Social Media and Innovation:

The Relationship between Firms' Facebook Activity
and Product Innovation Development

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Friederike John

f.john @student.utwente.nl

Executive Summary

The growth of social media platforms such as Facebook has allowed an increasingly large number of users to connect and communicate which each other online. At the same time, firms become more present on social media platforms, aiming to engage their customers. While social media is often perceived as a marketing channel, companies begin to realize the potential for user involvement in innovation processes as well. In today's competitive markets, firms are required to gain advantages over their competitors by developing innovations that correspond to user needs and can thus be successfully commercialised. Hence, involving customers in innovation through social media can hold multiple benefits.

This thesis investigates whether social media can act as a facilitator for firm innovation. After a review of theoretical and empirical innovation literature specifically involving users, the effects of social media on firms are shown and four success factors for social media involvement in innovation are developed: quantifying engagement, developing a specific and goal-oriented social media strategy, providing a firm culture of openness, and applying co-creation methods via social media. In four hypotheses, each of these success factors is proposed to positively influence innovation. In conjunction, they form a research model to connect social media with innovation.

The hypotheses are tested using product innovation data and a small sample of firms from the Innovation Survey 2012 conducted by the Centre for European Economic Research. Facebook is chosen as a representative social media platform. User engagement numbers on Facebook are collected and analysed with a logit regression. Social media strategy, openness culture, and application of co-creation methods are captured through an online survey with 16 firms and evaluated descriptively.

The results for the engagement rates show that the *scaled conversation rate* of a Facebook fan page, i.e. the number of comments per post per fan, positively influences innovation. Also, more innovators than non-innovators of the online survey had developed a social media strategy, indicating that a strategic approach to social media management improves firm innovation. The impact of openness culture and the application of co-creation methods could not be shown empirically, but a variety of limitations of this study aid in explaining the absence of clear results and offer multiple future research directions.

The overall theoretical and empirical finding of this thesis is that social media can indeed foster innovation, but only if social media management is prudently and intelligently executed, ideally focusing explicitly on innovation tasks.

Key words: Social Media, Web 2.0, User Innovation, Co-Creation

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# 1.	Introduction

## 1.1.	Research Gap

The development of the Internet to the Web 2.0, as well as the establishment of numerous social media platforms are a "revolutionary new trend" (Kaplan & Haenlein, 2010, p. 59) that is changing communication patterns and is fuelled by online interactions of users worldwide. The social media sites allow for historically unparalleled user empowerment and seamless interactions with firms. At the same time, in an increasingly competitive landscape involving an innovation imperative for companies, firms have to find new ways to connect with their customer base and stay innovative. Baldwin and von Hippel have noted that innovations "are solutions to the problems of a specific time and place using the technologies of that time and place" (Baldwin & von Hippel, 2009, p. 29). The new development of online social media platforms constitutes such a current technology; it enables users to articulate their needs and wishes, and provides chances for collaborations with firms in the innovation process.

The possibilities for understanding the consumer through social media interactions for market research purposes have been increasingly exploited, as "the zeitgeist of the consumer, once accessible only through focus groups or research, was laid bare by YouTube, Facebook, LinkedIn and a host of other online meeting places." (Accenture Interactive, 2012, p. 2). However, user integration can go even further; this thesis proposes that joint problem solving in the form of customer co-creation as developed by Prahalad and Ramaswamy (2004) can also be facilitated by social media.

The research streams concerned with co-creation methods on the one hand, and with the social media phenomenon on the other hand, are both receiving increased attention in the past years. Prahalad and Ramaswamy (2004) have advanced the field of co-creation by proclaiming the necessity for companies to change the firm-centric view of innovation into a customer-centric view, a paradigm shift that has been adopted for instance by O'Hern and Rindfleisch (2010) who categorise and evaluate different forms of co-creation.

As for social media research, Kaplan and Haenlein (2010) define social media and highlight the importance of social media management for firms, and Kietzmann, Hermkens, McCarthy, and Silvestre (2011) present a conceptual model of functional building blocks of social media. A link between both domains is developed for instance by Sawhney, Verona, and Prandelli (2005), highlighting the Internet's unique capabilities to support co-creation processes of firms and users, especially through social media, as well as by Sashi (2012), who models customer engagement via social media as a cycle involving different steps,

leading from interaction to user satisfaction, commitment, and finally engagement. Thus, the research suggests that social media can aid in understanding customer needs and involving users in developing solutions that fit to the market.

However, the research often has a theoretical nature where the impact of social media on innovation is rarely specified, and empirical research is scarce. Hence, a research gap exists, as the role of social media in the innovation process is not yet clear (Kärkkäinen, Jussila, & Väisänen, 2010).

1.2.   Research Questions and Research Approach

Therefore, the central research problem of this thesis considers the support function of social media in innovation processes mentioned in previous research: *Can social media act as a facilitator for firm innovation?*

To address this research problem, four research questions are posed. They enable a comprehensive understanding of the issue by including a theoretical perspective that involves prior conceptual and empirical research, culminating in the development of a research model, as well as a first empirical application of this research model:

1. *Which theoretical approaches to social media and their role in innovation exist?*
2. *What are the main empirical findings concerning the role of social media in innovation?*
3. *How can the impact of social media on innovation be conceptualised in a model?*
4. *Can the impact of social media on innovation be measured empirically?*

To answer research questions 1 and 2, this thesis first provides a literature overview about relevant concepts from innovation and co-creation to social media, and presents notable empirical research concerned with the role of social media in innovation processes. From this, four success factors for social media use that impact innovation are derived and conceptualised in a research model that contains four corresponding hypotheses, thereby answering research question 3. Then, the research model is empirically analysed with a small sample of firms to provide an answer to research question 4. Thus, while the theoretical section of the thesis gives suggestions on *how* to improve innovation through social media, the empirical part tests *if* social media use can lead to increased innovation.

To understand the relationship between social media and innovation empirically, the possibility to analyse the results of the Innovation Survey 2012 conducted by the Centre for European Economic Research was provided by the Chair of Innovation Economics at

Technische Universität Berlin. This research focuses on product innovation. In order to capture social media factors quantitatively, user engagement rates at the selected social media platform Facebook were collected for a sub-sample of the firms that had participated in the innovation study. Furthermore, an online survey with 16 firms was conducted to comprehend firm-internal factors that affect social media use for innovation.

Overall, the consideration of these new and evolving research streams as well as the small sample size give this study an exploratory character. The aim is thus to provide first insights to the role that social media can play in innovation, rather than achieving globally generalizable results.

1.3. Structure of the Thesis

The thesis is structured as follows. First, the theoretical background is provided (chapter 2), beginning with an overview of innovation in general, and specifying the focus on user involvement in open innovation processes, leading to the theory of co-creation. After defining Web 2.0 and the social media phenomenon, their impact on co-creation is explained and co-creation methods which can be facilitated by social media are derived to answer research question 1. Subsequently, previous research on the effect of social media on innovation is investigated to address research question 2. Then, four success factors for social media use for innovation are identified. Based on this theoretical background, a research model with four hypotheses is developed, where each hypothesis reflects the relationship between one of the four aforementioned success factors and innovation, thus providing an answer to research question 3.

Next, the methodology section (chapter 3) illustrates the empirical testing of this research model using data on product innovation from the Innovation Survey 2012 conducted by the Centre for European Economic Research, and focusing on the social network Facebook, thereby addressing research question 4. Quantitative data on user engagement rates was collected and a survey about social media approaches was conducted with a small sample of firms. Descriptive statistics for the data are provided in the following part (chapter 4).

The results of the hypotheses' empirical testing are presented next (chapter 5). User engagement rates are statistically analysed with a logit regression for the first hypothesis, and the survey data is descriptively evaluated to test the remaining three hypotheses. The empirical findings are put into context in the discussion section (chapter 6), followed by theoretical and managerial implications as well as limitations and future research directions (chapter 7).

2. Theoretical Background

2.1. From Innovation to Co-Creation

2.1.1. Innovation

Innovation has been extensively discussed in the literature and several approaches to definitions of innovation were taken. This chapter provides as short overview on innovation research, before setting the focus of this study on open innovation (2.1.2), and especially open innovation involving customers (2.1.3).

One of the earliest publications on innovation is the seminal work by the economist Joseph A. Schumpeter describing innovation as the driving factor of economic development, since disruptions caused by entrepreneurs and innovative developments replace existing technologies and processes, allowing society to advance (Schumpeter, 1934). Schumpeter labelled this process "creative destruction" (Schumpeter, 1942). Other researchers have proposed different definitions for innovation, such as "any thought, behavior or thing that is new because it is qualitatively different from existing forms" (Barnett, 1953, p. 7), or that is "perceived as new" (Rogers, 1983, p. 11). Innovation has further been conceptualised as a new combination of means and ends (Rickards, 1985), and as the process leading from the invention to the commercial exploitation of a new idea, thus emphasising that an application for the invention needs to be found (Roberts, 1987). Innovations have also been classified according to their impact. Schumpeter distinguished between *incremental* innovations promoting continuous change, and *radical* innovations leading to discontinuous, disruptive changes (Schumpeter, 1934).

In the OECD's and Eurostat's joint publication on the guidelines for the collection and interpretation of innovation data, the Oslo Manual, innovation is defined as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD & Eurostat, 2005, p. 46). This comprehensive definition thus includes product, process, marketing and organisational innovation. It also covers incremental and radical changes with the minimum requirement that they need to be "new to the firm" (OECD & Eurostat, 2005, p. 18). Especially for product innovations, innovation can be conceptualised as a process involving multiple stages, the New Product Development process (NPD process). The early, front-end stages include ideation and

concept development, while the later, back-end stages involve product design, testing and market introduction (Urban & Hauser, 1993).

Firms innovate to achieve a competitive advantage over competitors in order to improve firm performance (Porter, 1990). This can be accomplished by the introduction of new products, augmented product quality, or the opening of new markets, all increasing demand for the firms offering. Enhancing productivity and reducing costs allows for higher margins and profits. Katila and Ahuja (2002) highlight further that innovations are essential for firms to keep up with technical developments and changing market conditions. Several empirical studies have found evidence for a positive relation between firm innovation and performance outcomes (Crossan & Apaydin, 2010), such as between new product development and key performance indicators (before-tax profit, ROI, market share) (Li & Calantone, 1998), between the development of process innovations and sales (Klomp & van Leeuwen, 2001), and between a firm's ability to adopt innovations and financial performance measured by ROI and ROA (Calantone, Cavusgil, & Zhao, 2002). However, the importance and impact of innovation differ by economic sector, firm size and region (OECD & Eurostat, 2005).

A key aspect in innovation development is uncertainty, as the process, result and commercial success of innovation activities cannot be completely foreseen. Across different studies, failure rates of innovations from 40% to 60% are reported (Castellion & Markham, 2013; Cierpicki, Wright, & Sharp, 2000). Reasons for this high percentage include heterogeneous customer needs which are not understood and fulfilled by firms, as well as increasingly shorter product life cycles and price pressures (Ogawa & Piller, 2006; Reichwald & Piller, 2005; Simon-Kucher & Partners, 2014). The access to knowledge on technical aspects as well as on the market is thus crucial for firms. Therefore, the importance of networks and interactions with external stakeholders increases, and also influences the innovation process. Innovation can further be categorised as closed and open, with open innovation involving external stakeholders – and being the focus of this study.

2.1.2. Open Innovation

Henry Chesbrough coined the term *open innovation* by distinguishing between the closed innovation and the open innovation paradigm (Chesbrough, 2003). These paradigms describe two fundamentally different mind-sets regarding a firm's approach to innovation. Closed innovation refers to companies' practices of conducting R&D internally and thus developing innovations within the firm, refraining from utilizing external sources as well as

from releasing internally gained information to external parties or to new markets. The main reason for firms to focus on closed innovation is the so called "not invented here" syndrome, which refers to a negative attitude that employees might have about external knowledge due to a lack of trust about the "quality, performance, and availability of a particular technology" (Chesbrough, 2003, p. 30). According to Chesbrough, this practice was well-established in major U.S. corporations until the end of the 20th century, but its drawbacks become more apparent nowadays.

In today's knowledge-based economy, four factors render a closed innovation view outdated. First, an increasingly mobile workforce enhances the rate at which both explicit and tacit knowledge enter and leave the company. Second, the growing venture capital market allows employees to pursue innovations independently from established firms, thus threatening their possibly inert in-house R&D departments. Third, as a combination of the first two factors in conjunction with increasingly shorter product life cycles, ideas which are currently not pursued by the R&D teams might be taken to market on an external path. Last, the dependency of firms with complex products on highly capable suppliers can become an obstacle when these suppliers collaborate with potential competitors and utilize cooperatively gained knowledge (Chesbrough, 2003)

Driven by these factors as well as technological developments such as low-priced and widely available high speed Internet access, an increasingly open environment of innovation develops, where "the distribution of knowledge has shifted away from the tall towers of central R&D facilities, toward variegated pools of knowledge distributed across the landscape" (Chesbrough, 2003, p. 40). Virtually all stakeholders in the environment of a company can become a source of knowledge, from suppliers and customers, to research institutions and universities, to consultants and even competitors. Chesbrough further emphasised that "open innovation is both a set of practices for profiting from innovation, and also a cognitive model for creating, interpreting and researching those practices" (Chesbrough, Vanhaverbeke, & West, 2006, p. 286). Thus, the firm's mind set and culture need to support open innovation.

The open innovation paradigm has received notable attention from scholars and managers alike. In their review of openness literature, Dahlander and Gann (2010) highlight that most researchers regard "R&D as a necessary complement to openness for ideas and resources from external actors" (Dahlander & Gann, 2010, p. 701). Thus, the closed and open innovation paradigms are viewed as two extremes on a continuum. It is the firm's task to find the right degree of openness, considering its resources and its environment. While most research focuses on advantages of openness, Dahlander and Gann (2010) also point out

costs arising from open innovation: costs of coordination, when innovation teams collaborate across organisational boundaries; costs of competition involving the "risk that one actor would act opportunistically in bad faith" (Dahlander & Gann, 2010, p. 706); and the cost of protecting proprietary ideas.

Open innovation approaches naturally differ from firm to firm, as a variety of partners can be found in a company's network. For instance, Bossink (2002) uses the term co-innovation to describe collaborate innovation efforts between two or more organisations. In contrast, this study focuses on innovation involving customers who "can provide firms ideas about discovering, developing and refining innovations" (Chesbrough et al., 2006, p. 10)

2.1.3. Customer Engagement and Co-Creation

While users have long been involved in the development of innovations (cf. Enos (1962) and Freeman (1968) as highlighted by Baldwin and von Hippel (2009)), the specific consideration of their role in the innovation process began with the work of von Hippel (1976; 1986) who described *lead users* as sources of innovation. Lead users are consumers with specific characteristics, such as being ahead of trends and being aware of certain needs before other consumers on the market. At the same time, they also expect to benefit from contributing to innovation, and firms can utilize the input and ideas generated by lead users to innovate more successfully (von Hippel, 1986). Several studies have shown that a structured lead user method has multiple benefits for innovation developments, such as cost reductions and improved variety (Lilien, Morrison, Searsl, Sonnack, & von Hippel, 2002; Magnusson, 2003).

Research on innovation with customers has since moved from the integration of lead users in the front end of innovation, i.e. the early stages of the innovation process, to a more comprehensive view on user involvement. In their seminal work, Prahalad and Ramaswamy (2004) proclaim that companies need to shift their perspective on value creation from a firm-centric view to a customer-centric or co-creation view. As today's consumers are increasingly "connected, informed, empowered, and active" (Prahalad & Ramaswamy, 2004, p. 6), they are presented with a variety of choices, increasing inter-firm competition and efficiency imperatives, which in turn drive down costs. The key to differentiation are personalised *interactions* which allow for the co-creation of value with the users, based on four building blocks: *dialogue*, i.e. rich conversations and mutual engagement, facilitated by *access* to the firm and increased *transparency*, allowing the users to assess *risks and benefits* of the interaction. The authors thus go beyond the lead user approach by emphasising the

need for *joint* problem definition and problem solving, so that "all points of interaction between the company and the consumer are opportunities for both value creation and extraction of firms and consumers" (Prahalad & Ramaswamy, 2004, p. 11). As production and consumption converge, users become *prosumers* or *produsers*, both creating and consuming (Bruns, 2008; Proulx, Heaton, Kwok Choon, & Millette, 2011; Toffler, 1980). Co-creation allows firms to not only understand users' *needs* information, involving their preferences and purchasing motivators, but also to tap into *solution* information they might possess, such as the technical know-how of efficiently satisfying customer needs (Blazevic & Lievens, 2008; Reichwald & Piller, 2005).

2.2. Internet-Enabled Co-Creation

2.2.1. Web 2.0 and Social Media

Almost all research in the co-creation domain since the 2000s, including the above presented studies, has highlighted the impact of new information technologies and especially the Internet and social media on innovation and co-creation, qualitatively changing these processes (Baldwin & von Hippel, 2009; Chesbrough, 2003; Dahlander & Gann, 2010; Jeppesen & Molin, 2003; Prahalad & Ramaswamy, 2004). Co-Creation is facilitated by social media – from simple polls and conversations in social networks aiming to understand user needs, to carrying out ideas competitions and fostering innovation communities on interactive platforms. This chapter answers the first research question: *Which theoretical approaches to social media and their role in innovation exist?* It provides a definition of Web 2.0 and social media with usage statistics, and an overview of different forms of user co-creation activities that are facilitated by social media is given, including real-life examples (2.2.2). Then, benefits and challenges for firms are shown (2.2.3) and success factors enabling co-creation via social media are identified (2.3).

The Internet has evolved from a medium through which users could mostly consume content, to an interactive, collaborative space with vast possibilities for user involvement and contribution. O'Reilly described this as Web 2.0, a participatory and social web, which is shaped by improved technologies including JavaScript and HTML5 (O'Reilly, 2005).

