficients of individual firms in the industry network, where a clustering coefficient of firm *i* was calculated as a density of ties among partners of firm *i* and the weights were the number of pairs of partners of firm *i* (Borgatti et al, 2013).

The alternative measure that can be used to capture the effects of densely interconnected clusters in a network is a network transitivity (Borgatti et al., 2013). Network transitivity is based on the expectation that if firm *i* is connected to firm *j* and firm *j* is connected to firm *g*, it is likely that firm *i* is also connected to firm *g*. If so, the triad of firms *i*,*j*,*g* is transitive. A network transitivity was operationalized as a ratio of the number of triangles in the network tripled to the number of connected triples, where a triangle was a set of three firms all connected to each other and a triple is a set of three firms, where at least one of the firms is connected to the two other (Borgatti et al., 2013).

Control variables

To control for alternative explanations of the hypothesized relationships, additional variables were included in the models, based on the literature review. The definitions of the control variables, rationales for inclusion, and the details of operationalization are provided below.

Partnership duration AD_t*:* Networks literature suggests that relational connections or informal ties among network partners can complement formal channels and enhance inter-organizational learning (Coleman, 1988;

Vanhaverbeke, 2006). Trust and reciprocity were shown to influence emergence of informal ties in inter-firm relationships.

Trust can be defined as a willingness of one party (trustor) to rely on the actions of the other party (trustee) (Newell & Swan, 2000). Relational reciprocity refers to mutual expectations that a given action will be returned in kind (Falk & Fischbacher, 2006). Trust stimulates close interactions among partners, reduces fear of knowledge appropriation, and creates greater learning opportunities because firms exhibit more willingness to exchange information with trustworthy partners (Mc Evily et al, 2003; Norman, 2004; Rindfleisch & Moorman, 2001). Reciprocity norms reinforce firm motivation to open and share valuable information as each partner expects others to respond symmetrically (Phelps, 2010).

Trust and reciprocity norms develop gradually as firms engage in continuous interactions (Gulati, 1995). Organizations establish and strengthen informal ties over time as they learn about each other (Larson, 1992). This suggests that a partnership duration should be positively associated with firm innovation. Based on that, the measure of repeated partnerships was included in the model. The Partnership duration AD_t was measured as the average number of years the firm *i* has participated in existing partnerships at year *t*.

Repeated partnership RA_t: Repeated partnerships can also breed trust and reciprocity (Gulati, 1995). Firms with prior shared partnership experience are likely to trust each other more, than to firms with no history of cooperation, because they have more and better information about former partners, than about "strangers" (Goerzen, 2007). Based on that, the measure of repeated partnerships was included in the model. The measure of repeated partnerships shows how much a firm repeatedly cooperates with the same partners. Following Wuyts et al (2004), the repeated partnership index was calculated as follows:

$$RA_t = 1 - (P_t^{cum}/A_t^{cum}),$$

where P_t^{cum} is the number of unique partners firm has partnered with since the beginning of the period of observations and up to year *t*. A_t^{cum} is a number of partnerships the firm has formed from the beginning of observations and up to year *t*. To measure RA_t at the beginning of the period of observations, I searched and included into estimation 5 years prior the period of observations.

Partnership Experience AE_{it}: Extant literature provides abundant evidence that firms engaging in multiple strategic collaborations develop a distinct capability to manage inter-firm arrangements (Gulati, 1999, Simonin, 1997). A partnership capability can enhance firm ability to benefits from knowledge exchange in inter-organizational relationships. To account for that, the amount of firm's prior partnership experience in year *t* was measured with a count number of partnerships a firm formed in the previous five years.

Firm Network Size NS_{it}: Firm network size relates to the number of partnerships firm *i* maintains in year *t*. A larger number of technological partnerships can provide a firm with greater and more diverse knowledge resources, thus enhancing a firm's potential to create novel knowledge. A firm network size was operationalized as a simple count of technological partnerships firm *i* maintained in year *t.*

Firm network competition NC_{it}*:* Many organizations, especially large ones, have extensive networks of inter-firm relationships. It is not uncommon for firms to collaborate with multiple companies from the same industry, e.g. to have multiple suppliers. Competition, explicit or hidden, presents in those networks. Strategic partnerships can be seen as another form of competition because goals and objectives of partners are not entirely compatible (Hamel et al, 1991). Firms collaborating in one industry might remain direct competitors in the other markets or can become rivals in the future.

Green innovation often represents radical departure from conventional technologies and renders firms vulnerable to risks and uncertainties associated with disruptive innovation (Poliakoff et al., 2002). In such circumstances, firms become especially protective about strategic knowledge resources. They seek to absorb the maximum of distinctive competencies of partners, while limiting access to their own proprietary assets (Kale et al, 2000).

Networks multiply risks of appropriation and inflate negative effects of inter-firm learning race. The larger a firm's network is, the higher chances that it involves partners operating in some industries. Announcements of strategic partnerships are often publicly available information, and firms are aware when their partners collaborate with competitors. Fears of spillovers to undesired recipients inhibit free information exchange, lowering the chances for novel knowledge creation and inhibiting firm innovation (Simonin, 1999).

To operationalize firm network competition NC_t, the following strategy was utilized. Firms were assumed competitors if they operated in the same industry sector as defined by 3-digit SIC code. For every partnership in the network of firm *i* in year *t*, I assigned 1 if the partners were operating in the same industry sector, and 0 otherwise. For partnerships involving more than 2 parties, I calculated the average partnership competition index. Then I calculated the firm network competition index as an average of competition indices of individual partnerships in the network. The network competition index varies from zero to one, where zero means that all partners of firm *i* in year *t* operate in alternative industries, and 1 means that all partners run operations in the same industry sector.

Firm R&D Intensity $RDInt_{it}$: Prior studies have shown that R&D intensity positively relates to firm innovation. As a firm increases investments into R&D activities, its potential to create novel knowledge increases (Griliches 1990). Firms with higher levels of R&D investments possess more complex knowledge resources and are better equipped to recognize and internalize novel knowledge from the external environment (Dutta et al., 1999). R&D intensity was operationalized as a ratio of R&D investments to firm sales in year *t*. In the estimation models, I used natural log of R&D intensity.

Firm size: Firm size is expected to negatively affect firm green innovation. Larger companies often experience difficulties in diversification into new technological fields, rather favoring specialization into established areas (March, 1991; Levinthal & March, 1993). Firm size was operationalized as a natural log of firm sales. Firm sales, not firm market capitalization was used to measure firm size because for the international firms in the sample market capitalization information was not available from Compustat.

Green Association Membership GAM_{it}: Business group affiliation might promote organizational innovativeness (Chang, Chung, & Mahmood, 2006). Chemical industry runs a global multi-year initiative aiming to improve safety and environmental performance of the industry, named "Responsible Care". To become members of Responsible Care, firms are required to consistently perform at high environmental and safety standards. Such companies might be particularly interested in eco-friendly technologies and allocate more organizational resources to green innovation. The effects of a green association membership for firm *i* in year *t* was operationalized with a number of years elapsed since firm *i* joined the Responsible Care initiative. Dates of joining the Responsible Care program by the firms in the sample were collected based on archival search of Factiva and LexisNexis databases and firms' annual reports.

Proportion of Green Patents PGP_{it} in the patent portfolio of firm *i* in year *t*: It is expected that green knowledge accumulated by a firm prior to engaging in a partnership will affect its green value creation potential because firms tend to build upon their prior investments in knowledge creation (Dutta et al., 1999). The proportion of green patents in the patent portfolio of firm *i* in year *t* was calculated as a ratio of a number of green patents firm *i* applied for in 4 years preceding the partnership, to the total number of patents firm *i* applied for in the same period.

Annual dummy variables Y_t: Economic conditions might affect the rates of which patents are applied for (Griliches, 1990). Dummies for each year of observations were added to the models, to control for economic shocks.

Industry dummy variables I_t: Dummies for each SIC code were added to the models, to control for industry effects.

Region dummy variables R_t: The firms in the sample were headquartered in 3 global regions, North & South America, Europe, and Asia. To control for the region-related effects, dummies indicative of those regions were added to the models.

Table 20 provides a summary of the variables used to estimate the models.

