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Working Paper

Let the user speak: Is feedback on Facebook a source of firms' innovation?

ZEW Discussion Papers, No. 17-015

Provided in Cooperation with:

ZEW - Leibniz Centre for European Economic Research

Suggested Citation: Bertschek, Irene; Kesler, Reinhold (2018) : Let the user speak: Is feedback on Facebook a source of firms' innovation?, ZEW Discussion Papers, No. 17-015, Zentrum für Europäische Wirtschaftsforschung (ZEW), Mannheim

This Version is available at:

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Let the User Speak:

Is Feedback on Facebook a Source of Firms' Innovation?[§]

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First Version: March 2017

This Version: May 2018

Abstract

Social media open up new possibilities for firms to exploit information from various external sources. Does this information help firms to become more innovative? Combining firm-level survey data with information from firms' Facebook pages, we study the role that firms' and users' activities on Facebook play in the innovation process. We find that firms' adoption of a Facebook page as well as feedback from users are positively and significantly related to product innovations. Analysis of the content of Facebook posts and comments reveals that firms are more likely to introduce product innovations if they actively ask for feedback, while only negative user comments are positively and significantly related to innovation success. These results withstand a large set of robustness checks, including estimations that take potential endogeneity of firms' Facebook use into account.

JEL classification: D22, L23, O31

Keywords: social media, knowledge sources, product innovation

[§]Support from the 7th European Framework Program (Grant Agreement no. 320203) is gratefully acknowledged. We are grateful to Chris Forman, Ulrich Kaiser, Jenny Meyer, Peter Winker and Michael Zhang for their valuable comments. We thank the participants of the CRE8TV workshops in Milan and Manchester, the SEEK digital economy workshop in Turin, the research seminars at the University of Ulm, University of Giessen, University of Münster and University of Kassel, as well as the participants of the annual conferences at IIOC 2016 in Philadelphia, EARIE 2016 in Lisbon and the German Economic Association 2016 in Augsburg for their helpful comments. We thank Niklas Gösser and Florian Schoner for their outstanding research assistance and Erin Goldfinch for proof reading the paper. An earlier version of this paper is available as CRE8TV Project Deliverable DEL: 4.2.4-R titled "Social Media as a Source of Creativity: Hype or a Serious Strategy?". For further information on other projects by these authors see www.zew.de/staff_ibe and www.zew.de/staff_rke as well as the ZEW annual report under www.zew.de/en.

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1 Introduction

In today's information-rich environment, a firm's competitive advantage is increasingly determined by the leverage of external knowledge (Tambe et al., 2012). Social media including online social networks and microblogging services, open up new possibilities to exploit this knowledge. As the largest of these platforms, Facebook has more than two billion monthly active users as of the end of December 2017¹ and is also of great importance with respect to the time spent online by the average user (GlobalWebIndex, 2017). Attracted by the opportunity to access a large user base, firms increasingly adopt a social media presence with Facebook being the favourite platform with more than 65 million business pages in the beginning of 2017² (Stelzner, 2017).

While the main purpose of social media is marketing, business surveys show that it also relates to other firm operations such as receiving customer feedback in order to improve products and services (German Federal Statistical Office, 2017). Accordingly, it provides faster and less costly access to knowledge, thereby facilitating product development and innovation due to users' input. External information from social media can be utilised by firms across all innovation stages ranging from idea generation contests and user feedback through comments or polls to entire co-creation campaigns (Roberts and Piller, 2016).

Examples include Gillette launching the very first product for assisted shaving based on feedback inferred from social media³, Tesla improving the company's app based on CEO Elon Musk reading a complaint from a customer on Twitter⁴, and Airbnb CEO Brian Chesky asking on Twitter what the company should launch in 2017⁵. Beyond anecdotal evidence of sourcing information from social media users, there is, to the best of our knowledge, no large-scale empirical evidence on whether or not firms' external focus in the form of a social media presence significantly enables corporate innovation.

In this paper, we examine the role that social media, specifically Facebook, plays for firms' innovation activity, i.e. the realisation of newly developed or significantly improved products

¹<https://newsroom.fb.com/company-info>, accessed on 23 April 2018.

²<https://venturebeat.com/2017/04/10/facebook-has-more-than-5-million-advertisers-with-75-from-outside-the-u-s/>, accessed on 23 April 2018.

³<http://www.pgnewsroom.co.uk/blog/innovation-en/gillette-treo-first-product-ever-designed-assisted-shaving>, accessed on 23 April 2018.

⁴<https://www.inc.com/justin-bariso/elon-musk-takes-customer-complaint-on-twitter-from-idea-to-execution-in-6-days.html>, accessed on 23 April 2018.

⁵<https://twitter.com/bchesky/status/813219932087390208>, accessed on 23 April 2018.

or services ('product innovation'). We use a unique and rich data set of 2,932 German manufacturing and service firms collected in 2015 and supplemented by information from firms' Facebook pages available from 2010 until 2013. Combining survey data with web-crawled data allows us to not only take into account a huge set of firm characteristics relevant for innovation output but also to conduct a content analysis of both firm and user activity on Facebook. Moreover, in contrast to studies focussing on large listed companies, our data set includes a large share of small and medium-sized enterprises which fairly accurately reflects the structure of the German economy. As a rather inexpensive communication tool, social media might be particularly relevant for small and medium-sized enterprises.

We find that the probability to introduce product innovations is positively and significantly correlated with firms' adoption of a Facebook page and with user activity on this page. Analysing the content of posts and comments on Facebook reveals that firms actively seeking for feedback from users are significantly more innovative. Surprisingly, negative user comments turn out to be significant determinants of firms' innovation output. A large set of robustness checks supports these results. These checks comprise considering Facebook activity from earlier periods, employing different social media measures, controlling for further sourcing channels and taking the persistence of firms' innovation behaviour into account. Moreover, an instrumental variable approach taking into account the potential endogeneity of firms' Facebook use underpins the credibility of our results.

Thus, a firm's Facebook presence and the information from users is particularly relevant for introducing product innovations. However, simply adopting a Facebook page and posting generic content does not necessarily mean that firms are benefitting from the knowledge of the user base. Firms should rather use this social media channel strategically by actively encouraging users to leave valuable feedback that can be then translated into improved products and services or into developing new ones. The quality of this user feedback is crucial for the innovation outcome and, in particular, firms should consider negative user comments.