The possibilities offered by the Web 2.0 have led to the rise of the social media phenomenon. Previous research has given different conceptualisations of social media, including a variety of approaches to understanding how firms can make use of it. Kaplan and Haenlein (2010) define social media as a "group of Internet-based applications that build on the ideological

and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content" (Kaplan & Haenlein, 2010, p. 61), where User Generated Content describes media content that is publicly accessible, involves creative effort and has not been created within a professional setting. The common denominators of other definitions of social media are that sophisticated web-technologies allow the creation and usage of content for a broad mass of users (Aula, Laaksonen, & Neiglick, 2010; Kietzmann et al., 2011; OECD, 2007).

The social media landscape can be seen as an ever evolving ecosystem consisting of the different social media sites that are used by consumers, companies and other organisations (Hanna, Rohm, & Crittenden, 2011). A categorisation is not straightforward, as a many dynamically developing sites exist, so that new trends increase or reduce the importance of certain social media types. Table 1 depicts three different categorisations of social media; all three of them involve blogs, social networks, and content communities as the basic types.

Table 1: Categorisations of Social Media Platforms

Constantinides and Fountain (2008)	Kaplan and Haenlein (2010)	Vernuccio (2014)
Blogs	Blogs	Blogs
Social networks	Social networking sites	Social networks
(Content) communities	Content communities	Content communities
Forums	Virtual social worlds	Virtual worlds
Content aggregators	Virtual game worlds	Content-on-demand
	Collaborative projects	

The addition of virtual worlds by Kaplan and Haenlein (2010) reflects the trend of applications such as Second Life or World of Warcraft. Vernuccio's classification in 2014 takes the current rise of interactive multimedia content into account, including podcasts and video streaming, as well as RSS syndications.

Independent of a categorisation, social media is increasingly present in user lives and firm activities and, based on the Web 2.0, has redefined how the Internet is used. It has become a facilitator for the involvement of customers in the innovation process (Constantinides, Brünink, & Lorenzo-Romero, in press; Sashi, 2012), due to five distinctive capabilities which were outlined by Sawhney et al. (2005): The Internet is *interactive*; it has a global *reach* that encompasses customers as well as non-customers; it allows for *persistent* communication as the frequency of interactions can be high; it can improve communication *speed* through real-time interactions; and it provides *flexibility* as customers can vary their level of involvement. These factors are supported by the Internet's ease of use, cost-effectiveness and openness

(Afuah, 2003). Hence, a continuous, two-way dialogue with current and prospective customers can be established, shaped by access and transparency, as required by Prahalad and Ramaswamy (2004). Customers can thus become more strongly involved, especially as they "self-select themselves and participate in spontaneous conversations" (Sawhney et al., 2005, p. 3). Prahalad and Ramaswamy (2004) further stress that ubiquitous connectivity of users allows the volume of information sharing to increase tremendously. In the ten years since their study, Internet usage has grown significantly; especially the use of mobile devices makes the users' connectivity truly ubiquitous.

While in 2004, 58% of the German population used the Internet, this number increased to 79% in 2013 (Statistisches Bundesamt, 2013). Of those people, 80% access the Internet on a daily basis, and half use it on the go via smartphone or tablet. On average, Germans use the Internet six days a week for almost three hours per day (ARD/ZDF-Medienkommission, 2014).

The user numbers for social media also continue to rise. In 2013, 78% of German Internet users were members of at least one social media platform (Bitkom, 2013b). People younger than 30 years use social media the most, with 89% of them accessing it daily. According to the Social Media Atlas 2013, the leading social media site is the social network Facebook; of all German social media users, 92% have an account on Facebook. The second-most used platform is YouTube, followed Google+, MyVideo, Twitter, Stayfriends.de (Faktenkontor, 2013).

Driven by the user growth, the social media activity of firms is increasing as well. According to the German industry associations BITKOM, 47% of German companies currently use social media and 15% plan to do so in the future (Bitkom, 2013a). A study by the German organisation Bundesverband Digitale Wirtschaft e.V. (BVDW) showed that 53% of German firms expect to increase their social media budget in the next year (BVDW, 2014a). Several studies have demonstrated that firms judge social networks to be the most important social media channel before blogs and social media sharing sites such as YouTube (Harvard Business Review Analytic Services, 2010). Thus, similarly to the users, the highest share of firms is most present in social networks (86%), video platforms (28%) and micro-blogging platforms such as Twitter (25%) (BVDW, 2014a). Facebook is the leading social network used by firms in Germany and as well as in the United States (Peakom & absatzwirtschaft, 2011; Stelzner, 2014). The interaction between users and firms via social media proves to be fruitful. More than 55% of social media users are connected to at least one brand; on average, users follow eleven firms on social media and actively engage with five of them (Nair, 2012).

The importance of social media for firms of different size and sector differs. While BITKOM reported that social media is equally used by small and medium enterprises (SMEs) and large enterprises (Bitkom, 2013a), the BVDW study showed that SMEs are more active in social media: While only 40% of large enterprises in their sample used social media, over 60% of SMEs did (BVDW, 2014a). Similar results have been produced by a study of the marketing agency Peakom which suggested that the higher flexibility of SMEs allows them to test different channels, while large enterprises concentrate their efforts on established platforms such as Facebook (Peakom & absatzwirtschaft, 2011). Regarding the economic sectors in which social media activity is more relevant to firms, studies have shown that companies in the information and communication (ICT), services, and retail sector are more prone to use social media than firms that operate in the construction, utilities or government sector (Harvard Business Review Analytic Services, 2010; Statista, 2014c).

For firms, social media is mainly perceived as an increasingly important marketing and communication channel, which not only impacts the reputation of a firm, but also its sales and profits (Constantinides & Fountain, 2008; Hanna et al., 2011; Kaplan & Haenlein, 2010; Kietzmann et al., 2011; Parent, Plangger, & Bal, 2011; Vernuccio, 2014). Marketing is therefore the driver for social media use in firms; in the BITKOM study, 75% of surveyed companies support marketing through social media (Bitkom, 2013a). Specific marketing-related goals that firms want to reach with their social media presence include promoting the company, increase of brand awareness, reaching new target groups, special sales promotions, and special product offerings (Peakom & absatzwirtschaft, 2011). Social media also becomes part of the firms' customer relationship management (CRM); according to the BVDW, 70% of firms utilize social media for CRM activities (BVDW, 2014b). Corresponding pursued goals are the development of new customer relations and offering special customer services (Peakom & absatzwirtschaft, 2011). Lately, the facilitation of recruiting processes has also become a goal for companies' social media presences (Maximum, 2013). Finally, innovation-related objectives for social media sites gain importance, as users can offer valuable insights (BVDW, 2014b). These goals can be summarised as getting customer feedback and getting customer input for new products or their improvements.

However, firms are often at a loss to understand how and when to use social media (Kaplan & Haenlein, 2010; Kietzmann et al., 2011), potentially leading to a mismanagement of the firm's social media presence (Aula et al., 2010).

2.2.2. Forms of Internet-Enabled Co-Creation

Despite the focus of firms on marketing-related goals for their social media presence, a variety of online co-creation forms has been developed which can be facilitated by Web 2.0 technologies and are often carried out using social media. Different researchers have categorised them along different dimensions[1]. For this study, the focus is set on user-involving online innovation methods supported by social media.

Figure 1 provides an overview of these methods, ordered by the inherent degree of user participation from passive to active, and grouped in three categories: Monitoring, Dialogue, Crowdsourcing. In their description in following, it becomes apparent that different methods are often used in conjunction.

Figure 1: Online User Collaboration Methods

Source: Author's own depiction,
based on Adorf (2014), Fichter (2005), Helms et al. (2012), Piller et al. (2010)

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[1] For instance, Fichter (2005) classifies such methods along the dimensions of *interactivity* and *performance incentives*; Sawhney, Verona, and Prandelli (2005) categorize them by the *nature of collaboration* and the *stage of the innovation process*; Piller, Ihl, and Vossen (2010) also use the *stage in the innovation process,* as well as the *degree of collaboration* and the *degree of freedom*; O'Hern and Rindfleisch (2010) distinguish the methods by the *selection activity* (from firm-led to customer-led) and the *contribution activity* (from fixed to open).

a) Monitoring

The most passive form of user involvement in the innovation process is *Monitoring*. Existing content in already established communities is analysed for its innovation implications (Helms, Booij, & Spruit, 2012). Thus, the user becomes a passive object of observation on whom the firm listens in, reflecting a market orientation rather than customer orientation (Fichter, 2005; Piller, Ihl, & Vossen, 2010). Methods employed for monitoring include firstly *netnography*, a qualitative and ethnographic immersion in users' conversations (Bartl, Hück, & Ruppert, 2009), secondly *profiling*, the creation of demographic user profiles allowing to understand community characteristics (Helms et al., 2012), and third *content analysis*, employing monitoring techniques such as sentiment analysis and trend tracing to efficiently evaluate relevant aspects of a large amount of online content (Adorf, 2014; Pal & Saha, 2010). These techniques have become research streams on their own, including the development of software solutions for linguistic analyses (Feldman, 2013; Liu, 2012). For example, sentiment mining software can allow a firm to efficiently capture opinions posed on the micro-blogging platform Twitter, as shown by Pak and Paroubek (2010).

b) Dialogue

When firms involve users as more active dialogue partners in the innovation process, co-creation begins (O'Hern & Rindfleisch, 2010). Firms also have to become more active, setting up participatory and responsive processes for collaboration (Helms et al., 2012). These can include *online polls or surveys*, for instance by asking users for new product preferences (Adorf, 2014; Piller et al., 2010). Coca Cola's brand Vitamin Water as well as Lay's potato chips did so by letting Facebook users decide which flavour should be produced next (Mitchell, 2013; van Grove, 2009).

More interactive are *conversations* with users that aim at generating qualitative input for innovations or feedback (Helms et al., 2012). Ideally, users connect with each other via online platforms, allowing them to exchange experiences on the company's products.

c) Crowdsourcing

The largest part of research on online co-creation focuses on crowdsourcing. Coined by Jeff Howe (2006), crowdsourcing is an umbrella term for the outsourcing of tasks traditionally performed in house to a group of people through an open call (Howe, 2006). Thus, not only innovations, but also marketing and IT solutions can be crowdsourced. The assignments can differ from simple or repetitive tasks to complex problem-solving efforts (Stanoevska-Slabeva, 2011). When applied to innovation, crowdsourcing best reflects the customer-

centric view proposed by Prahalad and Ramaswamy (2004) as the user is seen as interaction partner or even as collaborator (Fichter, 2005). Crowdsourcing encompasses three main methods through which users are involved in building innovative solutions (Piller et al., 2010):

First, *ideas competitions* are challenges of varying specificity that are initiated by firms (Helms et al., 2012). The winner of the price is selected either by the firm itself or by a panel of experts or consumers; the latter has been described as "adaptive idea screening" by Toubia and Florès (2007), who emphasised the need for a structured approach involving selection algorithms. Ideas competitions can be held on social network sites or on designated innovation community platforms.

As the second crowdsourcing method, the participation in such *innovation communities* constitutes a more participatory form of co-creation, since the user involvement is not limited to one competition. Rather, users of these communities are invited to participate in multiple problem solving tasks (Piller et al., 2010; Stanoevska-Slabeva, 2011).

In recent years, a variety of innovation communities with different foci have developed. Some communities are intermediary platforms, connecting different firms and users, while other communities are run by the firms themselves. One of the best known intermediary platforms is the innovation community InnoCentive[2] with clients such as Procter & Gamble and NASA, focusing on R&D and thus requiring a certain degree of user expertise (Howe, 2006). Similar platforms are Hypios[3] and IdeaConnection[4]. One Billion Minds[5] is an innovation community with an emphasis on social projects, and the German platform unserAller[6] offers mostly projects related to consumer product design involving conversations and polls.

Examples for company-run innovation communities focusing on the improvement of the firms' own products include the BMW Co-Creation Lab[7], a community of car enthusiasts interested in further developing BMW's products, Procter and Gamble's platform Connect and Develop[8], as well as MyStarbucksIdea[9] by the Starbucks Coffee Company. Coca Cola[10]

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[2] www.innocentive.com
[3] www.hypios.com
[4] www.ideaconnection.com
[5] www.onebillionminds.com
[6] www.unseraller.de
[7] www.bmwgroup-cocreationlab.com
[8] www.pgconnectdevelop.com
[9] mystarbucksidea.force.com
[10] www.coca-colashapingabetterfuture.com

and Unilever[11] have both created innovation communities with contests for entrepreneurial ideas solving pressing social issues. While continuous engagement in these communities is possible, they are often employed as platforms for ideas competitions; for example, BMW started the "Interior Idea Contest" in 2011, calling for innovative interior design solutions for their cars. The 750 submitted ideas were evaluated by the community, who then selected the winning concept: A colour matching camera that adapts interior lighting to the colour of passengers' clothes (BMW Group, 2010).

Third, in *participatory design* efforts, users become fully integrated in the innovation process and can thus be seen as collaborators (Fichter, 2005). They take part in several or all of the innovation process stages, from problem definition to idea generation and selection, as well as development and evaluation (Helms et al., 2012). For this purpose, toolkits can be used which aid in involving users at different locations. Already described by von Hippel and Katz (2002), toolkits are a frequently emphasised method for true user engagement in innovation (Piller et al., 2010). Often, they are employed in conjunction with ideas competitions, where designs created by users with the toolkits are then judged by the firm or other users (Piller & Walcher, 2006). In 2013, the cosmetics manufacturer Manhattan initiated a crowd-sourcing campaign via unserAller by sending toolkits to create a new nail polish colour to 600 consumers. Consequently, Manhattan's Facebook fans were asked to vote for the best designs, leading to a limited edition of nail polishes (Roskos, 2012). Similarly, in 2011, the German drug store dm used toolkits with gels and scents, as well as subsequent user voting to create a new shower gel for winter (unserAller, 2011).

2.2.3. Benefits and Challenges of Co-Creation for Firms and Users

Improved access to both needs and solution information provides the basis for the advantages that firms can gain from co-creation. As needs information is often sticky, i.e. costly to transfer, it might be the users themselves who know best how to satisfy their needs. Products corresponding to user preferences will fit to the market better, and thus improve the probability of adoption and success (Bogers, Afuah, & Bastian, 2010; Reichwald & Piller, 2005), leading to a reduction of uncertainty and risks for the firms (Füller & Matzler, 2007; Prahalad & Ramaswamy, 2004) and augmented user satisfaction – in turn increasing market share and profitability as well as loyalty and referrals (Hoyer, Chandy, Dorotic, Krafft, & Singh, 2010; Mascarenhas, Kesavan, & Bernacchi, 2004). Moreover, user

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[11] www.unilever.com/innovation/collaborating-with-unilever

involvement can improve productivity and speed up the innovation process, thus allowing for shorter development times (Jeppesen & Molin, 2003; Kleemann, Voß, & Rieder, 2008).

When users are motivated to take the initiative in developing and presenting new ideas, firms can furthermore gain unanticipated inputs, allowing for more creative product differentiation (Bogers et al., 2010; O'Hern & Rindfleisch, 2010). Often, users participate without monetary compensation, thus leading to cost savings for the firm (Franke & Shah, 2003). Additionally, co-creation induces mutual learning which improves firm capabilities such as its absorptive capacity, allowing it to develop new innovations faster and more efficiently (Kafouros, 2006; Reichwald & Piller, 2005). Moreover, Fuchs and Schreier (2011) discussed the advantage of improved firm perception by users through co-creation activities. Accordingly, the involvement of consumers in the innovation process through idea creation as well as idea selection are forms of customer empowerment that "lead to higher perceived customer orientation, more favourable corporate attitudes, and more favourable behavioural intentions" (Fuchs & Schreier, 2011, p. 28) especially for customers that have not taken part in the innovation activities. Co-creation is most successful when the market is characterised by uncertainties and demand conditions change dynamically (Fichter, 2005).

Different researchers advance opposing views concerning the possible radicalness of co-created innovations. Lüthje (2000) and Reichwald and Piller (2005) argue that knowledgeable customers can initiate radical and incremental innovations through customer co-creation, and Jeppesen and Molin (2003) show that the radicalness of developed innovations depends on the involved level of customer learning.

In contrast, Lojacono and Zaccai (2004) contend that user input is only valuable when developing incremental innovations, as the spectrum of ideas is limited to pre-known factors and users are not able to anticipate future needs that can be fulfilled by radical innovations. Indeed, the differences between needs that can and cannot be articulated has been described before by the Kano model (Kano, Nobuhiku, Fumio, & Shinichi, 1984): Regarding product preferences, only performance-related factors are explicitly articulated and consciously realised by users. However, unarticulated needs exist as well. They involve basic factors that are taken for granted, and still unknown excitement factors which could lead to a surprise effect (Füller & Matzler, 2007). Thus, firms have to be aware that the scope of information they receive through co-creation can be limited.

At the contrary, firms can also face the problem of information overload when involving multiple users, leading to increased complexity, uncertainty about the best way to go, and a loss of control over planning processes (Hoyer et al., 2010). In addition, the interests of an increasing number of stakeholders need to be managed by the firm. Generally, the more

active the form of user collaboration is, the more time and resources are required (Fichter, 2005)

Further challenges for firms include secrecy and the protection of intellectual property (Füller & Matzler, 2007; Hoyer et al., 2010). As distinct firm-internal knowledge is often revealed during co-creation processes, especially if users participate more actively, the danger of creating new competitors rises (O'Hern & Rindfleisch, 2010). Hence, firms need to define norms and rules framing the collaborative innovation process (Jeppesen & Molin, 2003; Reichwald & Piller, 2005). Lastly, a major challenge for firms is attracting, retaining and motivating co-creators with adequate skills (Füller & Matzler, 2007; O'Hern & Rindfleisch, 2010)

User motivation has thus become an important research area. Only with sufficient reasons and the right incentives, firms can involve users in the innovation process. Reichwald and Piller (2005) distinguish *extrinsic*, *intrinsic* and *social* motivational factors. When users are motivated by the outcome of their participation effort, the motivation is *extrinsic*. This involves the expectation of using the innovation which then fulfils the user's needs better, more accurately, or faster, while the agency costs between firm and user are reduced (Bogers et al., 2010; Prahalad & Ramaswamy, 2004). Another extrinsic motivation can be presented through monetary compensation. However, users often participate in innovation tasks for free (Kleemann et al., 2008); in a study by de Jong and von Hippel (2009), 48% of user innovations were transferred to companies without compensation.