Table 20. Study 2. Variables and data sources

Variable	Description	Source
Dependent variable:	The number of green patent applications by firm *i*	USPTO database
Independent variables:		
Breadth of Knowledge Pool	Entropy index calculated for patent classes in firm network (Palepu, 1985)	USPTO database
Knowledge Compatibility	Average Mahalanobis distance between patent portfolios in firm network (Kumar et al., 2006)	USPTO database
Green Partnership Share in Firm Network	The ratio of a number of green partnerships to the total number of partnerships in firm network	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services
Green Partnership Share in Industry Network	The ratio of a number of green partnerships (excluding green patents of a focal firm) to the total number of partnerships in industry network	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services
Firm Network Density	The ratio of the number of unique ties among the partners of firm i to the difference between the square number of ties between firm *i* and its partners and the number of ties between firm *i* and its partners divided by 2, in year *t* (Borgatti et al., 2013)	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services, UCINET 6.0
Industry Network Reach	Averaged weighted minimum distance between two firms in year *t* (Borgatti et al., 2013)	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services, UCINET 6.0

Table 20 (continued). Study 2. Variables and data sources

Industry Network Clustering	Averaged densities of ties among the partners of firm *i* weighted by the number of pairs of partners of firm *i (*Borgatti et al., 2013*)*	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services, UCINET 6.0
Control variables		
Partnership Duration	Average number of years a firm has participated in existing partnerships in year *t*	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services
Repeat Partnerships	The ratio of a number of unique partners firm has partnered with since the beginning of the observation period and up to year *t* to a number of partnerships firm has formed from the beginning of observations and up to year *t.*	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services
Partnership Experience	The count number of partnerships firm formed in the previous five years	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services
Firm Network Competition	Average of the individual partnership competition indexes that take 1 if it is a partnership with direct competitor as measured by SIC code or 0 otherwise	COMPUSTAT
R&D Intensity	Natural log of a ratio of firm R&D investments to firm sales in year *t*	COMPUSTAT
Firm Size	Natural log of firm sales in year *t*	COMPUSTAT
Responsible Care Membership	The number of years since firm *i* joined the Responsible Care initiative	FACTIVA, LexisNexis, databases, newswire services

Table 20 (continued). Study 2. Variables and data sources

Green Patent Share in Firm Patent Portfolio	A ratio of a number of green patents firm *i* applied for in 4 years preceding the partnership, to the total number of patents firm *i* applied for in the same period	USPTO database
Firm Network Size	A number of technological partnerships firm i maintains in year t	SDC Platinum, FACTIVA, LexisNexis, databases, newswire services, UCINET 6.0
Industry controls	Dummies of SIC codes in the panel	COMPUSTAT
Year controls	Dummies of each year in the panel	COMPUSTAT
Region controls	Dummies for 3 regions, North & South America, Europe, Asia	COMPUSTAT, company reports

7.5. Model Specification

The proposed hypotheses suggest two different levels of analysis. The hypotheses H1a, H1b, H1c, H2a, H3a predict the effects at the level of the firm networks. The hypotheses H2b, H3b, and H3c predict the effects at the level of the industry network. Because individual firms' networks are embedded within the global industry network, the variables reflective of the network structure attributes at the firm and industry levels are not completely independent from each other. Thus, their effects on the dependent variable should be estimated in separate models to minimize endogeneity problems. Accordingly, I specify two separate models exploring firm green patenting activities at the firm network level and at the industry network level. Both models were estimated with the panel regression approach. The dependent variable in both models was counts of green innovation patents GIP_{it}. In line with prior research and in order to minimize threats of reverse causality, the independent variables in both models were lagged for 1 year. Before forming the interaction terms, the related variables were mean-centered to reduce risks of multicollinearity.

In general terms, the number of green patents GIP_{it} of firm *i* in year *t* is a function of the following factors:

Breadth of Knowledge Pool in a firm network $BKP_{it,}$

Knowledge Compatibility in a firm network MD_{it}^{avg}

square term of Knowledge Compatibility $(MD_{it}^{avg})^2$

interaction term of Breadth of Knowledge Pool and Knowledge Compatibility $BKP_{it} * MD_{it}^{avg}$

Proportion of Green Partnerships in a firm network FGA_{it}

Proportion of Green Partnerships in the industry network IGA_t

Density of Ties in a firm network ND_{it}

square term of Density of Ties in a firm network $(ND_{it})^2$

Industry Network Reach NR_t

interaction term of Proportion of Green Partnerships in the industry network and Industry Network Reach $IGA_t * NR_t$

Industry Network Clustering NCl_t

interaction term of Proportion of Green Partnerships in the industry network and Industry Network Clustering $IGA_t * NCl_t$

Repeat Partnership RA_{it}

Partnership Duration AD_{it}

Partnership Experience AE_{it}

Firm Network Size NS_{it}:

Firm Network Competition NC_{it}

Firm R&D Intensity $RDInt_{it}$

Firm Size F_{it}

Green Association Membership GAM_{it}

Proportion of Green Patents in firm patent portfolio PGP_{it}

Time effects Y_t

Industry effects I_t

Region effects R_t.

Firm Network Model was specified as follows:

$GIP_{i(t+1)} = f\,(BKP_{it,} MD_{it}^{avg}, (MD_{it}^{avg})^2, BKP_{it,*}MD_{it}^{avg}, FGA_{it}, IGA_t, ND_{it},$
$(ND_{it})^2 AD_{it}, RA_{it,}, NS_{it}, NC_{it}, RDInt_{it}, F_{it,}\ GAM_{it}\ PGP_{it}\ AE_{it}, Y_t, I_t, R_t)$

Industry Network Model was specified as follows:

$GIP_{i(t+1)} = f\,(BKP_{it,} MD_{it}^{avg}, (MD_{it}^{avg})^2, BKP_{it,*}MD_{it}^{avg}\ FGA_{it}, IGA_t, NR_t, IGA_t$
$*NR_{t,}, NCl_t, IGA_t *NCl_t, AD_{it}, RA_{it}, NS_{it}, NC_{it}, RDInt_{it}, F_{it,}\ GAM_{it}\ PGP_{it}\ AE_{it}, Y_t$
$, I_t, R_t)$

Model Estimation

The dependent variable in both models is a count of the number of green patents. It takes non-negative integer values and varies from zero to many. Data are repeated observations. It is a combined time-series cross-sectional panel. In these circumstances, traditional multivariate regression approach has a number of serious shortcomings. The Poisson regression method that explicitely recognizes non-negative integer character of a dependent variable is more suitable (Hausman et al., 1984).

The intuition behind the Poison regression approach in the context of firm patenting activities is that the hazard rate of innovation to happen is Poisson distributed. The basic Poisson regression model is defined as follows:

$$Pr\ \{Y_{it}=y_{it}\}=\exp(-\lambda_t)\ \lambda^{yit}{}_{it,}/y!$$

where y_{it} is a observed count variable (number of green patents) and the parameter λ_{it} represents the mean and the variance of the event count, such that $\lambda_{it} = \beta{*}x_{it}$, with x_{it} being a vector of the independent variables and β a parameter vector. The exponential form ensures that λ_{it} remains positive for any combinations of explanatory variables. Parameters of a model can be estimated with maximum likelihood.

One of the features of the basic Poisson model is that it assumes equal the mean and the variance of the event count. However, patent data often exhibit over-dispersion, which violates the assumptions of the basic Poisson model and invalidates the Poisson distribution (Hausman et al., 1984). Over-dispersion can arise from unobserved heterogeneity in observations due to differences among the sampled firms in their ability to achieve innovation. Alternatively, it might relate to the systematic time-period effects. Over-dispersion does not bias the regression coefficients, but the standard errors are understated, resulting in an overestimation of statistical significance. To address the problem of unobserved heterogeneity, random effects or fixed effects Poisson specifications can be used (Hausman et al., 1984).

To address specification challenges mentioned above, and ensure the estimation results were robust, I tested both random-effects and fixed-effects Poisson specifications of the models. Given that the random effects model assumes that errors to be uncorrelated with the independent variables, I used Hausman (1978) specification test to check for violations of this assumption. The null hypothesis in the Hausman tests is that a randem effects model is appropriate. The significance of Hausman test statistics indicates a presence of significant correlation between errors and independent variables, which suggests that the random effect model was not appropriate in this case. Accordingly, I used a fixed effects Poisson specification with conservative bootstrapped standard errors. The results of Hausman test are provided in Table 21.