2 Related Literature

The starting point of our analysis is the resource-based view of the firm suggesting that firms are conceptualized by a unique set of heterogeneous resources with a managerial role to determine the optimal allocation and application of resources in order to achieve a competitive advantage (Penrose, 1959). Based on this approach, Grant (1996) introduces the knowledge-based view of the firm with knowledge as the strategically most important resource, embodied in different individuals within the firm. The firm's role is to integrate, coordinate and apply this specialist knowledge to the development of products and services, with the integration outcome corresponding to the organisational capability. However, relevant knowledge might not exclusively reside with individuals inside the firm, but also outside the firm's boundary, as suggested by Chesbrough (2003). He argues that, according to the open innovation paradigm, firms' boundaries open up to include external ideas in conjunction with internal ideas for innovation.

According to Dahlander and Gann (2010), a firm's openness can be classified into inbound and outbound innovation strategies as knowledge going into or out of the firm, respectively, which is further differentiated according to pecuniary and non-pecuniary interactions. For the case of inbound strategies, Dahlander and Gann (2010) distinguish between acquiring and sourcing from external resources, with the latter relating to this paper. Empirical studies mostly based on firm-level data show positive effects of these open innovation practices on firms' innovation performance (see West et al., 2014, and Bogers et al., 2017, for comprehensive reviews). However, Dahlander and Gann (2010) argue that studies so far do not sufficiently account for new ways of collaboration with external actors facilitated by information and communication technologies (ICT). Moreover, as pointed out in the review articles by West and Bogers (2014) and by Randhawa et al. (2016), the role of individuals or users as a source of innovation receives less attention from open innovation research.

Two further strands of literature are addressed by our study comprising the literature on user innovation and on firms' use of social media for inducing users' ideas. The former strand of literature provides empirical evidence on users of a product or service themselves being the innovator as they have superior information about needs and preferences as well as derive own benefits from their innovation (Baldwin and von Hippel, 2011; Bogers et al., 2010), with Chatterji and Fabrizio (2014) as a more recent empirical study on physicians as innovators for medical device companies. The latter strand of literature comprises research on online user

innovation communities of companies such as My Starbucks Idea or Dell IdeaStorm (Bayus, 2013; Gallagher and Ransbotham, 2010; Di Gangi et al., 2010), for which Dong and Wu (2015) find evidence of corporate innovation (and business value) based on user ideas.

Aral et al. (2013) argue that social media in general transform firm boundaries, thereby creating a new way to interact with customers. Accordingly, studies focus on marketing outcomes such as user engagement based on firms' social media content and on the targeting of this content (Lee et al., 2016; Miller and Tucker, 2013). Consumers' purchase expenditures or shopping visits are positively affected by targeted content and user engagement (Goh et al., 2013; Rishika et al., 2013). However, the aforementioned advantages of social media not only affect marketing outcomes, but also might increase firm value more generally. Because of the real-time content produced by users, social media can even serve as a predictor of firm value (Luo et al., 2013). Firms' adoption and use of social media might affect firm performance through user engagement and user attention (Chung et al., 2015). The paper by Gans et al. (2017) refers to Hirshman's (1970) book "Exit, Voice, and Loyalty" and analyses Twitter as a social media platform for customers' voice. As Gans et al. (2017, p. 6) point out "firms are increasingly migrating their customer service activities to social media and these platforms are responding by incorporating dedicated tools for customer service purposes. The dramatic reduction in the cost of voice that social media provides suggests that voice is likely to become an increasingly important phenomenon in many markets". In their study, 'voice' is analysed in the sense of customers' complaints about shocks in airline service quality such as significant delay. In our study, we look at 'voice' more generally and across several industries and relate it to firms' product innovation output.

In order to fully reap the benefits from user-generated information on social media a firm may need complementary data analysis skills (Hitt et al., 2016). This finding implies that absorptive capacity (Cohen and Levinthal, 1989, 1990) is also necessary in the case of social media (Culnan et al., 2010). This is also in line with Aral et al. (2013), who state that it is necessary to account for organisational characteristics such as the interdepartmental coordination when looking at the transformative impact of social media platforms. As a consequence, engaging with customers on social media potentially creates a new channel for (open) innovation. However, there is so far only small-scale evidence of a positive relationship for firms' social media presence and innovation (Roberts et al., 2016; Mount and Garcia Martinez, 2014).

On the basis of the aforementioned literature, we investigate the role of social media for corporate innovation, thereby differentiating between firms' and users' activities. Due to its high proliferation rates, we focus on Facebook as the social media platform of interest. We intend to fill existing gaps in the literature both by conducting research on social media with respect to innovation and by contributing to the discussion on open innovation concerning the role of users.

3 Analytical Framework

Following the evidence provided by the literature outlined above, we employ the concept of the knowledge production function introduced by Griliches (1979) and employed in many empirical (open) innovation studies (see for instance Laursen and Salter, 2006, as an example closely related to our study). Accordingly, we assume that a firm's innovation output is determined by both internal as well as external knowledge sources. Therefore, a firm's innovation output (INNO) may depend on knowledge sources directly related to the innovation process, such as internal and external research and development (R&D). Moreover, the firm's social media presence (SM) is considered a medium for externally sourcing ideas and feedback from customers that might help the firm to further improve its products and services or to develop new ones. In our analysis, measures of social media activity comprise the firm's adoption of Facebook, the activity by the firm and the activity by the users on Facebook. Since quantitative Facebook measures cannot inform us about the exact purpose of firms' social media use and about users' actual input, we apply a qualitative analysis of the content provided by firms and users allowing us to dig deeper into the actual activities on firms' Facebook pages. Measures of Facebook activities might also reflect firms' technical affinity and openness more generally. Therefore, in the estimations we control for firms' information technology (IT) intensity, which is determined by the use of enterprise resource planning (ERP) software and the percentage of employees working predominantly with a personal computer (PC). Further control variables (X) account for firm size, qualification and age structure of the workforce, industry-specific effects and firms' export status. Hence, the probability of firm i introducing an innovation can be written as:

$$Pr[INNO_i = 1|x] = F(\beta_{R\&D}R\&D_i + \beta_{SM}SM_i + \beta_{IT}IT_i + \beta_{\mathbf{X}}\mathbf{X}_i + u_i) \quad (1)$$

including an i.i.d. normally distributed error term u_i . A linear probability model treating INNO as a continuous variable is applied and estimated by ordinary least squares (OLS).

In general, firms may innovate in terms of significantly improving existing products and services or in terms of developing new products and services.⁶

We expect Facebook activity to play a significant role for realising a product innovation. In particular, as a first main hypothesis (H1), we expect that the adoption of a Facebook page by a firm as well as the quantity of Facebook activity both by firms and users matters. The more posts a firm puts on its Facebook profile, the more likely it can start a dialogue and interact with users. The more comments users provide, the more likely this input contains relevant information that might be helpful for improving products and services. Thus, we specify the following hypotheses:

H1(a): For a firm, having a Facebook page is positively and significantly related to realising a product innovation.