Users are *intrinsically* motivated when the innovation task gives them a sense of enjoyment and a chance to apply their creativity while mastering a challenge, leading to feelings of satisfaction and competence (Bogers et al., 2010; O'Hern & Rindfleisch, 2010; Reichwald & Piller, 2005). Moreover, they often welcome the learning process accompanying co-creation (Jeppesen & Molin, 2003).

Social motivation is derived from the joy of interacting with other users and the appreciation of the collaborative process (Franke & Shah, 2003; Jeppesen & Molin, 2003). In communities where user behaviour is visible to other members, innovators can receive recognition and approval from peers while building a community of trust and reciprocity (Reichwald & Piller, 2005). Franke and Shah (2003) conclude from their study about free contribution in four sports communities that „the strongest motivations […] are reflective of social processes not personal benefit" (Franke & Shah, 2003, p. 27).

2.3. Social Media and Innovation

2.3.1. Empirical Findings

While the above cited examples show that social media sites can be involved in co-creation activities which lead to multiple benefits for firms, the actual impact of social media on the innovation success is not yet clear. To answer research question 2 (*What are the main empirical findings concerning the role of social media in innovation?*) this chapter examines the relationship between social media and innovation by presenting empirical findings and success factors identified by academics and practitioners, which provide the basis for the development of the hypotheses that build up the theoretical model.

In a study with 122 Finnish companies, Kärkkäinen et al. (2010) investigated the actual and potential use of social media for innovation. While less than 6% of the surveyed firms actually included social media in their innovation process, about 50% of them saw social media as a tool with which customer demand could be discovered, and 29% indicated that social media could aid in product development. However, the significant gap between current use and perceived potential reflects the firms' insecurities about including social media in the innovation process. Idota, Minetaki, Bunno, and Tsuji (2011) analysed 3,000 Japanese firms and found that the increased use of social networking sites positively impacted product innovation, with larger effects in the service industries than in the manufacturing sector.

In 2011, the U.S. innovation consulting firm Kalypso LP conducted a survey of 90 companies from different service and manufacturing industries, investigating the phenomenon they call "Social Product Innovation" (Kalypso, 2011, p. 2), which is the development of innovations via social media involvement of customers. More than half of the surveyed companies used social media in product innovation to some extent, although most firms were still in the pilot phases for these projects. However, 90% of firms using social media for innovation planned to increase their usage in the following year.

All studies emphasise that numerous benefits can be reaped from using social media in the innovation process, such as better product ideas, an increase in customer orientation, quality improvements, a reduction of time and costs of product development time, and improved product adoption, leading to growth of market share, margins and revenue (Idota et al., 2011; Kalypso, 2011; Kärkkäinen et al., 2010); thus, benefits that have been discussed for co-creation in 2.2.3 apply for social media involvement as well. However, the most pressing challenge for firms is the lack of understanding concerning the possibilities and efficient implementation of innovation-fostering social media campaigns. Firms are not

familiar with best practices, and estimating possible financial gains proves difficult. Lastly, the firms' reluctance to adopt unfamiliar mental models and new practices constitutes an impediment.

2.3.2. Success Factors for Involving Social Media in Innovation

The above developed theoretical background section showed that user involvement in the innovation process through co-creation is beneficial, and that social media platforms can be utilised in assisting certain collaboration methods. Therefore, it can be hypothesised that social media use positively influences innovation activities. Many of the theoretical and empirical studies cited so far have identified critical success factors for using social media to foster innovation. They can be grouped into four categories, from which the hypotheses for the empirical part of this study are derived: Quantifying Engagement, Social Media Strategy, Openness Culture, and Application of the Co-Creation Methods described in 2.2.2. In conjunction, those four success factors and the corresponding developed hypotheses form a theoretical research model, thereby answering research question 3: *How can the impact of social media on innovation be conceptualised in a model?*

a) Quantifying Engagement

First, the social media performance has to be measured to improve firms' understanding of the effects of their actions. Tracking the right metrics and KPIs allows firms to take a structured approach to social media, and to quantify the success of their social media efforts, thus making the effects comparable over time (Hanna et al., 2011; Kietzmann et al., 2011). The basis for such measurements is provided by the people that firms reach on social media. Initially, the pure number of fans or followers on a platform was used as a metric for inter-firm comparison. However, this led to a "bloated balloon of followers with ridiculously low levels of engagement" (Nair, 2012, p. 86), a phenomenon called the "follower fallacy". Although it can be argued that the number of followers provides proxy measures for word of mouth and brand engagement, (Nelson-Field, Riebe, & Sharp, 2012; Wallace, Buil, Chernatony, & Hogan, 2014), firms cannot know whether these users are actually engaging with the brand.

More evolved social media success measures are presented by Kaushik (2012) who emphasises the importance of actual engagement, for instance through gaining attention and initiating discussions. Three engagement rates as key engagement measures are proposed that "actually measure if you are participating in the channel in an optimal

fashion" (Kaushik, 2012, p. 93). They can be applied to different social media platforms, and tracking them over time provides valuable insights of the advances of a firm's social media efforts. The engagement rates are (Kaushik, 2012, pp. 93–95):

- Applause Rate: The number of likes per post
- Conversation Rate: The number of audience comments per post
- Amplification Rate: The number of shares per post

These rates are reflective of customer contributions and their empowerment via social media. Thus, the first set of hypotheses proposes that a better value in each of the three engagement rates positively affects innovation:

H1a: A higher social media applause rate is positively related to firm innovation.

H1b: A higher social media conversation rate is positively related to firm innovation.

H1c: A higher social media amplification rate is positively related to firm innovation.

b) Social Media Strategy

Second, the tracking metrics firms use have to be embedded in a social media strategy, so that they can provide meaningful benchmarks (Hoffman & Fodor, 2010). The importance of strategy development is heavily stressed by many authors; it is necessary for "monitoring, understanding, and responding to different social media activities" (Kietzmann et al., 2011, p. 249), it has to be elaborated and well-defined (Kalypso, 2011), and it has to go beyond being present on a social media platform by including processes and goals for the next years (BVDW, 2014a).

Moreover, the social media strategy cannot be separated from a company's overall goals defined in the corporate strategy, but has to be congruent with it (Kietzmann et al., 2011). At the same time, a firm's social media strategy has to fit to the pursued innovation strategy. Thus, social media activities have to be aligned with and integrated in corporate processes (Kaplan & Haenlein, 2010). Hypothesis 2 hence suggests that firms with a better thought-out social media strategy (in terms of specificity and goal orientation) have higher chances of being innovative.

H2: A more specific and goal-driven social media strategy is positively related to firm innovation.

c) Openness Culture

Third, social media use for innovation can only be sustainable when the company's mind-set adapts as well. Reflecting the willingness of firms to take new paths, they have to develop a culture of openness (Accenture Interactive, 2012; O'Hern & Rindfleisch, 2010; Vernuccio, 2014). This requires organisational changes and the adjustment of established processes, against which employees and managers are often reserved (Ogawa & Piller, 2006; Sawhney et al., 2005). However, their attitudes and capabilities are the key to enabling new approaches to innovation (Idota et al., 2011; Prahalad & Ramaswamy, 2004). A firm that has achieved such a shift in the mind-set towards openness and integrates Web 2.0 technologies and social media in their own internal processes can be called Enterprise 2.0 (BVDW, 2013; McAfee, 2006, 2009). Therefore, hypothesis 3 proposes that the openness of the innovation culture is beneficial for innovation development:

H3: A more open innovation culture is positively related to firm innovation.

d) Application of Co-Creation Methods

Lastly, chapter 2.2.2 had identified several methods which firms can employ to foster user collaboration and co-creation, ordered from a passive to an active user role. This study will test whether firms apply these methods through social media platforms, and whether this positively impacts innovation. Hypothesis 4 thus suggests that more collaborative methods improve innovation:

H4: The implementation of more participatory co-creation methods via social media is positively related to firm innovation.

The research model including all hypotheses is depicted in Figure 2. It will be empirically tested in the following in order to provide an answer to research question 4.

Figure 2: Research Model
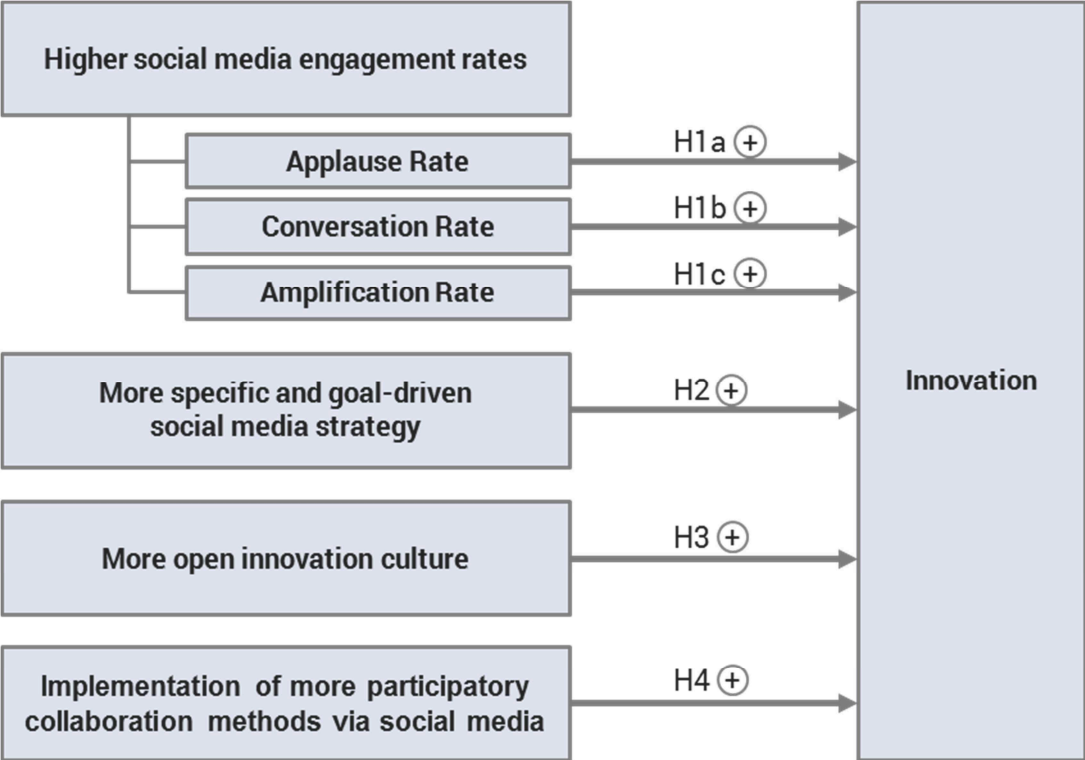
3. Methodology

3.1. Research Setting

3.1.1. ZEW Innovation Survey

The following chapter begins with the research setting for this study, explaining why the ZEW Innovation Survey 2013 was used for the innovation data and firm selection, and why Facebook serves as the exemplary social media platform (3.1). Subsequently, the sampling process is illustrated (3.2), as well as the used measures and means of data collection to capture Facebook engagement rates, Facebook strategy, openness culture, and co-creation methods that have been used through Facebook (3.3). Finally, the analysis methods are described (3.4).

To test the above stated hypotheses, the research is based on the firm selection and innovation measures of the Annual German Innovation Survey 2013 conducted by the Centre for European Economic Research (Zentrum für Europäische Wirtschaftsforschung, ZEW). The German Federal Ministry for Education and Research commissions the survey which is carried out in collaboration with the Fraunhofer Institute for Systems and Innovation Research as well as the project partner infas Institute for Applied Social Sciences (Rammer, Aschhoff, Crass, Doherr, Hud, Hündermund et al., 2014). The survey is designed as a panel and has been conducted yearly since 1993. Its goal is to collect data on the German economy's innovation activities, including the types of innovations and expenses for each, the number of finished and currently running innovation projects, the extent of public innovation funding, innovation cooperation, and intellectual property protection.

The ZEW Innovation Survey is the German contribution to the Community Innovation Survey (CIS) of the European Commission. The survey follows the Oslo-Manual, a set of rules developed by the OECD and Eurostat that "provides guidelines for collecting and interpreting innovation data in an internationally comparable manner." (OECD & Eurostat, 2005, p. 4). The ZEW Innovation Survey is thus a comprehensive, reliable and internationally comparable study on innovation activities. Access to the participating firms of the ZEW Innovation Survey 2013 was provided by the Chair of Innovation Economics of Technische Universität Berlin.

The current ZEW Innovation Survey 2013 gathered innovation data for the reference period of 2010 until 2012, as well as for planned activities for 2013 and 2014. The population for the ZEW Innovation Survey 2013 comprised all legally independent companies which have their legal domicile in Germany, have at least 5 employees, and operate in one of the target

sectors of the survey. Following the German classification of economic activities (Wirtschaftszweigsystematik), the target sectors lie in the research-intensive industries and other industries, as well as knowledge-intensive services and other services (Rammer, Aschhoff, Crass, Doherr, Hud, Köhler et al., 2014). The companies were clustered according to seven employment groups: 5-9, 10-19, 20-49, 50-249, 250-499, 500-999, 1,000 and more employees (Rammer, Aschhoff, Crass, Doherr, Hud, Hündermund et al., 2014).

The ZEW Innovation Survey gathered data on the firms, the number of employees, and revenue through a special analysis of the business register of the German Federal Statistical Office. The basic population for the ZEW Innovation Survey 2013 amounted to 276,600 companies with 15 million employees in total (Rammer, Aschhoff, Crass, Doherr, Hud, Hündermund et al., 2014). The gross sample was based on the prior study, the ZEW Innovation Survey 2012. After this sample had been adjusted for companies that went out of business and had not participated in the last five surveys, it was replenished with a stratified random sample, leading to an overall gross sample of 34,977 companies. 4,450 of these companies were neutral losses, which are companies that went out of business or could not be reached. Thus, 30,527 firms remained after adjustment for neutral losses. The net sample comprised all firms that returned the completed questionnaire. These were 7,241 companies, or 23.7% of the gross sample (adjusted for neutral losses). In addition, the ZEW sample incorporated innovation data on selected big enterprises gathered from annual reports and other sources, as well as answers given by non-participating firms in an extra interview. Overall, innovation data on 8,116 companies was collected.

3.1.2. Facebook as Social Media Exemplar

Regarding the influence of social media on innovation, a multitude of possible social media sites could be used. As a parallel investigation of their effects on innovation would exceed the limits of such a thesis, the social networking site Facebook is taken as an exemplary social media platform, using the German site www.facebook.de.

Facebook was founded in 2004 by Mark Zuckerberg and fellow Harvard students and is currently the largest social network worldwide (Ballve, 2013). After reaching the milestone of one billion global users in September 2012, the platform reported 1.3 billion users in the second quarter of 2014 (Statista, 2014a). In the same time, the user base in Germany has grown from 24 million to 27 million users, which equals 33.7% of the 80 million people living in the country (Statista, 2014b). Currently, Facebook is the second most frequently

visited website both worldwide and in Germany, ranking second after Google (google.com / google.de) (Alexa, 2014a, 2014b).

Characteristically of a social network site, users can create a profile and establish connections with other users, as well as exchange messages and multimedia content on Facebook (Boyd & Ellison, 2008). Firms and organisations have the opportunity to present themselves to current and potential customers with fan pages that allow them to share information and engage users. In 2013, over 15 million Facebook fan pages for firms and organisations existed worldwide (Koetsier, 2013). The user is presented with a news feed, the so called timeline, in which a blend of posts by friends, liked fan pages, and advertisements can be seen. Users can engage with the posts in three ways: they have the options to "like" a post, to comment on it, and to share it with their own friends.

As shown in 2.2.1, Facebook is currently the most used social media platform by consumers and companies alike. Thus, Facebook provides notable opportunities for firms to reach a large base of end users through their fan pages. However, not every post of the firms is necessarily seen by every fan. Facebook has implemented algorithms aiming at improving the relevance of posts that appear in each person's timeline. Influential factors in these algorithms include, among others, the affinity between the brand and the user, a weight of the post type, a time decay, and device-related considerations (McGee, 2013). Thus, when studying the impact of the engagement rates, it has to be acknowledged that user engagement is not only influenced by the firm's posts, but is also subject to platform-internal algorithms involving factors that cannot be measured autonomously.

3.2. Sampling

For this study, the author was provided with a list of all 8,116 firms for which innovation data from the ZEW Innovation Survey 2013 was available. This list comprised the firm name, zip code, sector, and number of employees[12]. It was used to identify appropriate firms for this study. The sampling process was purposive, i.e. the considered firms had to correspond to predefined criteria (Blumberg, Cooper, & Schindler, 2008), as the sample was refined in three ways:

First, as the ZEW Innovation Survey examined German firms nationwide, the scope of analysis had to be narrowed for this master thesis. Therefore, only one geographical region

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[12] To ensure the confidentiality of the ZEW Innovation Survey, the ZEW identification number and the answers concerning innovative activities were not provided to the author. The data analysis was conducted via an anonymised matching of the ZEW identification codes by the supervisor at Technische Universität Berlin.

is considered. The sample was thereby reduced to a size for which data collection of Facebook activities was possible in the given amount of time. Nevertheless, this approach still provides a sufficient sample size for this exploratory approach while not claiming to be representative or generalizable. For the previous ZEW Innovation Survey 2012, an innovation report focusing exclusively on the metropolitan area of Berlin was compiled, comparing innovation activities in Berlin with other major cities and the rest of Germany (Rammer & Horn, Mai 2013). Although no such report had been produced for the current ZEW Innovation Survey 2013, this thesis focuses on the Berlin region. Thus, firms from Berlin were selected via their zip code. Of all companies, 449 (6%) were resident in Berlin.