Table 21. Hausman test for a fixed versus random effect model

(b) (B) (b-B) sqrt(diag(V_b-V_B))
fe re Difference S.E.
(b) (B) (b-B) sqrt(diag(V_b-V_B))

	fe	re	Difference	S.E.
Firm Network Density	0.0175	0.0184	-0.0009	0.0011
Knowledge Compatibility	0.5524	0.5190	0.0333	0.0244
Knowledge Compatibility squared	-0.3919	-0.3807	-0.0111	0.0102
Breadth of Knowledge Pool	0.3656	0.3521	0.0134	0.0262
Breadth of Knowledge Pool * Knowledge Compatibility	-0.2093	-0.1941	-0.0152	0.0112
Green partnership Share in Firm Network	0.5233	0.5280	-0.0048	0.0134
Green Patent Share in Firm portfolio	-0.5612	-0.3667	-0.1945	0.0330
Firm Network Size	-0.0026	0.0001	-0.0026	0.0010
Firm Network Competition	0.1640	0.2442	-0.0802	0.0147
Repeat Partnership	-0.3261	-0.3142	-0.0119	0.0531
Partnership Duration	0.0145	0.0156	-0.0011	0.0006
Responsible Care Membership	0.1052	0.0895	0.0157	0.0030
Firm Size	-0.6224	-0.3129	-0.3095	0.0365
R&D Intensity	-0.1546	0.1555	-0.3100	0.0292

Test: Ho: difference in coefficients not systematic
chi2(14) = (b-B)'[(V_b-V_B)^(-1)](b-B)=197.34
Prob>chi2 = 0.0000

Chapter 8

Study 2. Results

8.1. Descriptive Statistics

The data set comprises of partnerships of 55 firms observed over 8-year period, from 2005 to 2012. Because some firms were acquired or restructured during the period of observations, it is an unbalanced panel.

The sample comprises large and established firms in the chemical and petrochemical industry. The average firm was 83-year old, with annual sales of $ 58 164 million and R&D investments of $ 715 million annually. Over the observed period of 2005-2012, the average firm maintained 2.5 partnerships annually with 28% of those with a green technology mandate. Some firms had no green technology partnerships per se, one firm in the sample had ‘all-green’ portfolio of partnerships, at certain years. The average firm applied for 68.9 patents annually, 27.83 of which were related to the green technology domains. The average firm network density was 11.6% which is comparable to another study in the context of chemical industry (Ahuja, 2000) reporting the network density of 5.7%. The observed firm network density suggests that partnership networks in the chemical industry are relatively sparse, realizing only 11.6% of all possible ties. Majority of the firms in the sample are the members of the environmentally-oriented Responsible Care Program, maintaining membership of 11.5 years, on average.

Table 22. Study 2 Descriptive Statistics and Correlations. Firm Network Model

		Mean	Std. Dev	1	2	3	4	5	6	7
1	Number of Green Patents	27.83	51.94	1.00						
2	Firm Network Density	1.16	2.49	0.05	1.00					
3	Knowledge Compatibility	1.77	1.92	0.04	-0.08	1				
4	Breadth of Knoowledge Pool	1.77	0.71	0.2751*	0.1892*	-0.1560*	1			
5	Green Partnership Share in Firm Network	0.28	0.36	0.01	0.2005*	0.0211	0.1406*	1		
6	Green Patent Share in Firm Patent Portfolio	0.35	0.17	0.2195*	0.05	-0.0896	0.4652*	0.1024*	1	
7	Firm Network Size	2.42	2.50	0.3455*	0.1627*	-0.1173*	0.3082*	0.2809*	0.2591*	1
8	Firm Network Competition	0.15	0.28	-0.07	0.2674*	-0.0791	0.0881	0.1898*	-0.0452	0.2771*
9	Repeat Partnership	0.08	0.13	0.1438*	0.1717*	-0.1231*	0.1036	0.3057*	0.1432*	0.3401*
10	Partnership Duration	0.00	3.60	0.1816*	0.2186*	-0.2515*	0.3735*	0.1797*	0.1375*	0.3815*
11	Partnership Experience (ln)	-4.54	10.18	0.2220*	0.2656*	-0.1501*	0.4072*	0.2962*	0.4195*	0.4197*
12	Responsible Care Membership	11.48	5.98	0.2649*	0.1277*	-0.0455	0.2689*	0.1103*	0.0971	0.1603*
13	Firm Size (ln)	9.90	1.42	0.2311*	0.1531*	-0.0615	0.3206*	0.3758*	0.1237*	0.4991*
14	R&D intensity (ln)	-4.20	1.10	0.3752*	-0.04	-0.1301*	0.1970*	-0.2181*	0.2939*	-0.0581

*** p<0.01 *p<0.05*

Table 22 (continued). Study 2 Descriptive Statistics and Correlations. Firm Network Model

		8	9	10	11	12	13
8	Firm Network Competition	1					
9	Repeat Partnership	0.1589*	1.00				
10	Partnership Duration	0.2478*	0.2089*	1			
11	Partnership Experience (ln)	0.2280*	0.3055*	0.5956*	1		
12	Responsible Care Membership	0.04	0.05	0.1429*	0.0337	1	
13	Firm Size (ln)	0.5350*	0.3442*	0.3303*	0.3216*	0.1917*	1
14	R&D intensity (ln)	-0.4237*	0.05	-0.1368*	0.0217	0.0513	-0.3676*

*** p<0.01 *p<0.05*

Table 23. Study 2 Descriptive Statistics and Correlations. Industry Network Model

		Mean	Std. Dev	1	2	3	4	5	6
1	Number of Green Patents	27.83	51.94	1.00					
2	Industry Network Reach	0.27	0.05	0.10	1.00				
3	Industry Network Clustering	0.31	0.06	0.01	-0.12*	1.00			
4	Number of Green Partnerships in Industry	27.07	4.66	-0.07	0.02	0.01	1.00		
5	Green Partnership Share in Firm Network	0.28	0.36	0.01	0.17*	-0.08	0.05	1.00	
6	Green Patent Share in Firm Patent Portfolio	0.35	0.17	0.22*	0.00	0.00	0.00	0.10*	1.00
7	Firm Network Size	2.42	2.50	0.35*	0.08	0.01	-0.04	0.28*	0.26*
8	Firm Network Competition	0.15	0.28	-0.07	-0.06	0.01	-0.14*	0.19*	-0.05
9	Repeat Partnership	0.08	0.13	0.14*	0.18*	0.03	-0.01	0.31*	0.14*
10	Partnership Experience (ln)	-4.54	10.18	0.22*	0.06	-0.02	-0.10	0.30*	0.42*
11	Responsible Care Membership	11.48	5.98	0.27*	0.32*	0.02	0.06	0.11*	0.10
12	Firm Size (ln)	9.90	1.42	0.23*	0.13*	0.00	-0.05	0.38*	0.12*
13	R&D intensity (ln)	-4.20	1.10	0.38*	0.00	0.00	0.10	-0.22*	0.30*

***p<0.01 *p<0.05*

Table 23 (continued). Study 2 Descriptive Statistics and Correlations. Industry Network Model

		7	8	9	10	11	12
7	Firm Network Size	1.00					
8	Firm Network Competition	0.28*	1.00				
9	Repeat Partnership	0.34*	0.16*	1.00			
10	Partnership Experience (ln)	0.42*	0.23*	0.31*	1.00		
11	Responsible Care Membership	0.16*	0.04	0.05	0.03	1.00	
12	Firm Size (ln)	0.49*	0.54*	0.34*	0.32*	0.19*	1.00
13	R&D intensity (ln)	-0.06	-0.42*	0.05	0.02	0.05	-0.37*

** *p<0.01 *p<0.05*

Table 22 and Table 23 report descriptive statistics and correlations for the firm network and industry network models, respectively. The analysis of Tables 19, 20 shows that most correlations are in the expected directions, except the effect of the number of green partnerships in the industry network on the number of green patents of a firm, which is negative (Table 23).