H1(b): The number of posts by the firm on its Facebook page plays a significant role for realising product innovations.

H1(c): The number of user comments on the firm's Facebook page plays a significant role for realising product innovations.

Both firms and users might engage in social media in various ways. Therefore, it depends on the purpose for which firms use social media and on the quality of users' feedback whether or not firms can realise product innovations. In the case of Facebook, it is unclear whether firms use it with the purpose of gathering information or for marketing, for example. Similarly, it is unclear, whether users provide feedback that is helpful for improving products and services, or whether the feedback is generally not informative. Therefore, our second main hypothesis (H2) is that the role of Facebook activity for product innovation depends on the content and its quality. More precisely, we specify the following two hypotheses:

H2(a): Regarding firm activity, it is important to actively encourage users to give feedback in order to realise product innovations.

H2(b): For user activity, it is the length and the sentiment of user comments that play a role for product innovation.

⁶This definition follows the Oslo Manual (OECD, 2005) and corresponds to the definition used in the Community Innovation Survey, see also section 4.1.

In order to test for the first set of hypotheses, we analyse whether a firm's Facebook presence as well as the amount of firm posts and user comments are in fact specific determinants of product innovation success. The second set of hypotheses is tested by employing a content analysis of both user activity and firm activity on firms' Facebook pages in order to verify whether firms actually use Facebook to actively source information from users as well as to see whether length and sentiment of user activity matter.

In order to check the robustness of our results, we run a large set of further regressions: (i) Facebook activity dating back further than 2013, to the period 2010 to 2012, is considered for a better match with the corresponding period covering the innovation measure and to account for lags in the innovation process. (ii) Both customer attention and firm attention are considered as additional explanatory variables to control for further sourcing channels and to account for firms' openness. (iii) Several alternative measures of social media activity reflect the interaction between firms and users. (iv) Path dependency of innovation implying that success breeds success (Peters, 2009; Flaig and Stadler, 1994) is taken into account by including the lagged innovation success approximating a cumulation of prior innovation activities as another explanatory variable for a subsample of firms. Finally, (v) an instrumental variable approach is employed to consider the endogeneity problem resulting from reverse causality with innovative firms being more likely to adopt new technologies such as social media and having a more active presence of both the firm and users on social media, than less innovative firms. Identification relies on a combination of two variables indicating a firm's business-to-consumer (B2C) focus (see also section 4.4). Firms operating in the end consumer market, as opposed to business-to-business (B2B) firms, are more likely to communicate with their customers by means of an external social media platform such as Facebook. Hence, a variable indicating the firm's market focus predicts the likelihood of a Facebook presence and its activity, which has also been suggested by prior research and business surveys (Culnan et al., 2010; Stelzner, 2017). At the same time, firms being more active in the B2C market do not systematically differ from B2B firms with respect to their innovative output.

4 Data and Measures

The data basis used for the empirical analysis is the 2015 wave of the ZEW ICT survey, a business survey carried out by the Centre for European Economic Research (ZEW).⁷ The sample is stratified according to 17 manufacturing and service sectors and three size classes with respect to the number of employees. The data set comprises 4,510 firms located in Germany. Detailed information on the use of ICT, innovation activity, size, attributes of employees, and many further firm characteristics are included. After cleaning the data and taking account of item non-response, the estimation sample is reduced to 2,932 observations.⁸

4.1 Innovation

The main dependent variable is realised product innovation as a measure of innovation output.

- *Product Innovation Dummy* is measured by a dummy variable indicating whether or not a firm has introduced new or significantly improved products or services to the market between 2011 and 2013.⁹

For a subsample of firms, information on the lagged realisation of a product innovation is available, which is defined analogously and covers the period from 2007 to 2009.

4.2 Social Media

Information on firms' adoption of social media was collected in the 2015 wave of the ZEW ICT survey. Firms were asked whether they use the following social media applications: online social networks, (micro-)blogs, wikis and collaboration platforms.

In order to present a more detailed picture of firms' social media activities and of their interaction with users, we enrich the survey data with external information from the firm-initiated

⁷See Bertschek et al. (2017) for further details. The data is available at the ZEW Data Research Centre (<http://kooperationen.zew.de/en/zew-fdz>, accessed on 23 April 2018).

⁸More specifically, observations are dropped i) in case of item non-response, ii) if the firm is affiliated with none of the considered industries or is in the very heterogeneous industry "Other Manufacturing", iii) has less than five or more than 5,000 employees, or iv) has implausible values for R&D expenditures, IT intensity or investments. Compared to the full sample, the estimation sample does not differ considerably with respect to the stratification criteria as shown in Table 2, implying that observations are missing at random.

⁹The definition follows the Oslo manual (OECD, 2005) and corresponds to the definition used in the European Community Innovation Survey (CIS).

social media profiles on Facebook. A firm can create a corporate profile in the form of a Facebook page providing general information about the company and what is known as a ‘ timeline’ comprising posts by the firm possibly supplemented with a range of media content such as photos, videos or links. Every Facebook user can engage with the firms’ publicly available posts through the like, comment and share features, and this activity is then displayed on the user’s timeline and can be seen by the user’s friends. Moreover, users can write posts on the firm’s timeline directly or mention the firm’s Facebook page in their own posts with similar media content and engagement possibilities.¹⁰

The information regarding a firm’s social media presence on Facebook is obtained for the surveyed firms following the standardised procedure outlined in Appendix 7.1. Based on the profile information, the data of the firm’s Facebook page activity from the year 2013 is collected¹¹ with the assumption that, in the absence of an account, all activity is equal to 0. We make use of the following variables for the firm and user activity on Facebook, for which the information is available for the complete year of 2013¹²:

- *Facebook Dummy* is a dummy variable equal to the value one, if the firm has adopted a Facebook page before 2014.
- *Firm Posts* measures the number of posts by the firm on the Facebook page.
- *Firm Comments* measures the number of comments by the firm replying to its own posts, user posts or other comments.
- *User Posts* measures the number of posts by users on the Facebook page.
- *User Comments* measures the number of comments from users replying to posts from the firm or users, or other comments.

Besides quantitative Facebook measures we have also collected qualitative information on firms’ Facebook accounts. As an initial quality approximation of user input, the average length of user comments is considered.

- *Average User Comment Length* is the average number of characters of user comments.

¹⁰Facebook users can also become fans of the firm’s Facebook page by liking the profile. As a consequence, these users receive the firm’s content in their personal news feed.

¹¹See section 7.1.2 in the Appendix 7.1 for the procedure.

¹²For a series of robustness checks, information on these Facebook variables dating back to the period 2010 to 2012 is additionally retrieved, although a minority of firms had a Facebook page back in 2010 as displayed in Figure 1.