Second, to further refine the scope of the thesis, this study focused on small and medium enterprises (SMEs). These firms make up 99.7% of all 165,000 firms in Berlin and particularly "shape the economy" (Wirtschaft aktuell, 2014); consequently, they represent the largest part of the sample firms. As shown in 2.2.1, social media use in SMEs is higher than in larger firms. Limiting this study to SMEs further facilitates inter-firm comparison, as usage numbers are not exacerbated by the inclusion of a few large firms with potentially deviating social media activity. All companies with more than 250 employees were excluded from the study, leading to an omission of 25 firms from the ZEW sample of 449 firms. Furthermore, the list of participants contained several firms with less than five employees, as they had been included in the ZEW Innovation Survey 2013 to ensure continuance over several years. 51 companies had one to four employees and were thus removed, reducing this thesis' sample to 373 firms.

Third, to facilitate data collection, the thesis concentrated on economic sectors in which social media activity is most likely and relevant to firms and users, as explained in 2.2.1. Appropriate economic sectors for the study were selected using sector codes attributed to the firms. Although the ZEW Innovation Survey follows the German classification of economic activities, this code was not available for several firms. However, all firms could be identified via their NACE code which provides the international "statistical classification of economic activities in the European Community" (Eurostat, 2008, p. 5). This internationally comparable codification is broader than the German system, but could still lead to a meaningful categorisation of firms. For this thesis, companies mostly from service industries and B2C sectors were considered; see Appendix 1 for an overview of the economic sectors that were included and not included in this thesis. Certain sectors were excluded to restrict data collection to sectors in which social media activity is probable, while avoiding the drawing of conclusions from firms for which social media use is unlikely to begin with. The sample was hence reduced to a final size of 348 firms.

Figure 3: Sampling Process
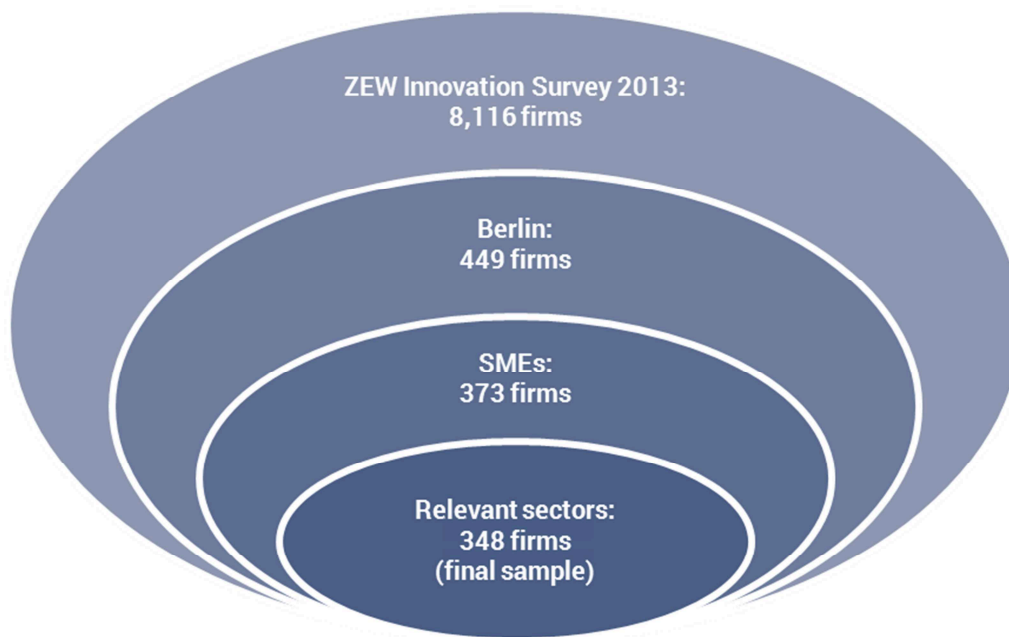
In summary, the hypotheses are tested using cross-sectional innovation data from the ZEW Innovation Survey 2013 with a final gross sample of 348 small and medium Berlin enterprises in the aforementioned sectors. Figure 3 summarizes the sampling process.

3.3.   Measures and Data Collection

3.3.1. Measure for Innovation

Firm innovation is the dependent variable for all four hypotheses. It is measured using the variable *product innovation* collected by the ZEW Innovation Survey 2013. This binary variable reflects whether or not a firm had developed a product innovation in 2012, i.e. the "introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses" (OECD & Eurostat, 2005, p. 48). In the following, firms are thus split into two groups indicating whether a product innovation has been developed: Innovators and non-innovators.

The ZEW Innovation Survey provided other innovation variables as well, such as the development of process, organisational, and marketing innovations. However, previous research has emphasised that the innovation potential of Facebook activities is highest on the product level, as it is closest related to the end user who can be engaged through social media (Idota et al., 2011; Kalypso, 2011). In contrast, process innovations (such as new production techniques) and organisational innovations (such as new administrative methods) are not explicitly directed at the customer, but have primarily firm-internal effects. Marketing innovations (including new methods concerning price, packaging,

promotion or placement) were not considered because the establishment of a social media platform as a new placement or promotion channel might include a marketing innovation in itself. With the available data from the ZEW Innovation Survey 2013, no distinction between the different types of marketing innovation could be made; thus, the relationship between explained and explaining variables would be intricate and convoluted.

3.3.2. Measures for H1a, H1b, H1c

Hypotheses 1a, 1b and 1c state that higher social media engagement rates (applause rate, conversation rate, amplification rate) proposed by Kaushik (2012) positively impact innovative output. In order to compile the firms' engagement rates, the firms that are actively running a Facebook fan page had to be identified.

Thus, the author conducted a search for the Facebook fan pages of the 348 sample firms by entering the name of the firm in the search field. Concurrently, the firms' websites were consulted to either find a direct link to the Facebook page, or to view the firm logo in order to select the right page when multiple similarly named pages were available. Only fan pages which were run by the firm itself were considered. Other pages, such as community pages (fan pages made by consumers), Wikipedia entries describing the company, or locational information, were not included, as usually no interaction between firms and customers takes place on these sites. Thus, none of them can account for a similar contribution to a firm's possible innovation activities as a firm-run Facebook page could. For all 348 sample firms, the existence of a Facebook page was noted as a dummy variable with 1 for "yes" and 0 for "no".

The search confirmed that 66 companies (19%) run a Facebook fan page. Exactly half of these firms, 33, could not be incorporated into this study for two reasons: The Facebook pages were either started after 2012 or, if started earlier, had no posts in 2012. Hence, those pages could not be used to find a correlation between Facebook activities and the data of the ZEW Innovation Survey 2013, as the latter refers to innovation behaviour in 2012. Therefore, the sub-sample containing only firms with an active Facebook fan page includes 33 firms, or 9.5% of the 348 firms of the sample.

a) Facebook engagement rates

Once the existence of a Facebook page was established, the number of posts, as well as the number of likes, comments and shares for the 33 firms on Facebook were collected. For this, the use of the professional social media tool "Fan page Karma" by the German tasqade GmbH

was considered. However, engagement numbers for 2012 were not available for all 33 firms, as many had not been indexed at the time. Furthermore, for those firms with retrievable data, the number of posts, likes, comments and shares indicated by the tool differed from what was visible on the firms' timelines. Thus, the data was collected manually. For each firm, the number of posts by the company on their timeline in the reference year 2012 was counted. Then, the sum of likes, comments and shares for all posts on their timeline in that year was collected, allowing the author to calculate the engagement rates for 2012: *applause rate* (number of likes per post), *conversation rate* (number of comments per post) and *amplification rate* (number of shares per post) (Kaushik, 2012).

Although these rates are useful in reflecting fan interaction on social media platforms, their application for the comparison of different Facebook fan pages is limited. Naturally, firms with a higher number of Facebook fans receive more likes, shares and comments for the same number of posts than a firm with a small fan base. Therefore, the engagement rates were scaled by the number of fans which the Facebook fan page had. The author faced the challenge of identifying the number of Facebook fans at the end of 2012, the year of reference, instead of the fan count that was visible on the Facebook fan pages during the data collection in the summer of 2014. Although the growth of Facebook fans is part of every page's statistics ("Facebook insights"), this number is only available for page administrators and not publicly accessible. However, historical data for 9 of the 33 firms could be retrieved via the social media tool "Fan page Karma", allowing the author to calculate their growth rates between 2012 and 2014. The remaining 24 firms had not been indexed in the tool's database in 2012.

Therefore, an approximation of the user number in 2012 was made, based on the assumption that the percent growth of a fan page's likes is higher in the early years and levels off later. The 9 firms for which likes in 2012 could be found were taken as a basis for this estimation, and the firms were grouped by the year of launch of the Facebook fan page. Finally, the following assumption was made: Between December 2012 and August 2014, likes of fan pages launched in 2009 grew by 50%, likes of fan pages launched in 2010 grew by 100%, likes of fan pages launched in 2011 grew by 200%, and likes of fan pages launched in 2012 grew by 300%, illustrated in Figure 4. Using these numbers and the visible number of likes in 2014, the approximated number of likes in 2012 could be established.

Figure 4: Estimated Growth of Facebook Fan Pages
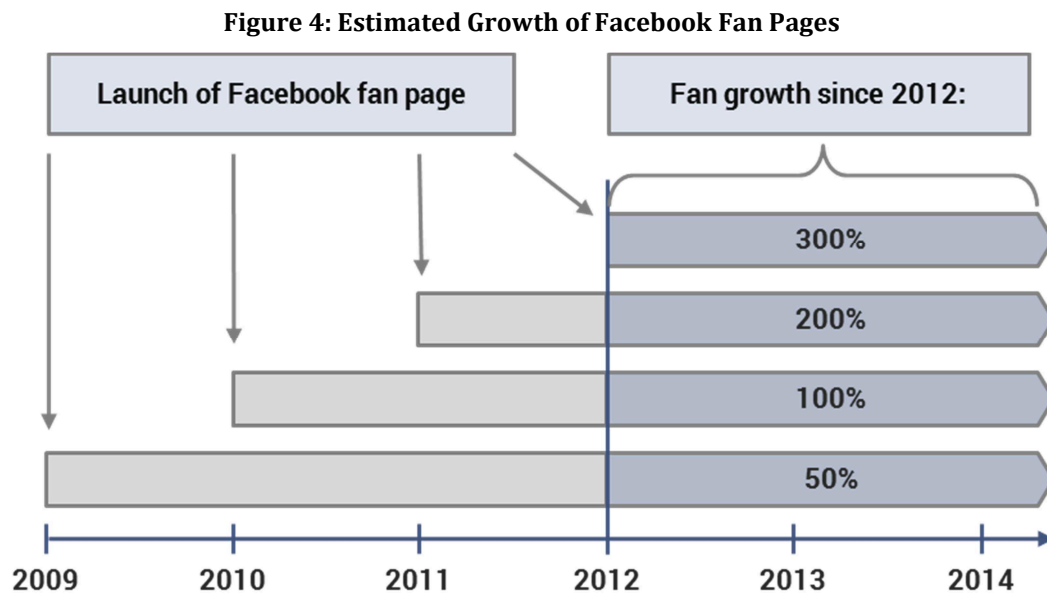
The concluded estimates have their limitations because the exact number remains unknown. However, an approximation was needed for a meaningful inter-firm comparison in the absence of actual growth data. Thus, this approach is more thorough than simply taking the fan numbers from the year 2014, as they reflect the firm's Facebook fan page in a very different stage of development, given that the number of fans can increase substantially in two years.

The scaling of the engagement rates by the number of fans deviates from the proposed rates by Kaushik (2012). Thus, the thesis continues with these scaled rates as depicted in Figure 5: *Scaled applause rate, scaled conversation rate, scaled amplification rate.*

Figure 5: Scaled Facebook Engagement Rates
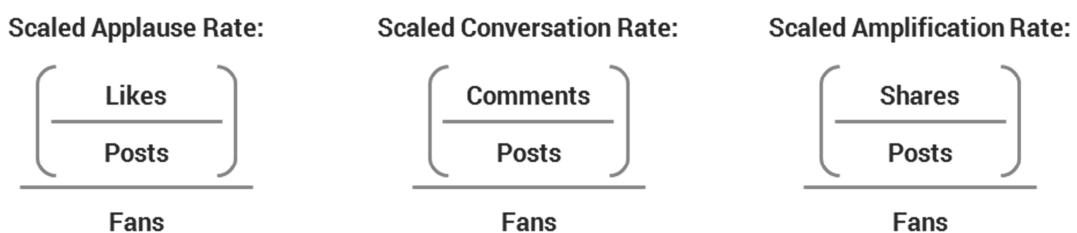
These three rates are used as independent variables for testing H1a, H1b and H1c, respectively[13]. They are continuous ratio variables. For the 315 firms without an active Facebook fan page, all rates were set to 0.

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[13] The three engagement rates were entered separately as independent variables. A possible combination of them as sum and average was considered and tested in the regression model; however, both the Akaike

b) Control variables

As control variables for the regression analysis, firm characteristics provided by the ZEW Innovation Survey were entered: *number of employees*, *number of employees with a graduate degree*, *revenue*, *export stocks*, and *total innovation expenses*, all of which were continuous interval variables. These controls were selected as the report compiled for the ZEW Innovation Survey 2013 showed differences in innovative activity related to firm size (Rammer, Aschhoff, Crass, Doherr, Hud, Köhler et al., 2014).

Furthermore, innovation differences could also be attributed to the firms' economic sectors, which were thus used as binary control variables in this thesis. Due to the low number of cases for the five sectors with the least firms[14], these sectors could not be incorporated individually (Hosmer & Lemeshow, 2000). They were thus aggregated into a reference group. Only one of those 17 firms developed a product innovation. Hence, they were combined with the sector *professional, scientific and technical activities*, as its share of innovators was the lowest of the remaining sectors. Finally, the sectors *manufacturing* and *information and communication* were entered into the model as controls, with the group of all other sectors providing the reference category.

Moreover, the binary control variable *existence of a Facebook fan page* was added with the value 1 for the 33 firms with a Facebook fan page, and 0 for all others. This way, it could be tested whether merely running a Facebook fan page impacts innovation.

3.3.3. Measures for H2, H3 and H4

Hypotheses 2, 3 and 4 propose that firm-internal decisions (social media strategy, openness culture, use of co-creation methods via social media, respectively) impact innovation. As corresponding data is not publicly available, an online survey was conducted. A survey was chosen over interviews in order to capture relevant firm-internal aspects focusing on the three hypotheses for a larger number of firms, rather than conducting only few in-depth interviews.

The 33 sub-sample companies with an active Facebook fan page were contacted by phone to introduce the research and invite them to participate in the survey. This approach involving personal contact was chosen in order to find the right person within the company, to get

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information criterion (AIC) and the Bayesian information criterion (BIC) for the model with separate engagement rates were lower, indicating that this model should be selected.

[14] The five sectors *Administrative and support service activities*, *Construction*, *Financial and insurance activities*, *Real estate activities*, and *Wholesale and retail trade* include less than ten firms each and account for only 17 cases in total (see Table 3 in the descriptive statistics section 4.1).

their attention and let them develop a sense of commitment by verbally confirming to take part in the study, which should eventually improve the level of participation (Boyer & Stron, 2012). 25 of the 33 companies were reached this way. The employee responsible for the Facebook administration was identified and the survey invitation was sent out to this person by e-mail. A reminder was sent if the firms hadn't participated after one week. Two firms refused participation when called, citing lack of time as the main reason. Six firms could not be reached by phone. For those eight firms, e-mails with a survey invitation and explanation of the purpose of the study were sent. Overall, 16 firms provided analysable answers.

For the questionnaire, the survey tool EFS Survey provided by Questback was used. In the introductory part of the survey, the purpose, research setting and expectations were explained to the participants, followed by preliminary questions about the firm's Facebook page and its management. Throughout the survey, the option *no indication* was available for all questions concerning possibly confidential firm decisions, aiming to reduce the dropout rates. The questions of the survey corresponded to the three hypotheses (see Appendix 2 for the complete questionnaire).

For H2, firms were asked first *whether* they had a *Facebook strategy*, second about its *specificity* and third about set *goals*. The proposed goals were adapted from the study by Peakom and absatzwirtschaft (2011) that was already highlighted in 2.2.1. Objectives related to marketing, customer relationship management, recruiting, and innovation were included. The participants also had the option to add a further goal in a free text field. Subsequently, the respondents were asked to rate whether they had achieved the goals they had selected on a five-point Likert scale ranging from *Completely* to *Not at all.*

For H3, the participants were required to judge the *openness* of their company culture for input coming from social media.

For H4, the companies were asked to indicate which of the *co-creation methods* presented in 2.2.2 they use via Facebook. First, the survey inquired about the use of the passive methods of content analysis in the form of *feedback analysis*, and if so, if a purpose for it was *profiling* of user demographics[15]. In addition, the participants were asked about the use of social media tools for these methods as an indication for their professionalization of the social media management. As elaborated above, those two methods are passive approaches to user collaboration, and do not represent the essence of co-creation. A more in-depth examination

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[15] Netnography was omitted for this survey, as it constitutes a more advanced and time-consuming research method. In order to keep the survey concise and avoiding a lengthy explanation of differences between netnography and content analysis, the former was excluded.

of the active methods was thus conducted by asking participants about the current use of *polls*, *conversations*, *ideas competitions*, *problem solving via innovation communities*, and *participatory design*; followed by a question about the planned use of these methods in the future.

3.4. Data Analysis Methods

Hypotheses 1a, 1b and 1c are tested using the statistical process of a regression analysis to understand the relationship between Facebook engagement rates and innovation. As the dependent variable *product innovation* is binary (see 3.3.1) a binominal logistic regression (logit regression) is conducted. It is used to model the logit-transformed probability that an event will occur (Hosmer & Lemeshow, 2000). In this case, the event is *development of a product innovation*, coded as an outcome of 1. Importantly, the logit regression does not model the *value* of the outcome, but the *probability* that this outcome will be 1 and not 0 as a function of all the independent variables.