Because the variables Proportion of Green Partnerships in Industry Network IGA_t and Industry Network Reach NR_t were extremely highly correlated ($r=0.89$, $p<0.05$), in the industry network model I replaced the proportion of green partnerships in industry network with the number of green partnerships in industry network. It is still consistent with the logic of the argument that the greater the number of green partnerships in the industry network and the higher industry network reach, the higher would be the propensity of a firm to create new green knowledge and apply for patents.

The variable Partnership Duration AD_{it} was relatively highly correlated with the variable Partnership Experience AE_{it} ($r=0.59$, $p<0.05$). I tested the models with the Partnership Duration AD_{it} and without it, to check if the results were robust to the multicollinearity effects. In both cases all the hypothesized relationships were significant and with the sign as predicted. However, based on the Wald statistics, the model without the Partnership Experience reported a better fit and, thus, was retained as a final model.

The variable Firm Network Competition NC_{it} was relatively highly correlated with the variable Firm Size F_{it} ($r=0.54$, $p<0.05$). I followed the same strategy and tested the models with the Firm Network Competition NC_{it} and without it. In both cases, all the hypothesized relationships were significant and with the signs as predicted. However, based on the Wald statistics, the model including Network Competition NC_{it} reported a better fit and, thus, was retained as a final model.

8.2. Estimation Results

Firm Network Model

Table 24 presents the results of analysis of the firm network model. The dependent variable in all models was a number of green patents of firm *i* in year *t* GIP_{it} . All models were estimated using fixed effects Poisson panel regression. The time invariant controls such as industry, year and region specific dummies were included in the model, but due to the specifics of a fixed effects model, their coefficients were not identified and thus absent from the results.

Model 1 included control variables only. Model 2 introduced the knowledge-related attributes such as Breadth of Knowledge Pool BKP_{it}, Knowledge Compatibility MD_{it}^{avg} , Green Partnership Share in firm network FGA_{it}, and Proportion of Green patents in a firm's patent portfolio PGP_{it} and the firm network attributes like Network Density of Ties ND_{it}. Model 3 added the square term of the Knowledge Compatibility $(MD_{it}^{avg})^2$ and the interaction term of Breadth of Knowledge Pool and Knowledge Compatibility $BKP_{it} * MD_{it}^{avg}$. In Model 4, a square term of Network Density of Ties $(ND_{it})^2$ was added to check if the argument for the optimal network density of ties (Burt, 1992) holds.

Table 24. Study 2. Poisson Panel Fixed Effects Regression, Firm Network Model

DV: Number of Green Patents in Firm *i* Portfolio in year (t+1)	Model 1		Model 2		Model 3		Model 4	
	Coef	St. Err.	Coef	St. Err.	Coef	St. Err.	Coef	St. Err.
Firm Network Density			0.01	0.02	0.02*	0.01	0.04	0.06
Firm Network Density squared							0.00	0.01
Knowledge Compatibility			0.06**	0.03	0.56***	0.13	0.50***	0.17
Knowledge Compatibility squared					-0.4***	0.11	-0.37***	0.10
Breadth of Knowledge Pool			-0.12	0.14	0.36**	0.20	0.25	0.22
Breadth of Knowledge Pool * Knowledge Compatibility					-0.21***	0.06	-0.19**	0.08
Green Partnership Share in Firm Network			0.60**	0.37	0.53**	0.29	0.44*	0.32
Green Patent Share in Firm Patent Portfolio			-0.46	0.59	-0.54	0.63		
Green Patent Share in Firm Patent Portfolio 1-year estimate							-1.81**	0.89

Table 24 (continued). Study 2. Poisson Panel Fixed Effects Regression, Firm Network Model

	Model 1		Model 2		Model 3		Model 4	
	Coef	St. Err.	Coef	St. Err.	Coef	St. Err.	Coef	St. Err.
Firm Network Size	0.02**	0.14	-0.01	0.01	-0.01	0.02	-0.01	0.01
Firm Network Competition	-0.15	0.28	0.21	0.23	0.15	0.21	0.02	0.29
Repeat Partnership	-0.42	0.63	-0.10	0.58	-0.28	0.65	-0.33	0.60
Partnership Experience(ln)	0.01	0.01	0.01	0.02	0.01	0.01	0.02*	0.01
Responsible Care Membership	0.11***	0.04	0.10***	0.04	0.10***	0.03	0.10***	0.03
Firm Size (ln)	-0.57**	0.31	-0.54***	0.26	-0.62***	0.22	-0.67***	0.24
R&D intensity (ln)	-0.04	0.27	-0.02	0.29	-0.17	0.21	-0.33*	0.24
Wald chi-square	20.23		48.04		176.65		79.94	

**** p<0.001 **p<0.05 *p<0.1*

It also includes the alternative specification of the Proportion of Green Patents in a firm's patent portfolio PGP_{it} estimated over 1-year period instead of 4-year window, preceding year *t*. Models 2 and 3 provide significant improvements in fit over Model 1 with controls only. Model 4 also shows improvement over Model 1, but performs worse than Model 3. Variance inflation factors (VIF) are below the cutoff of 10, with mean VIF=3.47 Based on the results and model fit statistics, Model 3 was retained as the main one. I discuss the results in more details below.

Hypothesis H1a predicted that the breadth of knowledge pool accumulated in a firm network is positively related to the number of green patents a firm applies for. The results of Model 3 supported hypothesis H1a. After controlling for other firm, knowledge, and network-related characteristics, the variable Breadth of Knowledge Pool BKP_{it} reported positive and significant ($p<0.05$) effect of the dependent variable Number of Green Patents GIP_{it}.

Hypothesis H1b predicted that compatibility of knowledge accumulated in a firm network has an inverse U-shaped relationship with green innovation of a firm. Models 3 provides support for this hypothesis. The square term of Knowledge Compatibility $(MD_{it}^{avg})^2$ reported negative and significant ($p<0.01$) relationship with the dependent variable Number of Green Patents GIP_{it} , suggesting a curvilinear relationship between knowledge compatibility and firm green innovation.

Hypothesis H1c proposed that the positive effect of the breadth of knowledge pool on firm green innovation would be moderated by the knowledge compatibility in a firm network. The results in Model 3 support hypothesis H1c. Knowledge compatibility was operationalized with the average Mahalanobis distance between patent portfolios in a firm network, implying that high values of Mahalanobis distance correspond to low values of knowledge compatibility.

In Model 3, the interaction term of Breadth of Knowledge Pool and Knowledge Compatibility (operationalized with Mahalanobis distance) showed negative and significant ($p<0.01$) relationship with the dependent variable Number of Green Patents GIP_{it} . The higher the average Mahalanobis distance between patent portfolios in a firm network is (and the lower knowledge compatibility, accordingly), the lower would be the positive effect of a breadth of knowledge pool accumulated in a firm network on firm green innovation.

As an additional robustness check, I also calculated the inverse of the average Mahalanobis distance in a firm network as an alternative measure for knowledge compatibility. I re-run Model 3 with the inverse of the average Mahalanobis distance, its square term, and the interaction term of the Breadth of Knowledge Pool and inverse of the average Mahalanobis Distance. All the hypothesized relationships held in terms of their significance and signs, and the interaction term of the Breadth of Knowledge Pool and the inverse of the average Mahalanobis Distance was significant ($p<0.05$) and positive, confirming the robustness of the results.

Hypothesis H2a predicted that a proportion of green partnerships in a firm network is positively related to firm green innovation. Model 3 provides support for Hypothesis H2a. After controlling for the overall “greenness” of firm innovation effort with a share of green patents in a firm’s patent pool, the variable Green Partnership Share in Firm Network reports positive and significant *($p<0.05$)* relationship with the dependent variable Number of Green Patents GIP_{it}. Firms that include green partnerships in their portfolios of interfirm collaborations are more likely to create green innovations than firms who do not invest into green partnerships.

Finally, Hypothesis H3a proposed that density of ties in a firm network would be positively related to firm green innovation. The results of Model 3 provide marginal support for Hypothesis H3a. The variable Firm Network Density had positive and marginally significant ($p<0.1$) effect on the dependent variable Number of Green Patents GIP_{it}.