In order to determine whether the sentiment of user activity matters, the German-language dictionary SentiWS (Remus et al., 2010) is used with opinion bearing words weighted within the interval of $[-1,1]$ totalling 15,632 negative and 15,649 positive word forms.¹³ Following data processing¹⁴, every word of a user comment is compared with the dictionary, with the sum of detected weights (of corresponding words) resulting in a score for each user comment.

- *% Negative User Comments* is the proportion of user comments that have a negative sentiment score.
- *% Positive User Comments* is the proportion of user comments that have a positive sentiment score.
- *Ratio Negative/Positive User Comments* is the number of negative comments divided by the amount of positive comments.

Finally, to take into account whether firms actually use Facebook to explicitly source information from users, a qualitative analysis of the firm posts is employed. Therefore, we create a list of 111 specific keywords and their word forms, which indicate that firms are actually interested in user input if mentioned in the firm posts.¹⁵ Each firm post is analysed with respect to engaging keywords resulting in the following variables:

- *Engaging Firm Post Dummy* is a dummy variable that takes the value one if the firm has at least one post containing engaging keywords.
- *% Engaging Firm Posts* is the proportion of firm posts that contain engaging keywords.

4.3 Further Firm Characteristics

Further variables that might be relevant for firms' innovation activity based on previous research are presented in the following.¹⁶ A knowledge source directly related to the innovation process is R&D activity measured by the internal and external R&D expenses. In order to take into

¹³See Schwaiger et al. (2016) for a recent study that uses SentiWS for analysing Facebook pages of German firms.

¹⁴Each user comment is divided into single words, thereby removing special characters, additional whitespace and stop words. Finally, words are converted to lower case and reduced to their stem form.

¹⁵See section 7.1.3 in the Appendix 7.1 for the list of keywords. The list is based on relevant keywords inferred from a random sample of 1,000 firm posts and corresponding synonyms.

¹⁶A detailed explanation of the variables in the order of appearance is provided in Table 1 in the Appendix 7.2.

account the innovation-enabling character of IT (see for example Brynjolfsson and Saunders, 2010), we include two measures of the firm’s IT intensity: the presence of an ERP software and the share of employees using a PC. We consider firm size as another important determinant of innovation activity (see for example Schumpeter, 1942, and Cohen and Levinthal, 1989) and measure it by the number of employees and gross investments. Furthermore, the qualification and age structure of employees are taken into account. They reflect the internal knowledge of the firms and the openness of the workforce towards new technologies. Additionally, firms’ export activity is included as a measure of exposure to international competition, which has been shown to be positively correlated with firm performance (see for instance Wakelin, 1998, and Wagner, 2012). Finally, 17 dummy variables control for industry affiliation.

As a robustness check, a variable from the survey is introduced indicating whether firms actually use the Internet as an information sourcing tool, while another control variable approximates the diffusion of Internet among employees. In order to include further channels of customer attention, a variable is created based on data from the Google search volume for the firm.¹⁷

4.4 Instrumental Variable

Information from users on firms’ social media accounts might help firms to introduce product innovations. However, more innovative firms may also be more likely to adopt new technologies such as social media and more likely to engage in social media. In order to take this potential reverse causality that might result in biased OLS estimates into account, an instrumental variable approach is applied. B2C-focused firms are assumed to be more likely to communicate with customers via external social media platforms such as Facebook, yet the market focus in general does not influence the innovation success. Thus, we construct a measure indicating a firm’s B2C focus, which is assumed to be exogenous and to affect firms’ innovation success only through their social media presence. We thereby follow McElheran (2015) and construct the share of output devoted to private consumption on a NACE 2-digit industry level based on the latest input-output tables published by the German Federal Statistical Office.¹⁸ If this share of output is larger than 30 percent, an industry or the firm belonging to this industry is defined to

¹⁷The R package **gtrendsR** is employed to retrieve the respective search data. Generally, the firm name corresponds to the search keyword, however, for ambiguous firm names, address information is also included. In individual cases variations, abbreviations and brands of the firm are alternative search keywords.

¹⁸<https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/VGR/InputOutputRechnung/InputOutputRechnung.html>, accessed on 23 April 2018.

have a B2C focus (see McElheran, 2015, for a similar procedure). Second, based on the ZEW ICT survey 2015, a B2C dummy variable is generated that takes the value one, if the firm is either completely or at least partially operating in the market for end consumers. As a result, the instrument corresponds to a combination of these two variables indicating a B2C focus:

- *B2C Indicator* is a measure taking the value one if the B2C output share on the industry-level of the firm is above 30 percent and taking the value two if both the B2C output share on the industry-level of the firm is above 30 percent and the firm operates at least partially in the market for end consumers.

5 Results

5.1 Descriptive Statistics

The descriptive statistics in Table 3 show that on average half of the firms in the estimation sample have introduced at least one product innovation. For the firms with information on previous innovation output, 53.9 percent stated in 2010 to have introduced a product innovation. The firm's expenses for R&D take up 5.1 percent of total sales on average.¹⁹ 56.8 percent of the firms employ an ERP software system and about 46.1 percent of the employees predominantly work with computers. The sample mainly consists of small and medium-sized enterprises with an average size of 103.1 employees and gross investments of about one million euro. Nearly a quarter of the firms systematically source information online, whereas on average 57.8 percent of the employees have access to the Internet. Google actually tracks the search volume for only 25 percent of the firms, suggesting that the estimation sample largely contains lesser known firms (figure not presented). This is also evident from the relative search volume of 0.23 for the average firm, which corresponds to a fraction of the benchmark firm.²⁰ 41.1 percent of the firms in the estimation sample are operating at least partially in the market for end consumers, while the average output share transferred to final use by private consumers across industries is 21.3 percent.

¹⁹This corresponds to the R&D shares as measured for instance by data from the German Community Innovation Survey (CIS) (http://www.zew.de/fileadmin/FTP/mip/16/mip_2016.pdf, accessed on 23 April 2018.)

²⁰See Table 1 in the Appendix 7.2 for more information on the benchmark firm.

[TABLE 3 ABOUT HERE]

Table 4 shows descriptive statistics for the firms' social media presence. On average, 46.4 percent of the firms use social media, i.e. at least one out of the four applications given in the survey. The most popular social media applications are online social networks, which are used by 31 percent of the firms in the sample. They are followed by collaboration platforms (21.8 percent), wikis (14.5 percent) and (micro-)blogs (7.8 percent). Table 4 also shows summary statistics for the 605 firms (20.6 percent) of the estimation sample with a Facebook page. Only 487 firms (16.6 percent) had a presence on Facebook before 2013.²¹ The 605 firms have on average 75.3 (145.1) firm posts and 150.6 (254.4) user comments for 2013 (2010-2013), while the average firm writes 12.3 comments and receives 8.5 user posts. The average user comment has 40.6 characters. For the average firm, 6 percent of the user comments are classified negative compared to 34.6 percent being positive, while the ratio of the two measures is 15.9 percent. Nearly three out of four firms write posts containing engaging keywords, while on average 18.4 percent of the firm posts are engaging, thus reflecting that firms are indeed interested in user input on Facebook.