Odds ratios are used to compare the likelihood that the outcome is 1 with the likelihood that the outcome is 0. As those two likelihoods are complementary (i.e. their sum is 1), the odds ratio can range from 0 to infinity. If the odds ratio is 1, the outcomes are equally likely; if it is larger than 1, the outcome of 1 is more likely; if it is smaller than 1, the outcome of 0 is more likely. For the coefficients that are estimated in the logit regression model, only the algebraic sign can be interpreted, reflecting the direction of change. As different scales are used for the coefficients, the coefficients' magnitudes do not yield interpretable information. With a positive sign, the outcome of 1 (the event) is more likely to occur; with a negative sign, the outcome is less likely to be 1 and more likely to be 0. A coefficient with the value 0 does not change the likelihood of the outcome. In order to interpret actual magnitudes of the predictors' influence on the outcome, marginal effects are estimated. They reflect the change of the probability that the event occurs if the predictor increases by one unit[16].

To compare models among each other, the log-likelihoods are examined. They increase with each iteration of the logit regression until the model has converged (UCLA Institute for Digital Research and Education, 2014b); thus, a higher log-likelihood suggests a better model. Further, models can be compared using the Pseudo R^2 measure of McFadden's R^2. It

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[16] Two ways to estimate marginal effects exist: *Marginal effects at the mean* construct an average case (firm) of the sample and then calculate marginal effects. In contrast, *average marginal effects* estimate marginal effects for each individual case. Both approaches lead to similar results in practice. However, average marginal effects are reported in this thesis as the differences between the cases make the construction of an average difficult.

represents a log-likelihood estimation of a coefficient of determination. Although it cannot be interpreted analogously to R^2 in multiple regression models, it is used to compare logit regression models as a higher Pseudo R^2 indicates a better explanation of the dependent variable. The model fit is tested using the Hosmer-Lemeshow statistic, a goodness-of-fit test which assesses whether "predicted frequency and observed frequency […] match closely" (UCLA Institute for Digital Research and Education, 2014a). For the Hosmer-Lemeshow statistic, larger Chi^2 values as well as p-values above the threshold of 0.05 indicate good fit.

To summarize, Figure 6 depicts the operationalised research model for H1a, H1b and H1c, including the scaled rates, the dependent variable product innovation, and the research method.

Figure 6: Research Model for H1a, H1b, H1c Applied to Research Setting
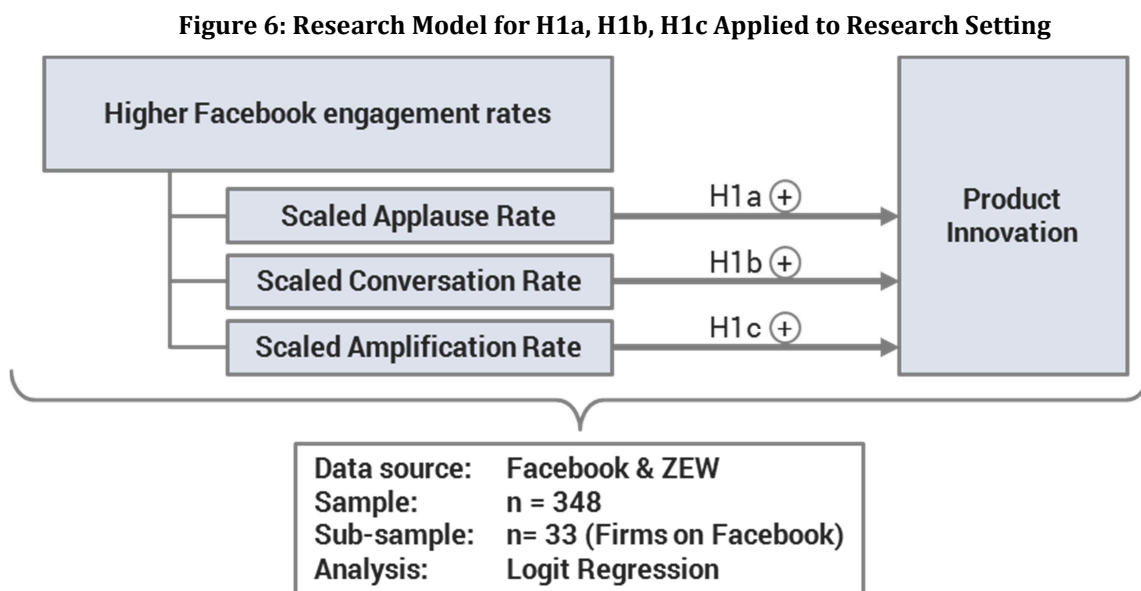
Hypotheses 2, 3 and 4 concern the relationship between social media strategy, openness culture, and co-creation methods employed in social media, and innovation, respectively. To capture these factors, the author conducted an online survey with 16 respondents (see 3.3.3). Due to the small number of participants, a statistical regression analysis would not be suitable. Thus, these three hypotheses are analysed descriptively using the answers given in the survey. Figure 7 summarizes the research approach for H2, H3 and H4.

Figure 7: Research Model for H2, H3, H4 Applied to Research Setting
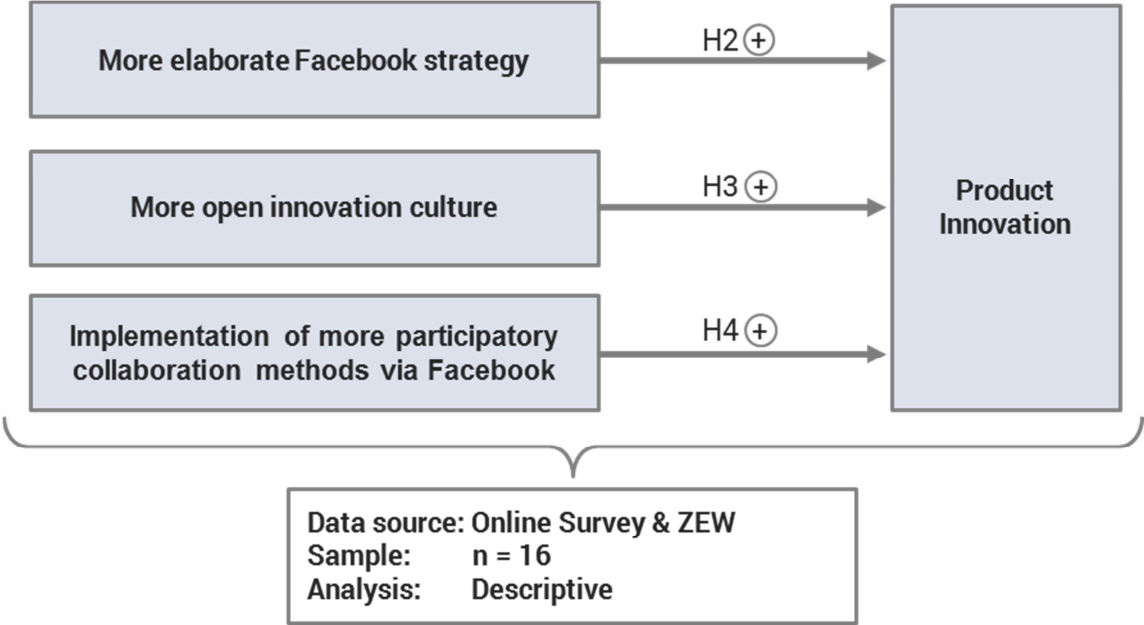
4. Descriptive statistics

4.1. Innovation Data: Innovators vs. Non-Innovators

To achieve a better understanding of the data used in this study, this chapter examines the 348 sample firms according to their size and sector characteristics. Firstly, differences between innovators and non-innovators are illustrated (4.1). Secondly, the 33 firms with an active Facebook fan page are compared with firms that do not use Facebook (4.2.1). Subsequently, the data collected for the engagement rates is presented (4.2.2), followed by descriptive statistics for the survey results (4.2.3).

For the 348 firms of the sample, the number of employees ranged from 5 to 230 with an average of 18.4 and a median of 10. Of all sample firms, 168 (48.3%) had developed a product innovation in 2012 and can thus be called innovators. As Table 2 depicts, the share of innovators on all firms grows with firm size, from 46.1% for companies with 5 to 9 employees, to 56.5% for companies with 50 to 249 employees.

Table 2: Number of Employees (Innovators vs. Non-innovators)

Employees	All firms	Innovators	Non-innovators	Innovators / all firms
5-9	154	71	83	46.1%
10-19	99	49	50	49.5%
20-49	72	35	37	48.6%
50-249	23	13	10	56.5%
Sum	**348**	**168**	**180**	**48.3%**

Of the 13 economic sectors that had been taken into account following the NACE classification, only eight were part of the final sample. As shown in Table 3, the majority of firms operate in three sectors: *Manufacturing* (140 firms, 40.2%), *professional, scientific and technical activities* (133 firms, 38.2%), and *information and communication (ICT)* (58 firms, 16.7%). The next largest sector is *administrative and support service activities* (8 firms, 2.3%). In each of the other four economic sectors, less than five firms were identified.

In this sample, innovators could only be found in the three sectors that included the highest number of firms, and in *financial and insurance activities*, see Table 3. The share of innovators on all firms ranged from 46.6% in *professional, scientific and technical activities* to 62.1% in the *ICT* sector.

Table 3: Economic Sectors (Innovators vs. Non-innovators)

Economic sector (NACE classification)	All firms	Innovators	Non-innovators	Innovators / all firms
Manufacturing	140	69	71	49.3%
Professional, scientific and technical activities	133	62	71	46.6%
Information and communication (ICT)	58	36	22	62.1%
Administrative and support service activities	8	0	8	0.0%
Construction	4	0	4	0.0%
Financial and insurance activities	2	1	1	50.0%
Real estate activities	2	0	2	0.0%
Wholesale and retail trade; repair of motor vehicles	1	0	1	0.0%
Sum	**348**	**168**	**180**	**48.3%**

4.2. Facebook Data

4.2.1. Firms on Facebook vs. Firms not on Facebook

For the 33 firms on Facebook, the number of employees ranged from 5 to 100 with an average of 20.3 and a median of 12. Table 4 depicts the number of employees per employee group as defined by the ZEW for both the sample firms and the sub-sample of firms on Facebook. It shows that the share of firms with an active Facebook fan page of all firms increases with firm size; for the largest employee group, it is almost twice the percentage as for the smallest.

Table 4: Number of Employees (Firms on Facebook vs. Firms not on Facebook)

Employees	All firms	Firms on Facebook	Firms not on Facebook	Firms on Facebook / all firms
5-9	154	11	143	7.1%
10-19	99	11	88	11.1%
20-49	72	8	64	11.0%
50-249	23	3	20	13.0%
Sum	**348**	**33**	**215**	**9.5%**

The 33 firms on Facebook operate in the aforementioned four largest sectors. The most represented of them is the *information and communication sector*, where 15 firms (or 26% of all firms) run a Facebook fan page (see Table 5).

Table 5: Economic Sectors (Firms on Facebook vs. Firms not on Facebook)

Economic sector (NACE classification)	All firms	Firms on Facebook	Firms on Facebook / all firms
Manufacturing	140	6	4.3%
Professional, scientific and technical activities	133	11	8.3%
Information and communication (ICT)	58	15	25.9%
Administrative and support service activities	8	1	12.5%
Construction	4	0	0%
Financial and insurance activities	2	0	0%
Real estate activities	2	0	0%
Wholesale and retail trade; repair of motor vehicles	1	0	0%
Sum	**348**	**33**	**9.5%**

Figure 8 depicts the share of firms in each sector – on the left side, for all 348 firms of the sample, and on the right side, for the 33 firms on Facebook. It is apparent that the share of manufacturing firms with a Facebook page is smaller, while the firms in the information and communication sector are more strongly represented.

Figure 8: Economic Sectors (All Firms vs. Firms on Facebook)

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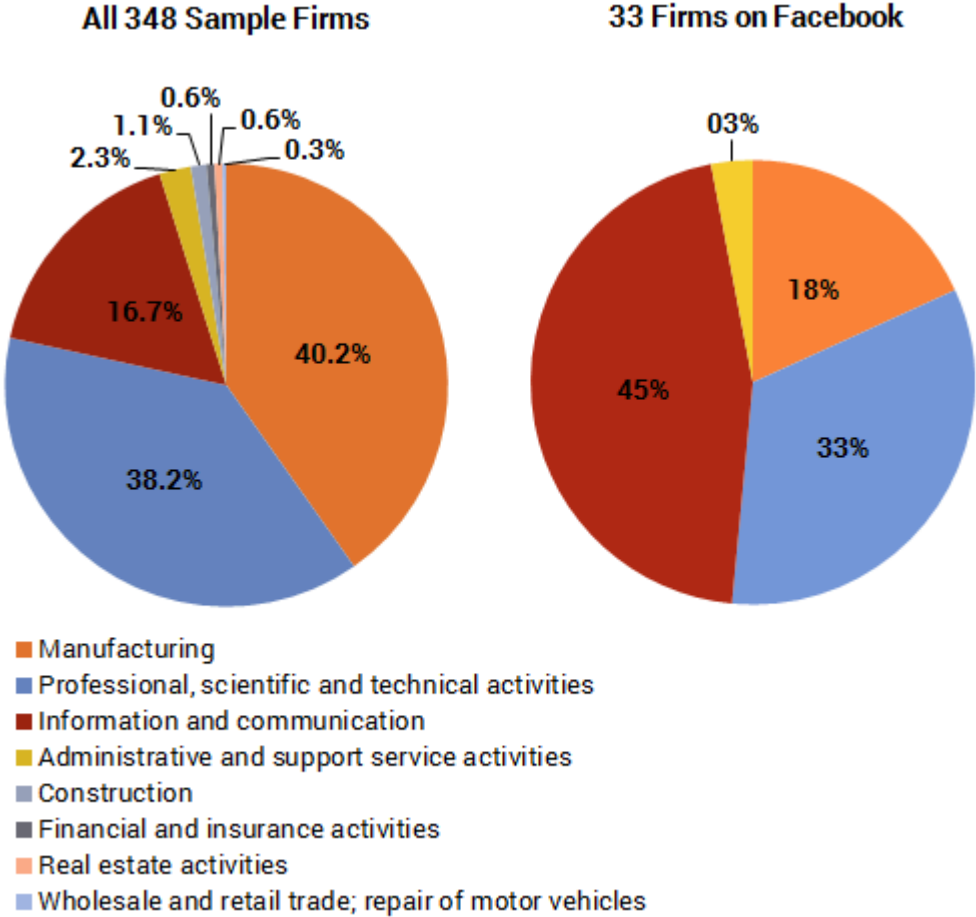
4.2.2. Facebook Engagement Rates

To compare the firms regarding their Facebook activities, the number of fans or likes gives a first indication, as described in 2.3.2. Table 6 provides descriptive statistics for the 33 firms on Facebook and their number of fans – for December 2012 (estimated, as explained in 3.1), and for August 2014. The large range of fans reflects the significant differences in the size of the pages. In 2012, only 8 of 33 fan pages had more than 1,000 fans, and only one of those more than 10,000 fans (see Appendix 3 for all values). These firms drive up the average number of fans; on a median level, the pages had 150 fans in 2012.

Table 6: Number of Facebook Fans 2012 and 2014

Number of Facebook fans	Dec. 2012 (*estimate*)	Aug. 2014 (*actual*)
Min.	10	34
Max.	13,471	15,879
Average	1,119	2,231
Median	150	301

Table 7 shows descriptive statistics for the number of Facebook posts and generated user engagements. The firms' activity on Facebook varied considerably. In the calendar year 2012, the number of posts by firms on their timelines ranged from 5 to 600, i.e. from one post every ten weeks to 1.6 every day, or 2.4 every business day of the year. On average, the firms posted 92 times in 2012, or 1.8 times per week. The median value for posts per year is only at 60, or two-thirds of the average posting frequency.

Regarding the three user engagement types (likes, comments, shares), substantial differences between the firms could also be observed. Naturally, firms with a higher number of Facebook fans generated higher absolute engagement numbers. The firm with the second-lowest number of fans in 2012 received neither likes nor comments or shares for their posts, setting 0 as the minimum for all three engagement categories. The highest number of likes and shares (7,999 and 1,009, respectively) were generated by the firm with the largest Facebook fan base, although it only published 37 posts in the whole year. The firm that had posted 600 times had also obtained the highest number of comments (1,391); it had the 3rd largest number of fans. For most firms, the absolute number of likes was highest, followed by comments and then shares. Only one fan page received less likes than comments, and five pages got less comments than shares (see Appendix 3 for all values). For all three types of user engagements, the differences between average (arithmetic mean) and median are large (see Table 7), which represents a heavy skewing of the data on interaction. The average is

strongly affected by extreme values of firms with very high engagement numbers; the median is therefore more representative for most of the firms.

Table 7: Number of Facebook Posts and User Engagements in 2012

	Facebook posts	Likes for Facebook posts	Comments on Facebook posts	Shares of Facebook posts
Min.	5	0	0	0
Max.	600	7,999	1,391	1,009
Average	92	683	126	90
Median	60	184	33	7

As described in 2.3.2, the reported absolute engagement numbers are less meaningful than the engagement rates *applause rate*, *conversation rate* and *amplification rate* proposed by (Kaushik, 2012) which respectively adjust the likes, comments and shares by the number of posts on the Facebook timeline. The range for the three engagement rates is again large, spanning from 0 to 216 likes per post, 29 comments per post and 27 shares per post. A few firms with outstanding engagement rates drive up the average; the median is again more representative for the majority of firms. The median values show that engagement per post is often limited, with 3.6 likes per post, 0.5 comments per post and 0.1 shares per post. Regarding the economic sectors, the data shows that information and communication firms lead in all three engagement rates; among the best performing fan pages are newspapers, online gaming communities, and a radio station. Lastly, a similar observation as for the absolute engagement numbers can be made: firms with a larger fan base have higher interaction rates, affirming again that the scaling of the rates by fans is important, as discussed above in 3.3.2.