Model 4 provided additional robustness check of the results. After a square term of the Network Density of Ties $(ND_{it})^2$ was added to check if the argument for the optimal network density of ties holds (Nooteboom, 2000), neither the linear term of Network Density of Ties ND_{it}, nor its square term $(ND_{it})^2$ obtained statistical significance. Thus, the alternative theoretical argument regarding the optimal network density was not supported in the context of this study. The results suggest that, all other factors being controlled, as a firm’s partners become more densely interconnected, a firm propensity to achieve green innovation increases.

Also, Model 4 included an alternative measure of a proportion of green patents in firm portfolio. In Model 3, a proportion of green patents was calculated over 4-year window period preceding year t and showed negative, but statistically not significant relationship with the dependent variable Number of Green Patents GIP_{it}. In Model 4, a proportion of green patents in firm portfolio was measured over 1-year period preceding year t and showed negative and statistically significant ($p<0.05$) relationship with the dependent variable Number of Green Patents GIP_{it}. This is in line with the argument in innovation literature that knowledge depreciate dramatically 4-5 years after a creation and further highlights the path-dependent nature of knowledge creation where more recent patents have greater impact on firm innovation patterns (Griliches, 1990). Secondly, the negative relationship between the proportion of green patents in firm portfolio and a number of green patents of a firm suggests that firms that have already built a portfolio of green innovations might be less likely to continue exploring green technologies, but rather focus on exploitation of the created green innovation (Phelps, 2010).

With respect to the effects of the control variables, the Firm Network Size had positive, but statistically not significant effect on the firm propensity to create green innovation. Also, Firm Network Competition reported no significant effect on the dependent variable Number of Green Patents GIP_{it}. As it was expected, the variable Green Association Partnership reflective of how many years a firm has been a member of the environmentally-oriented industry-wide Responsible Care

Program, had a positive and significant *($p<0.01$)* relationship with the dependent variable Number of Green Patents GIP_{it}. The Firm Size had a negative and significant *($p<0.01$)* relationship with the dependent variable Number of Green Patents GIP_{it}, which is consistent with the argument in innovation literature that although large firms might be more successful in commercialization of inventions, in comparison to small firms and start-ups, large firms might be less likely to innovate because of higher bureaucracy and inertia (Hansen 1992).

Industry Network Model

Table 25 presents the results of analysis of the industry network model. The dependent variable in all models was a number of green patents of firm *i* in year *t* GIP_{it}. All models were estimated using fixed effects Poisson panel regression. Time invariant controls like industry, year and region specific dummies were included in the model, but due to the specifics of a fixed effects model, their coefficients were not identified and thus absent from the results.

Model 1 included control variables only. Model 2 introduced the knowledge-related attributes such as Breadth of Knowledge Pool BKP_{it} and Knowledge Compatibility MD_{it}^{avg}, as well as the industry-related network attributes like Industry Network Reach NR_{it}, Industry Clustering NCl_{it} and the Number of Green Partnerships in Industry Network $NIGA_{it}$. It also included Green Partnership Share in Firm Network FGA_{it}. Model 3 introduced the square term of Knowledge Compatibility $(MD_{it}^{avg})^2$, the interaction term of Breadth of Knowledge Pool and Knowledge Compatibility $BKP_{it}*MD_{it}^{avg}$, the interaction term of the Number of Green Partnerships in Industry Network and Industry Network Reach $NIGA_t$ *NR_t and the interaction term of the Number of Green

Table 25. Study 2. Poisson Panel Fixed Effects Regression, Industry Network Model

DV: Number of Green Patents in Firm *i* Portfolio in year (t+1)	Model 1		Model 2		Model 3		Model 4	
	Coef	St. Err.	Coef	St. Err.	Coef	St. Err.	Coef	St. Err.
Knowledge Compatibility			0.62**	0.03	0.57***	0.21	0.57***	0.21
Knowledge Compatibility squared					-0.38***	0.13	-0.38***	0.10
Breadth of Knowledge Pool			-0.09	0.11	0.42*	0.28	0.41**	0.23
Breadth of Knowledge Pool * Knowledge Compatibility					-0.21**	0.10	-0.22***	0.09
Industry Network Reach			1.27	1.12	0.75	1.77	1.06	1.45
Industry Network Reach*Number of Green Partnerships in Industry					-0.18	0.16	-0.13	0.20
Industry Network Clustering			-0.02	0.41	-216.23	472.49		
Industry Network Clustering* Number of Green Partnerships					-8.12	17.73		
Industry Network Transitivity							-0.04	3.34
Transitivity*Number of Green Partnerships in industry							0.26	0.43
Number of Green Partnerships in Industry Network			-0.02	0.42	-0.02	0.05	-0.02	0.05

Table 25 (continued). Study 2. Poisson Panel Fixed Effects Regression, Industry Network Model

	Model 1		Model 2		Model 3		Model 4	
	Coef	St. Err.	Coef	St. Err.	Coef	St. Err.	Coef	St. Err.
Green Partnership Share in Firm Network			0.57*	0.37	0.53*	0.39	0.53*	0.37
Green Patent Share in Firm Patent Portfolio	-0.43	0.67	-0.24	0.59	-0.32	0.54	-0.35	0.67
Firm Network Competition	-0.19	0.27	0.24	0.85	0.26	0.32	0.23	0.31
Repeat Partnership	-0.55	0.71	-0.26	0.64	-0.46	0.54	-0.45	0.64
Partnership Experience(ln)	0.02*	0.01	0.01*	0.01	0.02*	0.01	0.02	0.01
Responsible Care Membership	0.12**	0.05	0.09***	0.03	0.10**	0.05	0.09**	0.05
Firm Size (ln)	-0.52**	0.30	-0.55***	0.24	-0.56***	0.25	-0.56**	0.30
R&D intensity (ln)	-0.12	0.31	-0.01	0.22	-0.16	0.32	-0.10	0.32
Wald chi-square	24.46**		30.22***		131.83***		69.29***	

**** p<0.001 **p<0.05 *p<0.1*

Partnerships in the Industry Network and Industry Network Clustering $NIGA_t$ $*NCl_t$.

Model 4 provided additional robustness check. Industry Network Clustering NCl_t and its interaction term with the Number of Green Partnerships in Industry Network $NIGA_t$ $*NCl_t$ were replaced with Industry Network Transitivity NT_t and its respective interaction term with the Number of Green Partnerships in Industry Network $NIGA_t$ $*NT_{t.}$

Models 2, 3, 4 all provided improvements in fit over Model 1 with controls only with Model 3 performing best. However, none of the hypothesized relationships in H2b, H3b, H3c was significant in any of the models. I discuss the results in more details below.

Hypothesis H2b proposed that a proportion of green partnerships in the industry network would have positive relationship with firm green innovation. As noted before, because of an extremely high correlation between the variables Proportion of Green Partnerships in Industry Network IGA_t and Industry Network Reach NR_t, I replaced the Proportion of Green Partnerships in Industry Network IGA_t with the Number of Green Partnerships in Industry Network $NIGA_{it}$. The results in Models 2-4 showed no statistically significant relationship between the Number of Green Partnerships in the Industry Network $NIGA_{it}$ and the Number of Green Patents $GIP_{it.}$. Thus, the Hypothesis H2b was not supported. The potential explanation for not observing significant effects might be the stability of local firm networks and low density of connections among the firms in the industry.

The average firm network size was 2.4 with the average partnership duration 4 years, which means that every firm in the data set had on average 2-3 partners and changed those once or twice over the observed 8-year period. Thus, the firms stayed locked in the established relationships, without much access to the environmental knowledge outside their respective firm networks.

Hypothesis H3b predicted that the relationship between the proportion of green partnerships in the industry network and firm green innovation would be positively moderated by the industry network reach. The results in Models 3 and 4 showed that the interaction term of the Number of Green Partnerships in Industry Network and Industry Network Reach $NIGA_t$ $*NR_t$ had no statistically significant relationship with the dependent variable Number of Green Patents GIP_{it}. Thus, Hypothesis H3b was not supported. The possible explanation here might be that because global network reach and local network density were relatively low (which is typical of the chemical industry as confirmed in other studies (Ahuja 2000), and the effect of green partnerships in the global network turned non-significant, and the interaction of the network reach and the number of green partnerships in the industry network got also non-significant.