[TABLE 4 ABOUT HERE]

Table 5 compares firms with and without a Facebook page with respect to firm characteristics. Firms using Facebook have a higher rate of product innovators and are more IT-intensive. They are larger²², invest more, have a higher fraction of young and high-skilled employees, are more often exporters and are more likely to be active in the market for end consumers. However, the average expenses on R&D as a share of sales are not significantly different in firms with or without a Facebook page, whereas the findings suggest that Facebook use is positively correlated with innovation output.

[TABLE 5 ABOUT HERE]

As can be seen in Figure 3, the adoption of Facebook is more prevalent in industries which are IT-intensive or B2C-focused, such as media services or retail trade, with adoption rates of 37.8

²¹88.1 percent of the firms for which a Facebook page was found also stated that they had a presence on an online social network in the ZEW ICT survey 2015.

²²Even though larger firms are more likely to be on Facebook as also displayed in Figure 2, a distinctive share of smaller firms have a corporate profile there as well.

percent and 28.3 percent, respectively. By contrast, more traditional B2B industries such as manufacturing of machinery or basic materials have adoption rates below 13 percent. For both user and firm activity on the corporate Facebook page there is a similar pattern across sectors as displayed in Figure 4. As an example, the average firm in the retail trade sector makes 20.9 posts in the year 2013 while receiving 111.4 user comments, whereas manufacturers of basic materials write 2.6 firm posts and get less than one user comment, on average.

[FIGURES 3 AND 4 ABOUT HERE]

5.2 Econometric Results

Table 6 shows the baseline OLS estimations²³ for product innovation output as the dependent variable and the three Facebook measures along with the outlined covariates as explanatory variables. The coefficient of Facebook adoption indicates a highly significant increase of 5.8 percentage points in the likelihood to introduce a product innovation, while firms' Facebook activity measured by the number of firm posts is insignificant. User activity measured by the number of user comments is significantly and positively correlated with the probability of realising a product innovation with 100 additional user comments (in a year) corresponding to a 0.4 percentage point higher likelihood of realising a product innovation. These effects remain in specifications containing two or three of these measures at once (columns 4 to 6 of Table 6). The results are not fully in line with our first main hypothesis (H1) suggesting a positive impact of the quantity of Facebook activity on product innovation. There are differences with respect to firms' and users' activities. While the firm's adoption of a Facebook page is relevant (as in H1(a)), the quantity of firm activity turns out to be insignificant and does not support hypothesis H1(b). In contrast, the quantity of user activity matters (according to H1(c)).

A further knowledge source that is positively and significantly related to product innovation is, as expected, the share of sales spent for R&D as a measure of innovation input. Moreover, the firm size measured by the number of employees, gross investments and export activity as well as the use of ERP software, the share of employees using a computer and the share of highly qualified employees are all significant determinants of the probability to introduce a product

²³We ran all subsequent regressions also with Probit. Since the results are very similar to the OLS estimations, we do not show them in the paper. This is in line with Wooldridge (2010) stating that the linear probability model yields consistent estimates.

innovation. The following analysis serves to further verify the generally positive impact of Facebook on the realisation of product innovation and to take a closer look at the firms' and users' activities in order to pinpoint important contributing factors.

[TABLE 6 ABOUT HERE]

Considering Facebook Activity 2010 to 2013

As outlined before, Facebook activity referring to the period 2010 to 2013 is considered both for a better match with the corresponding period covering the innovation measure (2011 to 2013) as well as to account for lags in the innovation process.

First, the specification of the baseline OLS estimations is slightly altered by including the cumulated firm posts and user comments covering the years from 2010 to 2013 (instead of 2013 alone) as explanatory variables. Table 7 shows that the regression results do not change considerably compared to the baseline specifications with the user activity being even more significant.

Second, lagged values of the Facebook measures are included as regressors instead. This translates to both a Facebook dummy variable indicating, whether the firm had a Facebook page before the year 2013 as well as the firm and user activity taking place in the period from 2010 to 2012. Table 8 reveals the coefficient for the Facebook adoption to be only weakly significant, whereas the user activity is still positively and significantly correlated with the realization of a product innovation.²⁴

[TABLES 7 AND 8 ABOUT HERE]

Content Analysis

Concerning our second main hypothesis (H2), as a next step, qualitative Facebook measures are considered as explanatory variables (Table 9). The results show that firms using keywords that encourage users to leave feedback, are significantly more likely to realise a product innovation, surpassing the size of the coefficient for firm's Facebook adoption (column 1 of Table 9). Thus, in line with hypothesis H2(a), an increase in the share of firm posts that contain engaging keywords

²⁴If only Facebook activity before 2012 or 2011 is considered, the results for user activity become insignificant. However, the share of firms with a Facebook page also decreases dramatically to about four percent for profiles adopted before 2011 (see Figure 1).

significantly correlates with a higher probability of a product innovation. Furthermore, the average user comment length as a first proxy of quality is positively and significantly correlated with the probability of realising a product innovation. When distinguishing the user input by its sentiment, only the share of negative user comments is significant, suggesting a higher share of negative user comments to be correlated with a higher probability to develop new products and services or to improve existing ones (columns 4 to 6 of Table 9). This is reflected by a significant coefficient with respect to the ratio of negative user comments for a positive user comment, a result in favor of H2(b) postulating that the sentiment of user activity matters for being valuable for product innovation. Thus, the results support our second main hypothesis (H2) implying that the content of firms' and users' Facebook activities matters for product innovation output.

[TABLE 9 ABOUT HERE]

Taking Account of Customer and Firm Attention

Including the relative Google search volume for a firm as well as firms' online sourcing behaviour and the level of Internet access among employees as control variables in Table 10 does not alter the findings of the baseline estimations. However, the coefficients of both Facebook adoption and user activity are slightly smaller when online sourcing is considered as a control variable (with the coefficient for the latter still rounding up to 0.004). Google search results as a further measure of customer attention and the share of employees with Internet access are of only weak significance, which is also due to a high correlation with firm size and IT intensity, respectively. In contrast, online sourcing is highly significant and positively correlated with the probability of introducing a product innovation, suggesting that the systematic search of external information on the Internet is relevant for product innovation.