Taking the estimated fan numbers for 2012 as a scaling base, Table 8 shows descriptive statistics for the three *scaled engagement rates* (multiplied by 100 for better comparability). The best scaled engagement rates are created by smaller fan pages which are able to engage each of the fewer fans better than larger pages.

Table 8: User Engagement Rates (Scaled and not Scaled)

	Applause Rate	Conversation Rate	Amplification Rate	Scaled Applause Rate (*100)	Scaled Conversation Rate (*100)	Scaled Amplification Rate (*100)
Min.	0.0	0.0	0.0	0.00	0.00	0.00
Max.	216.2	28.8	27.3	17.06	2.63	1.91
Average	10.9	1.6	1.2	2.53	0.37	0.17
Median	3.6	0.5	0.1	1.28	0.13	0.04

The share of innovators on all firms was higher for those firms with an active Facebook fan page than for those without, as Table 9 depicts: 58% of firms on Facebook were innovators, while only 47% of Firms not on Facebook had developed a product innovation.

Table 9: Share of Innovators (Firms on Facebook vs. Firms not on Facebook)

	All firms	Innovators	Non-innovators	Innovators / all firms
Firms on Facebook	33	19	14	58%
Firms not on Facebook	315	149	166	47%
Sum	**348**	**168**	**180**	**48%**

4.2.3. Survey Analysis

Of the 33 firms that were invited to the survey, 17 participated. This high response rate of 51.5% could be reached through the personal addressing of firms by the author. Two non-participant firms dropped out after opening the first question, and 14 did not start at all. The median time required to complete the survey was 7 minutes. Surprisingly, one respondent indicated that the firm does not run a Facebook fan page, although the author of this thesis had found one. He said that the firm does not have enough resources to manage a Facebook fan page and it is not certain whether they will launch a fan page in the future. Therefore, this participant was omitted, leaving 16 respondents. Of these, seven reported to be employees in the marketing or communications divisions, five were executives, two administrators and two worked in other departments. Their survey responses are presented and evaluated in 5.2, when examining H2, H3 and H4[17].

Table 10: Survey Participants: Number of Employees (Innovators vs. Non-Innovators)

Employees	Innovators	Non-Innovators	All firms
5-9	3	2	5
10-19	3	3	6
20-49	1	2	3
50-249	0	2	2
Sum	**7**	**9**	**16**

Of the 16 firms participating in the survey, 7 (44%) had developed product innovations in 2012, and 9 (56%) had not done so. Table 10 and Table 11 show employee numbers and economic sectors of the 16 participating firms, divided into innovators and non-innovators.

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[17] The complete anonymised survey data in German is available upon request.

Of the respondents, most the innovators were smaller firms with less than 19 employees. The four largest firms that participated were non-innovators.

Table 11: Survey Participants: Economic Sectors (Innovators vs. Non-Innovators)

Economic Sectors (NACE classification)	Innovators	Non-Innovators	All firms
Manufacturing	1	1	2
Professional, scientific and technical activities	3	3	6
Information and communication (ICT)	3	4	7
Administrative and support service activities	0	1	1
Sum	**7**	**9**	**16**

The distribution among the economic sectors is relatively balanced, with most participants operating in ICT and professional, scientific and technical activities, both for the group of innovators and non-innovators.

5.   Results

5.1.   Facebook Engagement Rates and Innovation (H1a, H1b, H1c)

The empirical results for each of the four hypotheses are presented in this chapter, beginning with correlations and regression results for hypotheses 1a, 1b, and 1c, followed by the descriptive analysis of the survey data for hypotheses 2, 3 and 4.

Table 12 shows the correlations between all variables used for the regression analysis to test H1a, H1b and H1c. The dependent variable *product innovation* is significantly positively related to several control variables: The *share of graduate employees*, the *amount of export stocks*, *innovation expenses*, and the belonging of firms to the *ICT sector*. Furthermore, the relationship between the *scaled conversation rate* and *product innovation* is positive and significant. However, the magnitude of all these correlations is small (below 0.25). Moreover, the control variable *existence of Facebook fan page* and all of the three *scaled engagement rates* are strongly positively correlated with each other, which is logical as only firms with a Facebook fan page had values for the scaled engagement rates larger than 0.

Table 12: Correlations between Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1 Product innovation	1.00											
2 Employees	0.07	1.00										
3 Share of graduates	0.22***	-0.04	1.00									
4 Revenue	-0.01	0.66***	-0.08	1.00								
5 Export stocks	0.11**	0.61***	-0.04	0.71***	1.00							
6 Innovation expenses	0.24***	0.44***	0.01*	0.26***	0.31***	1.00						
7 Manufacturing sector	0.02	0.08	-0.47***	0.13**	0.18***	0.05	1.00					
8 ICT sector	0.12**	-0.06	0.19***	-0.04	-0.08	-0.04	-0.37***	1.00				
9 Existence of FB page	0.06	0.03	0.12**	-0.03	-0.04	-0.04	-0.15***	0.25***	1.00			
10 Sc. applause rate	0.08	-0.03	-0.05	-0.03	-0.03	-0.02	0.01	0.08	0.55***	1.00		
11 Sc. conversation rate	0.12**	-0.03	-0.01	-0.03	-0.03	-0.02	-0.04	0.09	0.53***	0.66***	1.00	
12 Sc. amplification rate	0.03	-0.03	-0.08	0.01	-0.01	-0.02	-0.01	0.12**	0.39***	0.70***	0.45***	1.00

* $p \leq 0.1$ ** $p \leq 0.05$ *** $p \leq 0.01$

Before testing the hypotheses, only the control variables were entered into the regression as predictors to understand whether they influence innovation. See Table 13 for results.

Table 13: Logit Regression Results – Control Variables

Predictor	Coefficient	P>|z|	Odds ratio
Employees	0.019	0.146	1.019
Share of graduate employees	0.017***	0.000	1.017
Revenue	-0.229*	0.051	0.795
Export stocks	0.399*	0.074	1.491
Total innovation expenses	3.343***	0.001	28.317
Manufacturing sector	0.998***	0.005	2.712
ICT sector	0.988**	0.018	2.685
Existence of a Facebook fan page	-0.180	0.715	0.835
Constant	-1.777	0.000	0.169
Log-likelihood			-159.1661
Pseudo R^2 / McFadden R^2			0.1736
Hosmer-Lemeshow Statistic: Chi^2			6.2100
Hosmer-Lemeshow Statistic: Prob > Chi^2			0.6233

* $p \leq 0.1$ ** $p \leq 0.05$ *** $p \leq 0.01$

The coefficients for all controls are significant, except for the *number of employees* and *existence of a Facebook fan page*. For the control variables *share of graduate employees* and *export stocks*, the positive coefficients and odds ratios only slightly larger than 1 indicate a small positive influence of the variables on the probability that a product innovation is developed. If firms operate in the *manufacturing* and *ICT sector*, the odds ratios of 2.7 suggest that it is more than twice more likely for them to develop a product innovation as it is to not develop one. Not surprisingly, the odds ratio for the control variable *total innovation expenses* is very high, emphasising that firms which invest heavily in innovation are much more likely to be innovative. The only control variable with a negative coefficient is *revenue*; with an odds ratio of 0.8, the regression shows that firms with higher revenue are not necessarily more likely to develop product innovations. The *existence of a Facebook fan page* does not have a significant influence on the probability that a product innovation is developed.

Next, hypotheses 1a, 1b and 1c were tested. Due to the high correlations between the control variable *existence of a Facebook fan page* and the three *scaled engagement rates*, and well as among the *scaled engagement rates*, entering these variables simultaneously into the regression leads to multicollinearity with inflated results for coefficients and odds ratios, preventing an interpretation of the results. Therefore, the non-significant control variable

existence of a Facebook fan page was omitted and each of the three *scaled engagement rates* (*scaled applause rate, scaled conversation rate, scaled amplification rate*) was entered separately into a logit regression model. Table 14, Table 15 and Table 16 present the results of each of the logit regressions. In all of those, the coefficients, significance and odds ratios of the control variables change only marginally compared to the first logit regression analysis testing H1 (Table 13).

Table 14 shows that the *scaled applause rate* does not have a significant influence on the probability that a product innovation is developed. H1a is thus rejected.

Table 14: Logit Regression Results for H1a – Scaled Applause Rate

Predictor	Coefficient	P>|z|	Odds ratio
Employees	0.018	0.158	1.018
Share of graduate employees	0.017***	0.000	1.017
Revenue	-0.231**	0.050	0.794
Export stocks	0.408*	0.070	1.504
Total innovation expenses	3.409***	0.001	30.245
Manufacturing sector	0.992***	0.006	2.696
ICT sector	0.919**	0.024	2.507
Scaled applause rate	**0.119**	**0.304**	**1.127**
Constant	-1.799	0.000	0.165
Log-likelihood			-158.6012
Pseudo R2 / McFadden R2			0.1765
Hosmer-Lemeshow Statistic: Chi2			8.0100
Hosmer-Lemeshow Statistic: Prob > Chi2			0.4321

$* p \leq 0.1 ** p \leq 0.05 *** p \leq 0.01$

Table 15 displays the logit regression results for H2b. The coefficient for the *scaled conversation rate* is positive and significant at the 10% level. The odds ratio of 5.96 indicates that for firms with a higher *scaled conversation rate*, the odds of developing a product innovation are much higher than the odds of not doing so. As the predictor of interest is significant, average marginal effects have also been estimated. Hence, a one-unit increase in the scaled conversation rate will increase the probability of product innovation development by 34.3%. Therefore, H1b can be accepted.

Table 15: Logit Regression Results for H1b – Scaled Conversation Rate

Predictor	Coefficient	P>|z|	Odds ratio	Average marginal effect
Employees	0.018	0.154	1.019	0.004
Share of graduate employees	0.018***	0.000	1.018	0.003
Revenue	-0.235**	0.049	0.790	-0.045
Export stocks	0.417*	0.067	1.517	0.080
Total innovation expenses	3.444***	0.001	31.316	0.662
Manufacturing sector	1.018***	0.005	2.768	0.196
ICT sector	0.883**	0.032	2.418	0.170
Scaled conversation rate	**1.786***	**0.098**	**5.963**	**0.343**
Constant	-1.859	0.000	0.156	0.004
Log-likelihood				-156.5603
Pseudo R^2 / McFadden R^2				0.1871
Hosmer-Lemeshow Statistic: Chi^2				7.7600
Hosmer-Lemeshow Statistic: Prob > Chi^2				0.4572

* $p \leq 0.1$ ** $p \leq 0.05$ *** $p \leq 0.01$

Table 16 shows that the *scaled amplification rate* does also not have a significant influence on the probability that a product innovation is developed. H1c is thus rejected.

Table 16: Logit Regression Results for H1c – Scaled Amplification Rate

Predictor	Coefficient	P>|z|	Odds ratio
Employees	0.019	0.137	1.020
Share of graduate employees	0.017***	0.000	1.017
Revenue	-0.242**	0.047	0.785
Export stocks	0.422*	0.068	1.525
Total innovation expenses	3.364***	0.001	28.900
Manufacturing sector	1.009***	0.005	2.744
ICT sector	0.925**	0.023	2.522
Scaled amplification rate	**0.658**	**0.537**	**1.932**
Constant	-1.799	0.000	0.166
Log-likelihood			-159.0610
Pseudo R^2 / McFadden R^2			0.1741
Hosmer-Lemeshow Statistic: Chi^2			6.3800
Hosmer-Lemeshow Statistic: Prob > Chi^2			0.6053

* $p \leq 0.1$ ** $p \leq 0.05$ *** $p \leq 0.01$

The logit regression model testing H1b involving the *scaled conversation rate* has the highest log-likelihood and McFadden R^2 of all the models that were presented. Although the absolute differences are small, this indicates that the model for H1b has the greatest likelihood. Concerning the goodness of fit, the Hosmer-Lemeshow Chi^2 and its p-value are high for all models, representing adequate fit and applicability for them.

In summary, only hypothesis 1b was accepted, which proposed a positive impact of the *scaled conversation rate* on product innovation. Hypotheses 1a and 1c were rejected.

5.2. Facebook Strategy and Innovation (H2)

Hypothesis 2 proposes that a more specific and goal-oriented social media strategy positively impacts innovation, which was tested using data collected through an online survey with 16 firms. Due to this small sample size, a regression analysis would not yield meaningful results. Thus, the data was analysed descriptively, comparing the answers of innovators and non-innovators.

Before evaluating the specificity and goal-orientation, it has to be emphasised that not all firms followed a Facebook strategy. Of the seven innovators that participated in the survey, four had indeed developed a Facebook strategy (57.2%). Two of them had done so before launching the Facebook fan page, and two while it was already running. In contrast, four of nine non-innovators (44.4%) had a strategy for Facebook; only one of them had defined it before the launch (see Table 17). Thus, the survey showed that innovators are more concerned with strategy development for their Facebook activities.

Table 17: Survey Results for H2 – Development of a Facebook Strategy

Did your company develop a Facebook strategy?		
	Innovators	**Non-innovators**
Yes, before launch	28.6%	11.1%
While already live	28.6%	33.3%
No, never	28.6%	44.4%
Not indicated	14.3%	11.1%

Regarding the *specificity* of their strategy, just one of the four innovators indicated that he had devised a strategy involving *general* processes and goals at all, which reflects a more structured approach to strategy building, as explained in 2.3.2 All other respondents had

developed a less specified, *general direction*, and none of them indicated that they follow *specific* processes and goals.

Table 18: Survey Results for H2 – Specificity of the Facebook Strategy

[If yes:] How specific was your company's Facebook strategy?		
	Innovators	**Non-innovators**
We developed a strategy involving specific processes and goals.	0.0%	0.0%
We developed a strategy involving general processes and goals.	25.0%	0.0%
We developed a rather general direction.	75.0%	100.0%
Other: […]	0.0%	0.0%
No indication.	0.0%	0.0%

Even if not specified in a formal strategy, all firms indicated which *goals* they strive for with their Facebook presence (except for one non-innovator that selected none). Table 19 depicts the share of innovators and non-innovators pursuing each of the proposed goals, as well as their assessment of the extent to which they were achieved.

The most important goals for both innovators and non-innovators were in the marketing category, with *promoting the company* being the most often selected objective, followed by *increased brand awareness* and *reaching new target groups*. Six of nine non-innovators further chose the customer relationship management goal *development of (new) customer relations*. Goals related to special offers and recruiting were selected by fewer firms.

Concerning the achievement of these goals, the average assessment ranged from 2.0 (*goal rather reached*) to 3.5 (*goal partly / rather not reached*). There were no meaningful differences between innovative and non-innovative firms. Generally, the distribution of the number and achievement rating of goals among innovators and non-innovators is balanced; on average, innovators rated the achievement at 2.4, and non-innovators at 2.8.

One of the goals that have been categorised as stimulating innovation, *getting customer feedback*, was selected by 43% of the innovators, but only 22% of non-innovators. The two goals that specifically inquired whether firms aim at generating innovation-related input via Facebook were selected by none of the 16 participants. Therefore, the impact of an innovation-focused Facebook strategy on firm innovation could not be evaluated through the goal selection.

Table 19: Survey Results for H2 – Facebook Fan Page Goals and Their Achievement

Goals	Did your company set the goal?		Did you reach the goal? (1: Completely; 5: Not at all)	
	Innovators	Non-innovators	Innovators	Non-innovators
Marketing goals:				
Promoting the company	100%	67%	2.4	3.0
Increased brand awareness	71%	56%	2.6	2.3
Reaching new target groups	57%	56%	2.8	3.0
Special marketing / sales promotions	14%	33%	2.0	2.3
Special product offerings for customers	0%	22%	-	1.5
Customer relationship management goals:				
Development of (new) customer relations	29%	67%	3.5	3.2
Offering special (new) customer service	14%	22%	3.0	2.5
Human resource goals:				
Recruiting	14%	11%	1.0	2.0
Innovation-related goals:				
Getting customer feedback	43%	22%	2.0	1.5
Getting customer input for new products or improvements *before* the development phase	0%	0%	-	-
Getting customer input for new products or improvements *after* the development phase	0%	0%	-	-
Additional goals (free text field):				
Providing market information and linking to firm's blog	14%	0%	1.0	-
Average			2.4	2.8

It could thus not be shown that more innovative firms pursue a larger number or different types of objectives, with the exception of obtaining feedback from users. Here, innovator firms are in the lead. Although the sample size is not big enough to generalise the findings, this provides a first indication that an interaction-focused direction of the developed Facebook strategy can be linked to firm innovation.

Overall, some aspects found in the survey results support hypothesis 2. More of the innovative than non-innovative firms had developed a social media strategy, and innovators devised slightly more specific strategies. However, concerning the implementation of the strategy, no significant differences in the achievement rating of the goals could be found between innovators and non-innovators. H2 can thus only be partially supported.

5.3. Openness Culture and Innovation (H3)

Hypothesis 3 argues that a more open innovation culture allows for better integration of user input into the innovation process, thus leading to an increase in firm innovation. Contrary to the expectations, innovators are less interested in external ideas than non-innovators: Only 28.6% of innovators indicated to be *quite open* or *very open* to suggestions, while 77.8% of non-innovators did so. 42.9% of innovators prefer to not include user input received via social media. Hence, H3 could not be supported by this analysis.

Table 20: Survey Results for H3 – Openness of Innovation Culture

In your opinion, is your firm open for ideas and suggestions from users which reach you via social media channels?		
	Innovators	**Non-innovators**
Very open	14.3%	11.1%
Quite open	14.3%	66.7%
Prefer internal development	42.9%	11.1%
Not indicated	28.6%	11.1%

5.4. Use of Co-Creation Methods via Facebook and Innovation (H4)

Hypothesis 4 proposes that employing more participatory co-creation methods via social media improves innovation.