Finally, Hypothesis H3c predicted that the relationship between the proportion of green partnerships in the industry network and firm green innovation would be negatively moderated by the industry network clustering. The results in Models 3 and 4 showed that, although the sign was in the predicted direction, the interaction term of the Number of Green Partnerships in Industry

Network and Industry Network Clustering $NIGA_t$ *NCl_t had no statistically significant relationship with the dependent variable Number of Green Patents GIP_{it}. Thus, Hypothesis H3c was not supported. The potential explanation for the nonsignificant results here again might be the non-significance of the simple effect of the number of green partnerships in the global network on a firm's propensity to create green innovation.

Furthermore, the results in Model 4 further support the findings of Models 2 and 3. After substituting the Industry Network Clustering NCl_t with the Industry Network Transitivity NT_t and adding the interaction term of the Number of Green Partnerships in Industry Network and Industry Network Transitivity $NIGA_t$ *NT_t, none of the variables had changed in terms of their significance levels or signs.

With respect to the control variables in the Industry Network Model, the Proportion of Green Partnerships in Firm Network had positive and marginally significant ($p<0.1$) relationship with the dependent variable Number of Green Patents GIP_{it}. Also, the variable Green Association Partnership had a positive and significant ($p<0.05$) relationship with the dependent variable Number of Green Patents GIP_{it}. Finally, the variable Firm Size F_{it} had a negative and significant ($p<0.05$) effect on the dependent variable Number of Green Patents GIP_{it}. The controls showed consistency of the effects across the levels of analysis, firm networks versus industry networks, thus confirming robustness of the findings.

Chapter 9

Study 2 Discussion

In today's world, businesses are expected to contribute to well-being of society by reducing environmental pressures from production and consumption (Sheth, J. N., Sethia, N.K, & Srinivas S, 2011; Varadarajan, 2015). Green innovation plays increasingly important role in achieving these goals. As Cleff & Rennings (1999) show in the Europe-based study, about 80% of innovative firms there are involved in environmentally-oriented innovative programs. More recently, the USA statistics reported that in 2005-2009 green patents constituted up to 20% of firm technology portfolios across many industries (Breitzman & Thomas, 2011).

Even though the interest on environmental innovation is on rise, understanding how firms create green innovation is still lacking. Despite the repeated calls into more research into the antecedents, forms, and outcomes of green innovation, empirical inquiries into how those innovations are conceived, realized and managed are still scant and sparse (De Marchi, 2012; Horbach, 2005).

In Study 2, I provide partial answers to the questions regarding the drivers of green innovation, by exploring the effects of technological networks on organizational propensity to achieve green innovation. Building on the social networks and environment-oriented innovation literatures, I develop a theoretical framework that links the attributes of knowledge accumulated in a firm network, namely breadth of knowledge pool, knowledge compatibility, and knowledge specificity, to a firm green innovation. I further argue that the structural attributes of networks such as firm network density of ties, industry network reach, and industry network clustering have an impact on firm green innovation.

Overall, the results provide evidence that both the knowledge attributes and the network structural attributes have an impact on firm green innovation. However, mixed patterns emerge, if different levels of analysis such as local firm networks versus global industry network are considered.

At the level of a firm network, I found that the breadth of knowledge pool, knowledge compatibility and knowledge specificity (as operationalized by the proportion of green partnerships in the firm network) are all important determinants of a firm propensity to create green innovation.

The results show that the breadth of knowledge pool capturing a variety of unique knowledge resources accumulated in a firm network enhances firm green innovation. The knowledge compatibility reflective of how well knowledge resources can be re-combined to create novel insights (Fleming, 2001) is shown to have inverse curvilinear relationship with firm green innovation. Highly diverse and hardly compatible knowledge resources, as well as highly compatible and very similar, lacking novelty knowledge resources have detrimental effect on firm green innovation. Partially dissimilar and moderately compatible knowledge resources are optimal. They are diverse enough to enable novel re-combinations and re-configurations and at the same time share some commonalities to ease inter-firm knowledge exchange (Dyer & Singh 1998; Ahuja & Lampert 2001). Furthermore, the attributes of a breadth of knowledge pool and knowledge compatibility interact with each other, with lower knowledge compatibility reducing positive impact of a breadth of knowledge pool on firm green innovation.

Combined, these findings help reconcile mixed empirical results in general innovation literature regarding the impact of knowledge heterogeneity on firm innovation, i.e. linear positive versus linear negative versus curvilinear relationship between the two (i.e. Phelps 2010, Rodan 2002, Sampson 2007). The findings of Study 2 demonstrate that the breadth of knowledge pool and knowledge compatibility attributes represent distinct aspects of knowledge diversity. Each of the two attributes plays different, although complementary to another one role in knowledge creation process and thus, both are necessary for understanding of the impact of knowledge heterogeneity

Next, the attribute of knowledge specificity is also found to positively affect a propensity of a firm to create green innovation. Green technology industries represent a highly regulated sector of the economy, where firms face numerous legislative and normative pressures (Popp et al 2009). Firms operating here need to develop idiosyncratic mechanisms of knowledge transfer and integration to facilitate synthesis of information from the distinct functional domains, technological and administrative ones (Winkelbach & Walker, 2015). Firms maintaining green technology partnerships in their networks of partnerships are more likely to develop 'green domain'-specific knowledge transfer mechanisms and thus are more likely to create green innovation in interfirm relationships.

Regarding the role of the network structure attributes, I found that the firm network density is positively related to the firm green innovation. This is in line with other research reported similar effects of the firm network density on firm patent output (i.e. Ahuja 2000, Phelps 2010). In densely interconnected networks, firms benefit from increasing trust, improving collaborative learning routines, and reduced partner opportunism due to higher transparency and visibility created by multiple connections among the network members, altogether leading to greater potential to achieve innovation (Phelps 2010)

At the level of the industry networks, after controlling for the firm-level knowledge attributes, none of the knowledge attribute or the structural attributes of the global industry network such as Proportion of Green Partnerships in the Industry Network, Industry Network Reach NR_t, Industry Network Clustering NCl_{it}, or Industry Network Transitivity NT_t or their respective interaction terms had an effect on firm green innovation. This suggests that the knowledge and structural attributes of the local firm networks are more important determinants of firm green innovation, than the attributes of the global industry network. Even in the fragmented industries, lacking in terms of large technological networks, firms are still able to achieve green innovation, if wisely choosing partners in their local, small-scale networks.

The larger firms become, the less they are likely to innovate with green technologies. This is in line with previous research on the relationship between firm size and firm R&D (Liefer 2000; Vossen & Nooteboom1996) arguing that small firms are more innovative than the large ones, when exploring new technologies. It is also consistent with the strategy literature showing that large established organizations are less likely to diversify into new technological domains, preferring to focus on specialization along familiar technological trajectories and exploitation of existing technologies (Levinthal & March, 1991; March, 1991).

Firms who are members of private industry associations with environmental agendas are more likely to come up with green innovations. Furthermore, the propensity to create green technologies increases as firms maintain membership with those industry associations over time. A membership in a green association signals about firm commitment to the sustainability goals and helps them to choose partners with similar strategic interests in the green domains. Also, the longer firms stay in the associations, the more resources they dedicate cumulatively to improvements in environmental performance and the more relevant expertise they acquire, which consequently transfers into greater green innovation rates for them. The findings regarding the role of a membership in green trade associations further confirm the argument in the general environmental management literature that normative and regulatory forces within green technology sectors constitute the important determinants of environmental innovation (Porter & van der Linder 1995, Foxon & Andersen 2009).

Taken together, the findings of Study 2 provide support for the argument that green technology partnerships can enhance firm green innovation. All other things equal, firms with ‘greener’ portfolios of technological partnerships are more likely to develop ‘green domain’-specific knowledge integration mechanisms than firms who do not invest into green collaborations. Although initially stock markets react skeptically towards news about green technology partnerships, those interfirm arrangements do enhance firm green innovation efforts, subsequently resulting in a greater number of green patents firms apply for. This might explain why firms announcing green technology partnerships initially face a sizable drop in stock market price but, later experience a dramatic increase in firm market value, as evidenced in Study 1.