[TABLE 10 ABOUT HERE]

Alternative Measures of Social Media Activity

The results also remain robust to alternative measures of firms' social media adoption, firm activity and user activity on Facebook (Table 11). Specifically, the firm's social network adoption variable from the ZEW ICT survey 2015 is significantly and positively correlated with the probability to introduce a product innovation. Similarly, the sign and significance of the coefficients

for the number of firm posts and the number of user comments do not change considerably if the Facebook measures are rescaled by the number of employees, while user comments per firm post as a further rescaling is also significant. Interestingly, firm activity measured by the amount of firm comments is weakly significant and positively correlated with the probability to introduce a product innovation, suggesting that firms' additional interaction with users is another determinant. Finally, user posts as an alternative measure of user comments is similarly significantly and positively correlated with product innovation output.

[TABLE 11 ABOUT HERE]

Taking Account of Path Dependency of Innovation

Accounting for the hypothesis that (innovation) success breeds (innovation) success, the lagged innovation output is included as a further explanatory variable for a subsample. As Table 12 shows, the lagged innovation variable is positively and significantly correlated with the current innovation output, while both effects of the firm's Facebook adoption and user activity remain, though with a lower level of significance.

[TABLE 12 ABOUT HERE]

Instrumenting Social Media

Given the fact that the data set underlying our estimations is a cross section, the estimated coefficients for the Facebook measures can only be interpreted as correlations. They might be prone to reverse causality in the sense that the more innovative firms might be more likely to adopt social media applications and engage with users since they are generally more open-minded with respect to new technologies. In order to identify causal effects of a firm's Facebook presence, in a next step, an instrumental variable approach is applied. As outlined in section 4.4, the firm's Facebook adoption and the activity by the firm and users is instrumented by a B2C indicator capturing the link between a firm's focus on end consumers and its social media presence.

Table 13 presents the results. In the first stage, the B2C indicator is, as expected, positively and significantly correlated with all three variables: the firm's Facebook adoption, firm activity and user activity. The F-test values of the first stage suggest that the instruments are relevant, with the magnitude being larger than 10. Other factors explaining Facebook adoption are the

share of employees working with computers, firm size measured by the number of employees, age structure of employees and export status. Similar determinants are significant for both firm activity and user activity, except of the age structure of employees. Instead, the qualification structure of employees plays a significant role for the two measures of activity. In the second stage estimation, the coefficient of firms' Facebook adoption is now less significant for product innovation, while firms' Facebook activity is now weakly significant. For Facebook user activity, the coefficient for the number of user comments is still significantly positive for the probability of realising a product innovation, yet of less significance compared to the OLS estimation.²⁵ The results of the instrumental variable analysis are in favour of a causal and positive effect of Facebook activity on product innovation output. Firms seem to benefit from their users' feedback on Facebook in terms of a higher probability of introducing a product innovation.

[TABLE 13 ABOUT HERE]

6 Discussion and Conclusion

We examine the role of firms' social media presence, specifically on Facebook, in firms' product innovation success. Firms can use this channel to communicate with their customers, to receive their feedback and their ideas in order to improve existing products and services or to develop new ones. Our results suggest that the probability of introducing a product innovation is positively and significantly correlated with firms' adoption of Facebook and user feedback. Information gathered from users' comments seems to be channelled in a way that helps firms to improve or further develop their products and services or to create new products and services. Our results withstand a large set of robustness checks, i.e. using Facebook activity that dates back further than the innovation activity, controlling for further sourcing channels, considering alternative measures of social media activity, and taking previous innovation success into account. The results are also robust when taking account of potential endogeneity of social media use by instrumenting social media with the firm's B2C focus.

Differentiating between quantity and quality of Facebook activity, we find that, first, firms' Facebook adoption and the amount of user activity on firms' Facebook pages are relevant for

²⁵The results for the first and second stage remain qualitatively the same if the threshold indicating the B2C focus on the industry-level is lowered to 20 percent of the output transferred to final use by private consumers.

firms' product innovation, whereas the quantity of firms' Facebook activity is insignificant. Second, when analysing the activity and the content provided on Facebook by firms and by users, the analysis shows that firms benefit from their Facebook activity by actively encouraging users to give feedback. Thus, from a firm's perspective, instead of posting generic information, sending information that encourages users to provide their feedback is crucial for innovation success. Regarding the content of user feedback, the results show that, besides the length of user comments, in particular negative user comments are associated with firms' innovation success. This result does not necessarily imply that positive user feedback is useless for firms at all, but maybe it rather matters from a marketing perspective; users who buy the firms' products and like them are more likely to provide positive comments and contribute to firms' sales but not to their innovation output. In contrast, negative feedback helps firms to identify problems and to improve their products and services. Firms might even feel urged to improve their products and services if they are publicly criticised on their Facebook page. The results of our analysis are also in line with the concept of open innovation in the sense that they highlight the importance of customers or users in the innovation process, an aspect that has so far been under-researched in the open innovation literature.

Developing and successfully implementing a social media strategy is no trivial task. Human resources are needed to take care of developing a way to draw customers' and users' attention to the Facebook profile and to channel feedback in a way such that it can be translated into improvements of products and services or into the development of new ones. For instance, a recent ZEW survey shows that 28 percent of firms in Germany that do not use social media cite a lack of human resources as the main obstacle (Bertschek and Ohnemus, 2017). By using social media, firms can pursue several objectives such as marketing, customer relationship management, market research or innovation. Analysing Facebook feedback from these different perspectives demands interdepartmental permeability, i.e. exchanging information between people in charge and responsible departments in order to exploit the potential of social media.

Our analysis has some limitations. Firstly, it is focussed on mainly small and medium-sized enterprises located in Germany, so the results can only generally be applied to countries with a similar industry structure. Since German firms are rather conservative with respect to the adoption of new technologies, however, we might expect that the role of social media is more important in countries where firms and users are more open towards the adoption of new technologies. Secondly, our analysis is focussed on Facebook as the social media platform

of interest. Due to the high proliferation rate of Facebook we might expect that different platforms play minor roles for firms' innovation output. Future studies might include different social media channels. Thirdly, the analysis is based on a data base that is unique with respect to its combining comprehensive information from a firm survey with information from firms' Facebook pages. Although this way of combining different data sets might be a guiding approach for future research, the data set at hand is a cross section and we are thus unable to account for unobserved heterogeneity. The availability of panel data with comparable information across periods should provide further evidence on the role of social media in firms' innovation success.