First, regarding the passive methods, only two of the innovators, but six of the non-innovators indicated that they analyse user feedback received via Facebook to understand their users' wishes and needs, see Table 21. The amount of both innovators and non-innovators that had selected *no indication* was relatively high for these questions. This might reflect that firms are unsure about how to handle user feedback. Interestingly, one firm that does not evaluate user suggestions had selected *getting customer feedback* as a goal before and judged it as *partly reached*. Overall, while a higher share of innovators was aiming at soliciting feedback from their users, in practice, more non-innovators actually committed to analysing user feedback. All innovators that analysed feedback did so for *profiling* reasons; only 40% of non-innovators did so. Social media tools to facilitate the application of these methods are not used by any of these firms.

Table 21: Survey Results for H4 – Passive User Collaboration Methods

Does your firm analyse feedback or suggestions that users post on your Facebook brand page?		
	Innovators	**Non-Innovators**
Yes	28.6%	66.7%
No	28.6%	11.1%
No indication	42.9%	33.3%
[IF YES:] Does your firm conduct analyses to understand user profiles and the composition of your community?		
	Innovators	**Non-Innovators**
Yes	100.0%	40.0%
No	0.0%	60.0%

Second, concerning the active co-creation methods, Table 22 shows the share of innovators and non-innovators that currently apply one of the active methods via Facebook, and the share that intends to do so in the future. Surprisingly, non-innovators implemented more of these methods than innovators. While an equal share of both groups currently initiates *conversations* with their users and involves them through the crowdsourcing of problem solutions in *innovation communities*, only non-innovators conduct *polls* and *ideas competitions*. Still, the overall number of firms that implement one of these methods is low. Currently, 57% of innovators and 33% of non-innovators do not use any of the five proposed social media strategies for innovation.

Table 22: Survey Results for H4 – Active User Co-Creation Methods

Which of the following methods does your firm use to integrate Facebook fans into the development of products?				
	Currently		**In the future**	
	Innovators	**Non-innovators**	**Innovators**	**Non-innovators**
Polls	0.0%	11.1%	28.6%	33.3%
Conversations	42.9%	44.4%	57.1%	55.6%
Ideas Competitions	0.0%	22.2%	0.0%	22.2%
Problem Solving in Innovation Communities	14.3%	11.1%	28.6%	11.1%
Participatory Design	0.0%	0.0%	0.0%	22.2%
None of the above	57.1%	33.3%	42.9%	44.4%

However, in the future, more firms expect to implement the methods. While the innovators still only consider *polls*, *conversations* and problem solving in *innovation communities*, some non-innovators also intend to use *ideas competitions* and the *participatory design*, i.e. a highly participatory form of customer involvement, as users are integrated in the whole innovation process. A similar share of innovators and non-innovators intends to use at least one of these methods, as the fraction of innovators that do not consider using any method via Facebook at all declined to 43%, while the percentage of non-innovators rose to 44%. Of the five options given, initiating *conversations* was the most selected by all firms, both in the present and future.

Overall, non-innovators applied more of the active co-creation methods via Facebook, and also planned to do so in the future. Therefore, hypothesis 4 has to be rejected.

In summary, only H1b is fully supported, H2 is partially supported and the other hypotheses had to be rejected, as depicted in Figure 9.

Figure 9: Research Model: Empirical Results
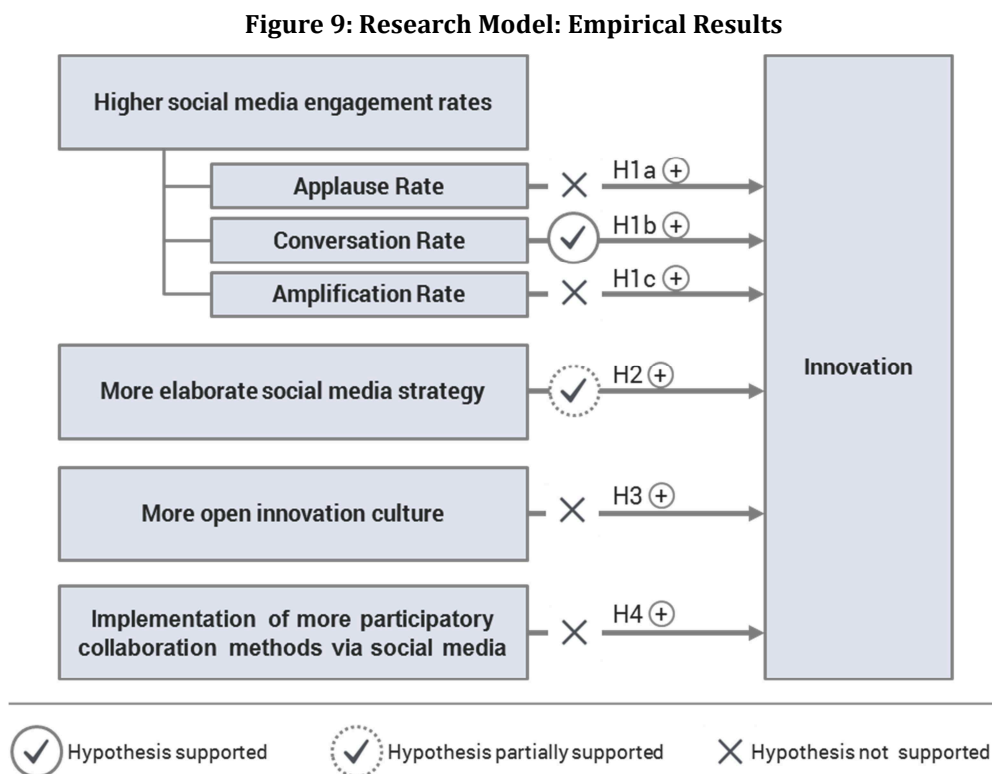
6.   Discussion

6.1.   Facebook Engagement Rates and Innovation (H1a, H1b, H1c)

The following chapter discusses reasons for the results presented in 5, thereby addressing research question 4: *Can the impact of social media on innovation be measured empirically?*

Hypotheses 1a, 1b and 1c concerned the quantitatively measurable Facebook-related predictors, the *scaled engagement rates*, and their influence on firm innovation. Only hypothesis 1b could be accepted: as described in 5.1, it indicates that the *scaled conversation rate* is positively related to the probability that a product innovation is developed. Thus, the amount of comments received is more important for innovation than the amount of likes and shares (scaled by posts and fans, respectively). This outcome is expected, as the theoretical section of this thesis has emphasised the importance of qualitative user input to improve innovation, which can only be supplied through comments. The non-significance of the control variable *existence of a Facebook fan page* shows that only running a fan page does not improve innovation, but engagement is crucial. Similarly, liking and sharing posts on Facebook are interactions with less substance. They are executed by the mere clicking on one button, without providing an indication about the reflection on the actual content. Comments, on the other hand, require the user to take more time, to consider his or her own opinion before expressing it. Possibly, the comment is a reaction to other users' comments, thus evoking true interaction with other users. Therefore, the results show that qualitative user engagement leading to conversations via comments on posts is a way in which social media can indeed be used to foster innovation.

However, the results have to be assessed with care: The marginal effect of 0.343 means that a one unit increase of the *scaled conversation rate* augments the probability of product innovation development by 34.3%. But this one-unit increase is not a simple straightforward change, as the *scaled conversation rate* is composed of three factors: comments, posts, and fans. Thus, the *scaled conversation rate* can be increased if the number of comments grows; but it can also rise if the amount of posts is reduced or the fan base declines. Certainly, it should not be concluded that Facebook posts should be scarce and fan acquisition is not desired. Rather, a more fruitful interpretation is that the number of comments should grow faster than the number of posts and fans if a firm aims at increasing their conversation rate. This can be done through posts that are meaningful for the fans, that engage them and incentivize their interaction, rather than just through plain advertising or announcements of achievements.

6.2. Facebook Strategy and Innovation (H2)

According to hypothesis 2, a more specific and goal-oriented social media strategy positively impacts innovation. A higher share of innovators than non-innovators had developed such a strategy, showing in a first instance that innovators' social media activities are better thought-out.

The sophistication of the strategy was operationalised by the specificity and the goals that were set for the social media presence. Innovators' strategies were slightly more specific, although the small differences can hardly lead to a meaningful conclusion. Concerning the setting and achievement of goals, innovators and non-innovators did not differ significantly, and the most important goals for all firms were marketing- and CRM-related. Of the goals linked to innovation, feedback generation was targeted by more innovators than non-innovators, showing that innovative firms aimed more at engaging their users and learning from them. However, non-innovators rated the achievement of this goal slightly higher. Both groups had not selected the other innovation-related goals. This reflects that Facebook is still mainly perceived as a marketing instrument by most firms, allowing them to increase brand awareness rather than utilizing customers for innovation purposes, although it might provide them with numerous benefits (see 2.3.1).

Overall, the fact whether a strategy had been developed plays a more important role in determining successful use of social media for innovation than goal setting, which is why hypothesis 2 could be partially accepted. Especially the small sample size for the online survey provides an impediment for drawing more refined conclusions. Further limitations are discussed in 7.3.

6.3. Openness Culture and Innovation (H3)

Hypothesis 3, proposing that the openness of the innovation culture positively affects innovation, was not supported, as the share of non-innovators with a more open innovation culture was higher than the share of innovators. This result is contrary to what was hypothesised based on the literature review and the recommendations for successful social media use for innovation.

However, while an open culture might still have a support function in co-creation, as theoretically developed in 2.3.2, this might as well indicate that the effect of the firm culture on innovation is not very large; rather, other factors such as employee qualification, sectors and strategy are more important for innovation development. Moreover, the survey asked specifically for the openness towards suggestions coming from social media channels,

embedded in a questionnaire about Facebook. It is conceivable that the company is indeed open for ideas from other channels.

6.4. Use of Co-Creation Methods via Facebook and Innovation (H4)

Hypothesis 4 reflected the theoretically derived proposition that more collaborative co-creation methods applied through social media improve innovation. However, contrary to the expectations, non-innovator survey participants used these methods to a higher degree than innovators, which is why hypothesis 4 could not be supported.

Nevertheless, meaningful observations could be made in the survey. Both in the present and in the future, *conversations* with users are the most popular method among both groups of firms. This fact can be attributed to the properties of the used social network Facebook specifically, as it is a platform designed for casual communication involving comments on posts, rather than long-term, in-depth collaboration efforts. Thus, the implementation of campaigns involving conversations on Facebook is possibly easiest; the same holds true for *polls*, which about a third of all firms aim to execute in the future.

Other co-creation methods might prove to be more difficult to implement via Facebook due to time and resource constraints of the responsible employees. While this leads firms to miss out on the possible advantages of cost reductions in the innovation process, faster feedback loops and improved customer orientation, they might reap these benefits through the use of other co-creation methods that have not been captured by the survey. It is conceivable that further co-creation methods such as *ideas competitions* or *participatory design* are carried out with the support of different social media platforms, fuelled by different expectations and motivations of users on these platforms. Rather than rejecting the premise for this hypothesis, it should therefore be applied to a different setting, investigating the use of other social media.

In chapter 7.3, a range of limitations of this study are presented; for this hypothesis, main restrictions are the focus on Facebook only, as well as the small and slightly skewed sample, in which all innovators are very small firms with mostly less than 20 employees, while the non-innovators also include firms with more than 100 employees (see Table 10 in 4.2.3). In addition, most firms' Facebook fan pages only had a small number of fans. Presumably, the first step to coherently integrate social media for co-creation processes is to build up the user base to a certain size, before attempting to utilize the fans for innovation. But, as emphasised in 2.3.2, a structured approach to co-creation is necessary; for instance, Helms et al. (2012) propose the "social media innovation method" which involves the definition of

the innovation task, the selection of the right social media platform, as well as a clarification of goals and rules. Thus, a thought-out approach to co-creation provides the basis for its success; due to the above mentioned factors, this study's sample might not have been at this stage (yet).

Furthermore, a striking point in the survey results was that no firm used social media tools to analyse their performance. While this fact might be attributed to the small size of the firms and a manually manageable amount of Facebook posts, it also implies a less professionalised approach to social media.

Overall, the answer to the initially posed research problem "*Can social media act as a facilitator for firm innovation?*" is not straightforward. On a theoretical level, the first three research questions have been answered by providing an overview of research on co-creation methods facilitated by social media as well as empirical results of prior studies, leading to the development of a theoretical model that conceptualises the impact of four social media success factors on innovation. Thus, indications that social media is indeed a facilitator for innovation have been presented.

However, the empirical part of this thesis aiming at answering research question 4 could not fully support the theoretically derived statements. While it has been shown that conversations on social media positively affect innovation, the role of the other three success factors for involving social media in innovation is not clear. The limitations outlined in 7.3 give possible explanations for the absence of more empirical results.

7. Contributions and Implications

7.1. Academic Contributions

The results presented in 5 and discussed in 6 are put into context in this chapter by presenting their academic and managerial implications, as well as limitations and future research directions.

Overall, academic contributions of this thesis are rather theoretical than empirical, as only H1b was fully supported by the data. Firstly, this study contributes to bridging the conceptual gap between social media and innovation by presenting a thorough literature review on the connections between these phenomena, answering calls for future research provided by Idota et al. (2011), Kärkkäinen et al. (2010) and Stanoevska-Slabeva (2011). The study goes beyond marketing applications of social media platforms to the innovation domain and provides an overview of co-creation methods that can be supported by social media. Further, four success factors for firms' social media use for innovations are identified: quantifying engagement, developing a specific and goal-oriented social media strategy, providing a firm culture of openness, and applying the developed co-creation methods via social media. Thus, a theoretical model is developed which connects social media success factors to innovation and can be applied in future studies. Overall, the theoretical section emphasises the facilitator role of social media for co-creation methods that, in turn, lead to innovation.

The empirical investigation of the concepts was not satisfactory due to several limitations that are discussed in 7.3. However, empirical contributions include the first application of Kaushik's (2012) engagement rates in practice, as well as their advancement through the scaling by fans to make them comparable among firms. This study statistically showed that a higher *scaled conversation rate* is meaningful for product innovation, highlighting the importance of qualitative user engagement.

Overall, the rather exploratory approach of this thesis provides indications for future studies by developing a multitude of research directions explained in 7.3.

7.2. Managerial Implications

In addition to the theoretical contributions, this study also has practical significance for managers. Most importantly, the understanding of social media's innovation implications can be improved. While most social media activities are currently focused on aspects of marketing and customer relationship management, they are seldom applied in the

innovation domain. This study enhances the firms' awareness of potential innovation benefits stemming from social media, leading to a more comprehensive view on social media. The presented research further implies that social media is a constantly evolving phenomenon, taking various forms and including different platforms, with an overall increase in the user base. It is therefore necessary for firms to go with this trend if they want to keep in touch with their users, and not only understand their wishes and needs, but capitalize on their ideas to ultimately maintain a competitive advantage.

Furthermore, this study provides four success factors for social media involvement in the innovation process. Thus, managers' attention is called to aspects of measurement, strategy, firm culture and possible social media supported co-creation methods. These methods developed in the theoretical background section of this study can be applied by firms to improve their understanding, development and successful implementation of social media for innovation.

The regression analysis showed that the *scaled conversation rate* is positively related to product innovation, thus highlighting the importance of user comments and qualitative engagements on social media sites. Managers have to take action to improve the communication with users by providing meaningful content to engage their customer base, so that their needs and wishes can be understood. At the same time, the positive impact of the *scaled conversation rate* implies that it is not the number of posts, but the number of comments that is most important for better engagement. Firms therefore have to avoid posting irrelevant information, as this can quickly be perceived as spam and drive down engagement.

Moreover, the development of the *scaled engagement rates* over time depends also on Facebook algorithms that impact viewing patterns for the posts. Facebook fan pages that receive low engagement will consequently be rated less attractive by these algorithms, reducing the number of users that can be reached. Hence, the importance of optimizing social media activities to reflect the algorithms' preferences is emphasised, as well as prudent social media management. Ideally, firms should use social media tools that facilitate the assessment of their social media activities by providing statistics about different forms of engagement, as well as suggestions for improvement.

7.3. Limitations and Future Research

This study is subject to several limitations which can aid in explaining why not all hypotheses could be empirically supported, and which underline that the results should be

interpreted with care. The limitations are presented in the following, along with corresponding possible future research directions.

a) Endogeneity

The most severe limitation of this study concerns the issue of endogeneity, caused by possible reversed causality between the dependent and independent variables. This would be the case when it is not social media activity and strategy influencing the innovative output of a firm, but the firm's innovation developments impacting its social media use and conceptualisation. A highly innovative firm might be more successful in using social media as an additional marketing channel through which it can reach a large base of potential buyers. The small sample size and the cross-sectional rather than longitudinal nature of the study add to this problem. However, in the logit regression, the control variable *existence of a Facebook fan page* did not have a significant impact on the probability of developing a product innovation. This fact slightly reduces the endogeneity issue for this study.

With panel data linking social media activity to innovation, the relation between both factors could be studied over an extended period of time, revealing the actual causality and possibly providing a remedy for the endogeneity problem. Furthermore, the dependent variable product innovation could be substituted by an instrumental variable which does not correlate with the predictors used in the study, thereby lessening possible endogeneity.

b) Sampling

Besides this aspect, issues of sampling and methodology reduce the generalizability of the results. The sample was limited to small and medium sized firms in Berlin in certain sectors. Thus, the results cannot be generalised to larger firms, as their social media use and its influence on firm innovation differs (see 3.1). Possibly, the development of a social media strategy as investigated by hypothesis 2 holds less importance for SMEs than for larger firms, as the SMEs internal firm processes are less formalised. Therefore, strategy effects might be different for enterprises with more than 250 employees.

Furthermore, social media use varies by sector; it became apparent that firms operating in the ICT sector and on a B2C basis use Facebook more than companies operating in the utilities or government sector. The findings can therefore not be applied to sectors not considered in this thesis. In addition, the study only regarded firms in Berlin. Thus, the results were found for a German metropolitan area, and cannot be generalised for more rural regions or other cultures in which Internet and social media adoption by both firms and users potentially differ.