The summary of the key results is provided in Table 26.

Table 26 Study 2 Predicted Effects and Findings

Independent Variable	Hypothesis	Sign	Findings
Breadth of Knowledge Pool	H1a	+	+
Knowledge Compatibility	H1b	+/- (inverted U)	+/- (inverted U)
Breadth of Knowledge Pool * Knowledge Compatibility	H1c	-	-
Green Partnership Share in Firm Network	H2a	+	+
Green Partnership Share in Industry Network	H2b	+	n.s.
Firm Network Density	H3a	+	+ (marginally significant)
Green Partnership Share in Industry Network * Industry Network Reach	H3b	+	n.s.
Green Partnership Share in Industry Network* Industry Network Clustering	H3c	-	n.s.

Chapter 10

Conclusions

The objective of this dissertation was to explore the implications of green partnerships on firm value creation potential.

Consumers and society have placed great emphasis on the importance of sustainability and corporate environmentalism and increasingly pressure firms to embrace environmental concerns as a key component of their corporate strategies (Peloza & Shang, 2011). As a recent research reported, US $6.22 trillion has been invested in the global green economy since 2007 (Henderson, Sanquiche, & Nash, 2015). Not surprisingly, in rapidly 'greening' society, interest towards environmental products and technologies is on rise.

Many organizations increasingly rely on inter-firm partnerships to manage their environmental agendas, and environmental innovations are a large part of this trend. An emerging stream in the innovation literature suggests that collaborative approach to innovation management becomes more noticeable in the green, than other technological domains (De Marchi 2012, Horbach 2008).

Yet, businesses continue to lack in understanding of the implementation forms and economic potential of green interfirm strategies. Despite their growing significance to business practice, green partnerships, and green technology collaborations in particular, still remain a largely unexplored terrain (Sharma & Kearins 2011; Wassmer et al 2014).

The major insight of this dissertation relates to whether green partnerships can be instrumental in unlocking value creation potential of a firm. Specifically, I examined the financial and innovation-related outcomes of green partnerships in a two-step project. In Study 1, I explored the financial aspects by examining how technology capabilities as opposed to marketing capabilities can be leveraged in green partnerships for eco-based competitive advantage. I also looked into the roles and contributions of other firm and industry-related greening factors to the green partnerships – firm market value relationship. In Study 2, I researched the patterns and predictors of green patenting behavior by firms engaging in complex networks of technological agreements. I explored how various knowledge and structural aspects of inter-organizational relationships impact firm propensity to create environmental innovation.

Overall, the findings of this dissertation have implications for theories of corporate social responsibility (CSR), organizational capabilities, marketing-finance interface, and social networks analysis.

10.1. Theoretical Implications

First, this dissertation contributes to the emerging stream of research in the corporate social responsibility (CSR) domain that focuses on the specifics of firm value creation in the context greening businesses. The concept of corporate social responsibility represents quite a diverse array of business practices related to diversity, governance, employees, community, product, and environmental efforts (Cronin et al., 2011). Although there exists a substantial body of literature linking corporate social responsibility strategies to firm economic outcomes, much of empirical research does not differentiate between the types of CSR, considering corporate social responsibility as an aggregate construct (i.e. Servaes & Tamayo, 2010; Surroca et al. 2010). Responding to repeated calls for more nuanced research into different aspects of corporate CSR (Connelly et al., 2011; Margolis et al., 2009), this dissertation focuses on the firm environmental practices. By parceling out the economic and innovation-generating impact of green strategies, it provides additional insight into the boundary conditions for different types of CSR in enhancing firm value creation potential.

Second, this dissertation explores the increasingly relevant type of green strategies, inter-firm green partnerships, and how those can influence performance of a firm. With respect to financial implications, the findings demonstrate that stock markets are selective in reacting to announcements of green collaborations, and some of those initiatives can, in fact, destroy shareholder value. This is consistent with a broader view in the CSR literature that financial impact of corporate environmentalism depends on the nature of firm green initiatives (Russo & Fouts, 1997). However, further in-depth examination of the variations in investor reactions reveals that the ultimate effect is contingent on the type of partnership implemented. Even more importantly, in the short-term perspective, green technology partnerships systematically underperform financially, in comparison to green marketing partnerships. This insight is in contrast with the prevailing perspective in extant strategy literature. Historically, variations in valuation of different types of inter-firm collaborations have been explained by the industry dynamism (see for example Park *et al*., 2004; Song, Droge, Hanvanich, & Calantone, 2005). According to the traditional point of view, in high-tech industries technology partnerships would be more rewarded by stock markets than marketing partnerships. Technology partnerships spur organizational innovation which is a better source of competitive advantage in conditions of the volatile and rapidly changing high-tech industries.

In contrast, the findings of Study 1 demonstrate that irrespective of industry dynamism, in the short-term perspective at least, green marketing partnerships seem superior and generate greater financial rents, than technology partnerships do. This finding contributes to the emerging stream of marketing literature advocating the relative advantage of marketing capabilities over technology capabilities and elevates marketing's positions in the hierarchy of organizational functions (Eisend, Evanschitzky & Calantone, 2015; Krasnikov & Jayachandran, 2008).

Third, the dissertation adds to the body of literature on organizational capabilities. Prior research has noted that both technology and marketing capabilities play critical role in organizational strategies and can be instrumental in enhancing firm value. Recently, several studies have started examining the interplay of organizational capabilities with CSR strategies and explore their joint value creation potential (Luo & Bhattacharya, 2009; Mishra & Modi, 2016; Servaes & Tamayo, 2012). This dissertation extends this line of research by, first, explicitly outlining the pathways through which technology versus marketing capabilities can be leveraged in the context of green strategic partnerships for eco-based competitive advantage and, second, by quantifying the effect of green technology versus green technology inter-firm strategies on shareholder value.

Fourth, the dissertation also advances research on the marketing-finance interface. Many studies examining the association between firm CSR and shareholder wealth focus on the short-term implications of those initiatives and analyze the immediate stock market reaction towards a firm's CSR news. Study 1 takes a step further by analyzing both the short-term and long-term consequences of green CSR initiatives and reveals an interesting reversing trend. The initial skepticism of investors regarding the future cash flows of green technology partnerships later turns into strong positive expectations, resulting in substantial upward stock market price adjustments over 1 year after the partnership commencement. Financial markets seem unable to immediately recognize the economic value of green innovation and incorporate it into stock market price slowly, with a drift.

Firms' past environmental performance also drives investors' sentiments towards green strategic partnerships. In contrast with the argument in extant literature that good corporate citizenship leads to a positive CSR reputation that protects a firm in times of crisis and offset negative consequences (Schnietz & Epstein, 2005), the current results show that stock markets in general are insensitive to the information about firms' past positive environmental behavior and do not adjust firm valuation upward, on that ground. Firms might be even penalized for being environmentally proactive in excessively polluting industries. Investors also become wary if a green partnership is announced by a firm with a history of poor green behavior in the past, which reinforces the idea of general investor conservatism regarding green interfirm partnerships.

The reason for stock market conservatism can be the lack of experience in the CSR domain and green partnerships in particular. Green collaborations just recently have started becoming a widespread phenomenon and investors might not have enough knowledge and expertise to evaluate them accurately (Harrison & Freeman 1999). Environmental quality in some of its aspects is a public good, and market prices often do not exist for those (Reinhardt 2000). When evaluating the economic potential of corporate environmental actions, investors have to make their investment decisions based on rather incomplete information and their own very approximate evaluations. Lacking reliable information about the costs and benefits of green initiatives, investors tend to be more conservative and discount future value of environmental investments.

The results of Study 2 about the patent-related outcomes of green technology partnerships further corroborate the conclusions about the economic value potential of green partnerships and the green technology partnerships in particular. While most of extant literature on environmental innovation focuses on green innovators and utilizes cross-sectional data, Study 2 is based on the panel data and a mix of green and non-green innovation and allows for in-depth exploration of the peculiarities of development of green technologies as opposed to non-green technologies and examining the causality relationships among the variables considered. The results show that firms that invest in collaborative green technology projects are more likely to apply for green patents a year after a partnership was commenced, than firms that do not engage in green technology partnerships. Thus, green collaborations indeed support and enhance firm green innovation effort. This might explain why those companies announced green technology partnerships and experienced on average 0.28% drop in stock market value on the day of an announcement (based on the sample of firms observed in Study 1), a year later were worth 4% more, by conservative estimate (based on the sample of firms observed in Study 1).