References

- Aral, S., Dellarocas, C. and Godes, D. (2013). Introduction to the Special Issue: Social Media and Business Transformation: A Framework for Research, *Information Systems Research* **24**(1): 3–13.
- Baldwin, C. and von Hippel, E. (2011). Modeling a Paradigm Shift: From Producer Innovation to User and Open Collaborative Innovation, *Organization Science* **22**(6): 1399–1417.
- Bayus, B. L. (2013). Crowdsourcing New Product Ideas Over Time: An Analysis of the Dell IdeaStorm Community, *Management Science* **59**(1): 226–244.
- Bertschek, I. and Ohnemus, J. (2017). Social Media - Ungewisse Bedeutung, aber hohes Potenzial, ZEW Branchenreport Informationswirtschaft, Januar 2017.
- Bertschek, I., Ohnemus, J. and Viete, S. (2017). The ZEW ICT Survey 2002 to 2015: Measuring the Digital Transformation in German Firms, ZEW Dokumentation Nr. 17-01.
- Bogers, M., Afuah, A. and Bastian, B. (2010). Users as Innovators: A Review, Critique, and Future Research Directions, *Journal of Management* **36**(4): 857–875.
- Bogers, M., Zobel, A.-K., Afuah, A., Almirall, E., Brunswicker, S., Dahlander, L., Frederiksen, F., Gawer, A., Gruber, M., Haefliger, S., Hagedoorn, J., Hilgers, D., Laursen, K., Magnusson, M. G., Majchrzak, A., McCarthy, I. P., Moeslein, K. M., Nambisan, S., Piller, F. T., Radziwon, A., Rossi-Lamastra, C., Sims, J. and Ter Wal, A. (2017). The Open Innovation Research Landscape: Established Perspectives and Emerging Themes Across Different Levels of Analysis, *Industry and Innovation* **24**(1): 8–40.
- Brynjolfsson, E. and Saunders, A. (2010). *Wired for Innovation: How Information Technology is Reshaping the Economy*, The MIT Press.
- Chatterji, A. K. and Fabrizio, K. R. (2014). Using Users: When Does External Knowledge Enhance Corporate Product Innovation?, *Strategic Management Journal* **35**(10): 1427–1445.
- Chesbrough, H. W. (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*, Harvard Business Press.
- Chung, S., Animesh, A., Han, K. and Pinsonneault, A. (2015). Do Social Media Efforts Matter for a Firm’s Bottom Line? Evidence from Facebook, PACIS 2015 Proceedings Paper 151.

- Cohen, W. M. and Levinthal, D. A. (1989). Innovation and Learning: The Two Faces of R&D, *The Economic Journal* **99**(397): 569–596.
- Cohen, W. M. and Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly* **35**(1): 128–152.
- Culnan, M. J., McHugh, P. J. and Zubillaga, J. I. (2010). How Large US Companies Can Use Twitter and Other Social Media to Gain Business Value, *MIS Quarterly Executive* **9**(4): 243–259.
- Dahlander, L. and Gann, D. M. (2010). How Open is Innovation?, *Research Policy* **39**(6): 699–709.
- Di Gangi, P. M., Wasko, M. and Hooker, R. (2010). Getting Customers Ideas to Work For You: Learning from Dell How to Succeed With Online User Innovation Communities, *MIS Quarterly Executive* **9**(4): 213–228.
- Dong, J. Q. and Wu, W. (2015). Business Value of Social Media Technologies: Evidence from Online User Innovation Communities, *Journal of Strategic Information Systems* **24**(2): 113–127.
- Flaig, G. and Stadler, M. (1994). Success Breeds Success. The Dynamics of the Innovation Process, *Empirical Economics* **19**(1): 55–68.
- Gallaughier, J. and Ransbotham, S. (2010). Social Media and Customer Dialog Management at Starbucks, *MIS Quarterly Executive* **9**(4): 197–212.
- Gans, J. S., Goldfarb, A. and Ledermann, M. (2017). Exit, Tweets, and Loyalty, NBER Working Paper No. 23046.
- German Federal Statistical Office (2017). Nutzung von Informations- und Kommunikationstechnologien in Unternehmen, <https://www.destatis.de/DE/Publikationen/Thematisch/UnternehmenHandwerk/Unternehmen/InformationstechnologieUnternehmen.html>.
- GlobalWebIndex (2017). Social Media Captures Over 30 % of Online Time, <https://blog.globalwebindex.com/chart-of-the-day/social-media-captures-30-of-online-time/>.
- Goh, K.-Y., Heng, C.-S. and Lin, Z. (2013). Social Media Brand Community and Consumer Behavior: Quantifying the Relative Impact of User- and Marketer-Generated Content, *Information Systems Research* **24**(1): 88–107.

- Grant, R. M. (1996). Toward a Knowledge-Based Theory of the Firm, *Strategic Management Journal* **17**: 109–122.
- Griliches, Z. (1979). Issues in Assessing the Contribution of Research and Development to Productivity Growth, *Bell Journal of Economics* **10**(1): 92–116.
- Hirshman, A. O. (1970). *Exit, Voice, and Loyalty*, Harvard University Press, Cambridge, MA.
- Hitt, L., Jin, F. and Wu, L. (2016). Data Analytics Skills and the Corporate Value of Social Media, *Kelley School of Business Research Paper No. 16-61* .
- Laursen, K. and Salter, A. (2006). Open for Innovation: The Role of Openness in Explaining Innovation Performance Among UK Manufacturing Firms, *Strategic Management Journal* **27**(2): 131–150.
- Lee, D., Hosanagar, K. and Nair, H. S. (2016). Advertising Content and Consumer Engagement on Social Media: Evidence From Facebook.
- Luo, X., Zhang, J. and Duan, W. (2013). Social Media and Firm Equity Value, *Information Systems Research* **24**(1): 146–163.
- McElheran, K. (2015). Do Market Leaders Lead in Business Process Innovation? The Cases of E-Business Adoption, *Management Science* **61**(6): 1197–1216.
- Miller, A. R. and Tucker, C. (2013). Active Social Media Management: The Case of Health Care, *Information Systems Research* **24**(1): 52–70.
- Mount, M. and Garcia Martinez, M. (2014). Social Media: A Tool for Open Innovation, *California Management Review* **56**(4): 124–143.
- OECD (2005). *Oslo Manual - Guidelines for Collecting and Interpreting Innovation Data*, OECD.
- Penrose, E. T. (1959). *The Theory of the Growth of the Firm*, Oxford: Blackwell.
- Peters, B. (2009). Persistence of Innovation: Stylised Facts and Panel Data Evidence, *Journal of Technology Transfer* **34**(2): 226–243.
- Randhawa, K., Wilden, R. and Hohberger, J. (2016). A Bibliometric Review of Open Innovation: Setting a Research Agenda, *Journal of Product Innovation Management* **6**(33): 750–772.
- Remus, R., Quasthoff, U. and Heyer, G. (2010). SentiWS - A Publicly Available German-Language Resource for Sentiment Analysis, LREC.