In addition, the sub-sample of firms with an active Facebook fan page was especially small, as it contained only 33 firms. As described in 4.2.2, large differences in the number of fans between these firms existed. Most firms had a relatively low count of fans for their page, which might make it less likely that the firm attempts to engage their users for innovation. However, the research approach followed in this thesis could serve as a basis for a similar study involving a larger number of firms across more industries and regions, which might lead to even more meaningful results.

c) Innovation Measure

A further limitation of the study is the utilisation of only one binary dependent variable to capture innovative output, *product innovation*. The binominal distribution disallowed an analysis of different levels of innovation, such as the number of product innovations that had been developed. Additionally, market success with the product innovations was not included.

The ZEW Innovation Survey provides further variables that could be considered for a more differentiated analysis in the future, such as other types of innovation (process, organisational, marketing), innovation intensity, types of and success with innovation partnerships, or planned innovation activities (Rammer, Aschhoff, Crass, Doherr, Hud, Köhler et al., 2014). As explained in 3.3.1, marketing innovations captured by the ZEW Innovation Survey possibly reflect the establishment of a social media presence. A more detailed longitudinal study could focus on understanding to which degree social media constitutes a marketing innovation.

Furthermore, the ZEW Innovation Survey data did not provide information on the different stages of the innovation process, as only the outcome of a product innovation was measured. However, social media can provide meaningful input at all stages of the innovation process (Adorf, 2014; Hoyer et al., 2010; Kärkkäinen et al., 2010; Piller et al., 2010). The set-up of this study also did not take a time lag in the innovation development into account. As the innovation process involves multiple steps, innovation development requires several months or years from the initial idea to commercialisation. However, this study evaluated Facebook activity *and* product innovation in 2012, as only data from the ZEW Innovation Survey 2012 was available during the study's execution in 2014. It is conceivable that an idea generated via a social media channel is introduced into the market a few years later. Therefore, a longitudinal study investigating the actual flow of communication between users and firms concerning specific innovations could capture such time lags.

d) Scaled Engagement Rates

As for the independent variables used in the logit regression analysis to test H1a, H1b and H1c, the three *scaled engagement rates* were gathered manually. While this was feasible for this small sample size, a larger and more representative study should acquire an appropriate social media tool which might also aid in collecting additional data such as the development of engagement over time.

Furthermore, the *scaled engagement rates* considered only the quantity of likes, comments, and shares per post, but not their quality. For the comments, no differentiation between the content has been made; thus, it has not been taken into account whether it was a general remark, a joke, a question, or actual feedback or input concerning the firm's products. Likewise, in the data collection process, no differentiation between the types of posts was made. All posts were considered, ranging from request for feedback to advertisements for the firm's products, and from recruiting calls to holiday greetings. Hence, it was not captured whether the engagement actually concerned the firm's innovation activities. Using techniques such as sentiment mining or linguistic detection software as described in 2.2.2, a large amount of data can be efficiently analysed to understand the content of posts and comments.

Additionally, the type of post influences the weighing in Facebook's ranking algorithms (see 3.1.2); that is, media-rich content such as photos or videos will be valued higher by Facebook and thus seen by a larger number of users. A future study could differentiate between post type and content to capture discrepancies in generated user engagement for each of them.

Moreover, the research design did not involve an assessment of the extent to which the whole user base was engaged, rather than only a selection of fans. Quite possibly, a small group of fans repeatedly liked, commented on and shared the posts. Although their individual engagement might be higher, the pool of possible ideas that can be generated is smaller, thus arguably limiting the innovation input that a firm can receive via Facebook. In a future study, using an adequate software tool, the actual number of engaged users could be captured, evaluating whether differences in this number impact innovation.

A further methodological issue in this thesis is the estimation of Facebook fans in 2012 which was carried out by the author. This very rough approximation might have not led to completely realistic values for the three *scaled engagement rates*, impeding correct regression analysis. Future longitudinal research could ensure that the actual number of fans is collected by constantly gathering data.

e) Survey Design

Concerning the online survey that has been conducted to test H2, H3 and H4, the small sample size of 16 respondent firms also constitutes a problem hindering generalisation, especially as these firms formed two even smaller groups of innovators and non-innovators that were then compared. The companies in the innovator group were small firms; six of seven firms had less than 20 employees, and only one had between 20 and 49 employees. In contrast, four of nine non-innovator firms had more than 20 employees. Therefore, the results might be distorted, as both dependent and independent variables for all hypotheses are influenced by the firm size.

All questions posed in the survey were developed by the author. Although they were all based on a thorough literature review, the reliability of the items had not been validated in another study yet.

For hypothesis 3, the openness culture was measured with only one question, asking for the personal impression of the participant. Additional questions including other, possibly more comprehensive items might be preferable to truly understand how advanced the firms' innovation processes are in terms of including different stakeholders, as well as utilizing new technologies. A future research direction thus concerns the evolution of Enterprise 2.0, in which social media is used internally as well to promote efficiency and innovation (McAfee, 2006).

The analysis of hypothesis 4 concerning the application of innovation-focused methods via Facebook was restricted by the small number of firms that had implemented such measures. In the future, the innovation impact of innovation-focused social media strategies should be studied with a larger sample. Another time-related distortion exists for hypothesis 4, as the participants were asked whether they *currently* used one of the co-creation methods via Facebook, i.e. referring to 2014. Linking these answers with the innovation data from 2012 is not ideal, but this approach was chosen as the alternative (asking firms for the application of those strategies in 2012) would have most likely not yielded any meaningful results. Again, a longitudinal study or at least the simultaneous collection of Facebook and innovation data could provide a solution for this problem.

Moreover, the survey assessed the firm's Facebook strategy, openness culture and use of co-creation methods via Facebook by posing mostly closed questions with a limited choice of answers. This might have impeded a more in-depth understanding of the participants' activities. Although additional free text answer fields were given for many questions, they were hardly used.

A further problem might be self-report bias which occurs when respondents "tend to under-report behaviours deemed inappropriate by researchers" (Donaldson & Grant-Vallone, 2002, p. 247) in order to represent them or their firm in the best possible light. The participants had been assured of the survey's confidentiality and anonymised analysis, which should have helped to reduce the self-report bias. However, the answer option *no indication* was selected several times, possibly reflecting the respondent's reluctance to report undesirable results. Donaldson and Grant-Vallone (2002) propose to use at least two data sources to overcome self-report bias. A validation with a second source was not possible. In addition, it is conceivable that the employees answering the survey did not have sufficient knowledge to accurately reflect the firms' actual strategy development. The survey was sent to the people who were currently in charge of the Facebook activities; they might however not have been responsible at the time of launch.

f) Choice of Social Media Platform

Lastly, the results only refer to the social network Facebook and can thus not be generalised for all social media. During the literature research and data collection, it became evident that other social media are relevant for firms as well, such as Twitter, Pinterest, YouTube, Google+, LinkedIn or Xing, as well corporate blogs. The use of these media as a possible influencing factor on innovation has not been taken into account; neither have been potential interaction effects between different types of employed social media. As the customer input generated on different social media types differs (Hinz, Schulze, & Takac, 2014), a future research should compare innovation impacts of several platforms. The research model developed in this thesis could thus be verified in another setting including one or more other social media platforms and a larger sample.

8.   Conclusion

The aim of this thesis was to understand whether social media can act as a facilitator for innovation. The theoretical section gave an overview of relevant literature, from which co-creation methods that can be supported by social media were derived, as well as success factors for social media use in innovation processes. The resulting theoretical model provides a conceptual approach towards the facilitating role of social media for firm innovation.

The empirical analysis showed that the *scaled conversation rate* of a Facebook fan page, i.e. the number of comments per post per fan, does indeed have a positive effect on innovation. Further, comparing the survey answers of innovators and non-innovators, it became apparent that more innovators had derived a social media strategy, providing an indication that a thought-out approach to social media aids in the development of innovations; thus, these factors suggest that using social media can facilitate innovation. However, the same could not be shown for the openness of the firm culture and the application of co-creation methods; supposably because numerous limitations impeded drawing meaningful conclusions, ranging from endogeneity to small sample size, and from time lags in capturing the variables to the measures themselves and the focus on Facebook only. Future studies could apply the developed research model to other social media platforms to go beyond the use of only one social network for a more comprehensive analysis of different social media types, ideally including a larger sample of firms.

Nevertheless, the theoretical and empirical findings of this thesis indicate that social media has to be perceived as more than a soft, nice-to-have marketing channel, as it can actually impact innovation, and thus ROI. Most importantly, the way *how* firms employ social media determines its effects; engagement of users is crucial and can only be achieved through sincere social media management that is not solely responsive, but pro-active in integrating consumers in firm processes. Additionally, firms should make use of the characteristics of different social media platforms for different tasks. While conversations and polls are suitable for Facebook, other more participatory co-creation methods can be applied through different sites, depending on the firms' needs.

Overall, firms should not overlook the benefits that social media can generate for innovation, but consider the integration of their user base to stay abreast of the competition in an increasingly connected world.

9.   Appendices

Appendix 1: Economic Sectors According to NACE Classification

Section	Title	Divisions
Economic sectors included in the sample		
Section	**Title**	**Divisions**
C	Manufacturing	10 – 33
F	Construction	41 – 43
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	45 – 47
H	Transportation and storage	49 – 53
I	Accommodation and food service activities	55 – 56
J	Information and communication	58 – 63
K	Financial and insurance activities	64 – 66
L	Real estate activities	68
M	Professional, scientific and technical activities	69 – 75
N	Administrative and support service activities	77 – 82
P	Education	85
Q	Human health and social work activities	86 – 88
R	Arts, entertainment and recreation	90 – 93
Economic sectors not included in the sample		
Section	**Title**	**Divisions**
A	Agriculture, forestry and fishing	01 – 03
B	Mining and quarrying	05 – 09
D	Electricity, gas, steam and air conditioning supply	35
E	Water supply; sewerage, waste management and remediation activities	36 – 39
O	Public administration and defence; compulsory social security	84
S	Other service activities	94 – 96
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	97 – 98
U	Activities of extraterritorial organisations and bodies	99

Annotation: Even though the manufacturing and construction sectors do not belong to the economic sectors with prevalent social media use, they included divisions related to textiles and food and drink, and civil engineering, respectively, which constitute services and B2C firms.

Appendix 2: Questionnaire of the Online Survey

Construct	Question / Item	
Introductory Questions		

Introductory Questions	Does your company run a Facebook fan page?
	   ○ Yes
	   ○ No	

	When did your company launch the Facebook fan page? ○ Month / Year	

	Does your company employ a social media manager?
	   ○ Yes, he/she is working full time on our social media activity.
	   ○ Yes, he/she is working on our social media activity besides other responsibilities.
	   ○ No, no employee is responsible for social media.	

Facebook Strategy (H2)		

Specificity of Facebook Strategy	Did your company develop a Facebook strategy?
	   ○ Yes, before launching the Facebook fan page.
	   ○ We began without a strategy, but developed a strategy while the Facebook fan page was already running
	   ○ No, we launched the Facebook fan page without a strategy and have not developed a strategy since.
	   ○ No indication	

	[If yes:] How specific was your company's Facebook strategy?
	   ○ We developed a strategy involving specific processes and goals.
	   ○ We developed a strategy involving general processes and goals.
	   ○ We developed a rather general direction
	   ○ Other:
	   ○ No indication	

Goal Setting	Which of the following goals did your company set for the Facebook activities?	
	Marketing	○ Promoting the company ○ Increased brand awareness ○ Reaching new target groups ○ Special marketing / sales promotions ○ Special product offerings for customers
	Customer relationship management	○ Development of (new) customer relations ○ Offering special (new) customer service

	Human resources	o Recruiting
	Innovation	o Getting customer feedback o Getting customer input for new products or improvements *before* the development phase o Getting customer input for new products or improvements *after* the development phase
	Additional Goals (free text field)	o Other:
	Did your company reach that [selected] goal? o 5 point Likert scale: Completely (1) to Not at all (5)	

Open Innovation Culture (H3)

Degree of Openness	In your opinion, is your firm open for ideas and suggestions from users which reach you via social media channels? o We have a very open innovation culture. Ideas received via social media are often considered. o We have a relatively open innovation culture. Ideas received via social media are sometimes considered. o We prefer to develop ideas internally. o No indication.

Use of Co-Creation Methods via Facebook (H4)

Passive Collaboration Methods	Does your firm analyse feedback or suggestions that users post on your Facebook brand page? o Yes o No o No indication
	[IF YES:] Does your firm conduct analyses to understand user profiles and the composition of your community? o Yes o No
Use of Social Media Tools	Does your company use social media tools to evaluate feedback and ideas? o Yes, we use one or more social media tools. o No, we do not use any social media tools. o No indication

Active Co-Creation Methods: Current Use	Which of the following methods does your firm <u>currently</u> use to integrate Facebook fans into the development of products? **Polls**: We conduct polls on our Facebook fan page to learn about user opinions concerning new developments. **Conversations**: We initiate conversations on our Facebook fan page to learn about user opinions concerning new developments. **Ideas competitions**: We invite users to ideas competitions via our Facebook fan page. **Problem solving in Innovation Communities:** We distribute problems to communities of users to solve. **Participatory Design**: We integrate users in the whole innovation process via our Facebook page, i.e. we involve them during problem definition, development and evaluation.
Active Co-Creation Methods: Future Use	Which of the following methods will your firm use <u>in the future</u> to integrate Facebook fans into the development of products? **Polls**: We will conduct polls on our Facebook fan page to learn about user opinions concerning new developments. **Conversations**: We will initiate conversations on our Facebook fan page to learn about user opinions concerning new developments. **Ideas competitions**: We will invite users to ideas competitions via our Facebook fan page. **Problem solving in Innovation Communities:** We will distribute problems to communities of users to solve. **Participatory Design**: We will integrate users in the whole innovation process via our Facebook page, i.e. we involve them during problem definition, development and evaluation.
Concluding Questions	
Concluding Questions	In which department and on which position do you work in your company? [Free text field]
	Do you have any additional comments or remarks concerning this study? [Free text field]

Appendix 3: User Facebook Engagement Data for the 33 Firms on Facebook

Firms	Fans Dec. 2012 (estimate)	Fans Aug. 2014 (actual)	Posts 2012	Likes 2012	Comments 2012	Shares 2012	Applause Rate: Likes/post	Conversation Rate: Comments/post	Amplification Rate: Shares/post	Scaled Applause Rate (*100)	Scaled Conversation Rate (*100)	Scaled Amplification Rate (*100)
1	13.471	15.879	37	7.999	1.065	1.009	216,19	28,78	27,27	1,60	0,21	0,20
2	5.295	10.590	45	523	88	31	11,62	1,96	0,69	0,22	0,04	0,01
3	5.171	13.954	600	4.216	1.391	916	7,03	2,32	1,53	0,14	0,04	0,03
4	2.691	3.904	58	1.464	113	160	25,24	1,95	2,76	0,94	0,07	0,10
5	1.403	5.612	109	309	41	17	2,83	0,38	0,16	0,20	0,03	0,01
6	1.375	5.501	177	1.173	115	427	6,63	0,65	2,41	0,48	0,05	0,18
7	1.195	2.389	116	386	71	4	3,33	0,61	0,03	0,28	0,05	0,00
8	1.039	2.078	86	1.154	182	1	13,42	2,12	0,01	1,29	0,20	0,00
9	860	4.475	169	1.175	140	142	6,95	0,83	0,84	0,81	0,10	0,10
10	711	1.003	114	607	115	6	5,32	1,01	0,05	0,75	0,14	0,01
11	589	1.177	53	220	26	13	4,15	0,49	0,25	0,71	0,08	0,04
12	559	609	125	206	408	16	1,65	3,26	0,13	0,29	0,58	0,02
13	439	1.673	60	342	33	19	5,70	0,55	0,32	1,30	0,13	0,07
14	429	858	102	558	55	25	5,47	0,54	0,25	1,28	0,13	0,06
15	191	574	64	184	16	7	2,88	0,25	0,11	1,50	0,13	0,06
16	180	301	69	144	11	7	2,09	0,16	0,10	1,16	0,09	0,06
17	150	174	266	167	19	10	0,63	0,07	0,04	0,42	0,05	0,03
18	141	281	127	272	37	8	2,14	0,29	0,06	1,52	0,21	0,04
19	137	411	42	16	0	0	0,38	0,00	0,00	0,28	0,00	0,00
20	126	252	37	81	11	0	2,19	0,30	0,00	1,74	0,24	0,00
21	110	219	29	104	29	1	3,59	1,00	0,03	3,28	0,91	0,03
22	105	210	30	146	51	4	4,87	1,70	0,13	4,63	1,62	0,13
23	95	189	20	24	0	0	1,20	0,00	0,00	1,27	0,00	0,00
24	86	172	81	97	19	4	1,20	0,23	0,05	1,39	0,27	0,06
25	85	256	34	162	29	1	4,76	0,85	0,03	5,58	1,00	0,03
26	72	143	147	118	4	15	0,80	0,03	0,10	1,12	0,04	0,14
27	62	248	97	431	48	115	4,44	0,49	1,19	7,17	0,80	1,91
28	36	109	58	52	11	5	0,90	0,19	0,09	2,47	0,52	0,24
29	32	97	40	58	34	4	1,45	0,85	0,10	4,48	2,63	0,31
30	32	96	14	57	3	6	4,07	0,21	0,43	12,72	0,67	1,34
31	27	109	20	93	6	3	4,65	0,30	0,15	17,06	1,10	0,55
32	17	34	5	0	0	0	0,00	0,00	0,00	0,00	0,00	0,00
33	10	40	13	7	0	0	0,54	0,00	0,00	5,38	0,00	0,00

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Declaration of Authorship

I, Friederike John, hereby certify that this thesis and the work presented in it is entirely my own, unless stated otherwise. No other person's work has been used without due acknowledgement in this thesis. All references and verbatim extracts have been quoted, and all sources of information have been properly acknowledged.

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