This dissertation also adds to the development of the social networks perspective in CSR literature. Complex and multi-scale nature of environmental problems requires a diversity of knowledge residing in multiple social actors and groups (Kotler, 2011). Stakeholders' participation for solving 'green puzzles' is progressively being embedded in organizational decision-making.

The social networks analysis offers a powerful tool for examining complex interactions between corporations and stakeholder communities. It has also been extensively used in innovation management literature. Building on both streams of literature, in Study 2 social networks analysis is applied for the increasingly relevant type of environmental strategies – green innovation in the context of inter-organizational relationships and offers novel insights.

A new, multidimensional conceptualization of knowledge heterogeneity is proposed and empirically tested (Wassmer et al., 2008). This conceptualization allows to reconcile a long-standing debate in the existing literature regarding the impact of knowledge heterogeneity on firm innovation in the context of inter-organizational networks. A newly identified dimensions of knowledge heterogeneity are shown to play complementary, but distinct roles in shaping firm innovation. Accounting for both dimensions helps identify the boundary conditions under which knowledge diversity enhances or inhibits firm innovation, thus leading to a more nuanced understanding of the role of knowledge heterogeneity in innovation processes.

Furthermore, the dissertation suggests a new additional knowledge attribute that may influence firm innovation – green knowledge specificity. The empirical results confirm the significance of effects of green knowledge specificity on a firm propensity to achieve green innovation and highlight the importance of exploring how different types of knowledge, for example green versus non-green, managerial versus administrative, etc. and their combinations diffuse in inter-organizational networks and affect firm innovation (Phelps et al., 2012).

However, knowledge attributes do not tell the full story and firm green innovation also depends on the structural attributes of the relational networks that organizations are embedded. With this regard, the dissertation contributes to the contingency perspective in the social networks literature about the effects of network structure on firm innovation, more specifically, the role of network density – high versus sparse. The contingency perspective argues that there is no a single overarching optimal network structure, and the ultimate benefits are contingent on the nature of exchange between partners, for example green versus non-green knowledge content (Burt, 2000; Podolny & Baron, 1997). The findings of Study 2 indicate that in the context of R&D intensive industry like chemicals, high network density increases firm ability to produce novel green knowledge and provides the benefits that sparse networks cannot supply. Thus, the findings highlight the importance of a composition and the structure of networks in shaping firm green innovation.

Finally, the dissertation explores the role of global industry structure, focusing on the global network reach and global network clustering. This approach enables analysis beyond firm-level dyadic relationships that most of extant literature focuses on. The empirical results suggest that in the context of the chemical industry the global industry network properties might not be critical for achieveing green innovation. This finding further informs the structural perspective of firm innovation (Stuart 1999, Stuart & Podolny, 1996) and suggest that the local search might be a more important driver of firm green innovation than the global search is.

10.2. Implications for Managers

This dissertation offers insights for managerial practice, as well. First, it addresses concerns of managers and important firm stakeholders regarding the returns of environmental CSR and provide empirical support for the importance of investing in green collaborations. The results give confidence that green partnership are instrumental in carrying out firm's environmental strategies and may have a beneficial effect on firm performance.

At the same time, managers must be aware that not all green strategic partnerships generate immediate positive returns, and should recognize the short-term and long-term implications of different types of green strategies. Based on the sample of firms studied, announcements of a green marketing partnership, on average, led to an increase in firm market value $126.99 million on the day of an announcement. By contrast, a firm's market value decreased, on average, by $102.41 million on the day, when a green technology partnership was announced. However, one year after an announcement of a green technology partnership, the companies concerned reported an average increase in stock market value of $1638.52 million. Managers interested in greening their operations have flexibility to choose the alternative pathways to allocate firm resources to green marketing vs. green technology domains, depending on the short-term and long-term goals.

Firms should also pay attention to their reputation for environmental performance. This dissertation highlights the fact that 'doing bad' hurts, financially, more than 'doing good' helps it, and it is in interests of firm shareholders to focus on the positive environmental performance. To minimize losses, managers should implement positive green strategies across all business domains and avoid negative green approaches altogether. At the same time, managers should be cognizant about potential risks associated with green strategies in the pollution-intensive industries as stock markets might not recognize those as investments with positive future cash flow. Furthermore, larger firms and firms with significant financial leverage may not be able to generate positive shareholder value by announcing green strategic partnerships, which also points to the important boundary conditions managers should be aware of.

Finally, with respects to the green technology partnerships, the results of the dissertation confirm that those collaborative arrangements do enhance firm green knowledge creation efforts, and managers should consider them among the instruments to improve firm environmental performance.

However, the results also demonstrate that there are certain limits to the benefits of inter-organizational networks for a purpose of green knowledge creation. For example, the negative interaction effect of a breadth of knowledge pool and knowledge compatibility as well as an inverted curvilinear relationship between knowledge compatibility and a number of green patents by a firm suggests that managers should be particularly careful when forming and maintaining networks of partnerships for environmental innovation. Besides, firms should attend to the structure of relationships they are embedded. Managers should evaluate carefully how their decisions regarding the termination of old relationships, establishment and a choice of strategic focus of new partnerships, i.e. green versus non-green will affect competitive outcomes of a firm.

10.3. Limitations and suggestions for further research

This dissertation has several possible limitations that suggest avenues for future research. First, one of the major challenges of Study 1 relates to the high heterogeneity of the sample due to the scarcity of green partnership announcements within any particular industry. Unobserved industry attributes may have affected the examined relationships. As popularity of green partnerships among practitioners increases and the amount of data on those collaborations accumulates, future research could explore whether the observed effects hold in more homogenous settings and if other ‘hidden’ relationships surface.

Second, in this dissertation financial implications of green partnerships were explored with a sample of the US firms only. It might be the case that stock markets in other countries exhibit different patterns of reacting to green corporate strategies. It seems interesting to expand this research by including data from other countries, for example those of Europe, where environmental issues are of high importance.

Third, in contrast with this research that focuses on the large and established corporations, future studies could explore how small and medium-sized companies use inter-firm partnerships to carry out their environmental agendas. Small and medium-sized enterprises comprise a majority of businesses worldwide and their business activities have substantial impact on society. They more often lack necessary resources and might be more interested in pursuing green partnerships for greater efficiency purposes.

Study 1 utilizes a sample representative of multiple heavily polluting industries with varying degrees of pollution, which are subjects to extensive public policy regulations. Further research could focus on exploring whether the same trends and relationships hold in non-polluting sectors setting and provide additional insight and assist managers in devising more effective corporate green strategies.

With respect to Study 2, although the results do empirically support that knowledge specificity, green versus non-green, influences firm propensity to achieve green innovation, these findings might be unique to the industry context. Chemicals are among the most highly polluting industries, and environmental knowledge might be critical element and a basis for competitive advantage here. Future research could investigate if this trends hold in less environmentally sensitive industries.

Also, the dependent variable firm green innovation was operationalized with a simple count of green patents, which implies that all patents are equally important in term of their technological and economic potential. Future research could apply weighing patents based on the number of citations patents receive, to capture differences in their value. Besides, this approach will enable testing the validity of the surprising findings regarding the non-significance of effects of the global network attributes on firm innovation performance. A relationship between the distinct dimensions of the knowledge heterogeneity deserve further investigation. Given the fact that one dimension, breadth of knowledge pool, has a liner positive effect on firm innovation, and another dimension , knowledge compatibility, has a curvilinear effect on frim innovation, it is interesting to investigate whether their interaction term follows a non-linear path as well. Finally, it is worthwhile to explore whether it makes any difference if more or less green partnerships in a firm's portfolio belong to the upstream than downstream channel members and to investigate the effects of the partnership size, i.e. multipartner versus dyadic partnership, and partner maturity gaps in terms of environmental expertise.

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