- Rishika, R., Kumar, A., Janakiraman, R. and Bezawada, R. (2013). The Effect of Customers' Social Media Participation on Customer Visit Frequency and Profitability: An Empirical Investigation, *Information Systems Research* **24**(1): 108–127.
- Roberts, D. L. and Piller, F. T. (2016). Finding the Right Role for Social Media in Innovation, *MIT Sloan Management Review* **57**(3): 41.
- Roberts, D. L., Piller, F. T. and Lüttgens, D. (2016). Mapping the Impact of Social Media for Innovation: The Role of Social Media in Explaining Innovation Performance in the PDMA Comparative Performance Assessment Study, *Journal of Product Innovation Management* **33**(S1): 117–135.
- Schumpeter, J. A. (1942). *Capitalism, Socialism and Democracy*, Harper.
- Schwaiger, J. M., Lang, M., Ritter, C. and Johannsen, F. (2016). Assessing the Accuracy of Sentiment Analysis of Social Media Posts at Small and Medium-Sized Enterprises in Southern Germany, 24th European Conference on Information Systems 2016.
- Stelzner, M. A. (2017). 2017 Social Media Marketing Industry Report.
- Tambe, P., Hitt, L. and Brynjolfsson, E. (2012). The Extroverted Firm: How External Information Practices Affect Innovation and Productivity, *Management Science* **58**(5): 843–859.
- Wagner, J. (2012). International Trade and Firm Performance: A Survey of Empirical Studies since 2006, *Review of World Economics* **148**(2): 235–267.
- Wakelin, K. (1998). Innovation and Export Behaviour at the Firm Level, *Research Policy* **26**(7): 829–841.
- West, J. and Bogers, M. (2014). Leveraging External Sources of Innovation: A Review of Research on Open Innovation, *Journal of Product Innovation Management* **31**(4): 814–831.
- West, J., Salter, A., Vanhaverbeke, W. and Chesbrough, H. (2014). Open Innovation: The Next Decade, *Research Policy* **43**(5): 805–811.
- Wooldridge, J. M. (2010). *Econometric Analysis of Cross Section and Panel Data*, The MIT Press.

7 Appendix

7.1 Facebook Data

7.1.1 Facebook Profile Research

A standardised three-step procedure shall represent the search behaviour of an interested individual. Starting with the company website, direct links to social media profiles are retrieved, while getting to know the respective firm. This is followed by a search of the company name on Facebook and concluded by a Google search comprising the company name and Facebook as keywords. In individual cases variations, abbreviations and brands of the firm are included as alternative search parameters along with further address information. Facebook pages with at least one post, which can be definitely attributed to a firm-run profile, are considered. Based on the firm's timeline, the first activity serves to restrict the sample to active profiles before the conducted interviews of the ZEW ICT survey. In case of several accounts, the main German profile of the surveyed firm is chosen, unless both activity and age falls below those of other relevant firm profiles.

7.1.2 Facebook Data Collection

Facebook provides an application programming interface (Graph API) to request data directly from the platform with requests ranging from objects, information about objects to connections between objects, where an object might, for example, correspond to a profile or post.²⁶ Every Facebook user is able to collect publicly available information from Facebook profiles, as is the case with firms' Facebook pages by means of the Graph API Explorer. Having an access token allows to access the respective Facebook page and choose which information on the Facebook page to examine. Following this procedure, several tools are used to query the Graph API more systematically, such as the Python software development kit for Facebook with a script collecting information from all the posts on the firm's Facebook page.

²⁶<https://developers.facebook.com/docs/graph-api/overview>, accessed on 23 April 2018.

7.1.3 Engaging Firm Post Keywords

in German

[ÄNDERN, ANGABE, ANKLANG, ANLIEGEN, ANMERKUNG, ANREGUNG, ANSICHT, ANSPRUCH, ANTWORT, AUFSCHLUSS, AUSKUNFT, ÄUSSERN, AUSTAUSCH, BEANSTANDUNG, BEDARF, BEDEUTUNG, BEFUND, BEITRAGEN, BEOBACHTUNG, BERICHT, BETEILIGEN, BITTE, DEFECT, DENKANSTOSS, EINDRUCK, EINFALL, EINSATZ, EINSCHÄTZUNG, EINWAND, EINWURF, EMPFEHLEN, EMPFINDEN, ENGAGEMENT, ENTDECKEN, ENTFALTEN, ENTSCHEIDEN, ENTWICKELN, ENTWURF, ERFINDEN, ERGEBNIS, ERHEBUNG, ERKENNTNIS, ERMESSEN, ERWARTUNG, ERWEITERN, FANTASIE, FAZIT, FEEDBACK, FEHLER, FESTSTELLEN, FORSCHEN, GEDANKE, GEFALLEN, GESCHMACK, GESTALTEN, HILFE, HINWEIS, IDEE, IMPRESSION, IMPULS, INITIATIVE, INNOVATION, INSPIRIEREN, INTERESSE, INTUITION, KREATIVITÄT, KRITIK, LOB, LÖSUNG, MÄNGEL, MEINUNG, MITARBEIT, MITTEILEN, MITWIRKEN, MODIFIKATION, NACHFRAGE, NEUERUNG, NOTE, PERSPEKTIVE, PROBE, PROBLEM, RAT, REAKTION, RESONANZ, REZENSION, RÜCKMELDUNG, STELLENWERT, STIMME, TEILHABE, TEILNAHME, TEST, TIPP, ÜBERLEGEN, ÜBERZEUGEN, UMFRAGE, UNTERSTÜTZEN, UNTERSUCHEN, URTEIL, VERBESSERN, VERLANGEN, VERSUCH, VORLIEBE, VORSCHLAG, VORSTELLUNG, VOTE, WAHL, WAHRNEHMUNG, WERTUNG, WUNSCH, ZEUGNIS, ZUFRIEDEN]

in English

[CHANGE, STATEMENT, APPEAL, ISSUE, REMARK, SUGGESTION, VIEW, CLAIM, ANSWER, INFORMATION, INFORMATION, EXPRESS, EXCHANGE, COMPLAINT, NEED, IMPORTANCE, FINDING, CONTRIBUTE, OBSERVATION, REPORT, PARTICIPATE, REQUEST, DEFECT, FOOD FOR THOUGHT, IMPRESSION, IDEA, EFFORT, ASSESSMENT, OBJECTION, SUBMISSION, RECOMMEND, FEELING, INVOLVEMENT, DISCOVER, DISPLAY, DECIDE, DEVELOP, DRAFT, INVENT, OUTCOME, SURVEY, INSIGHT, JUDGEMENT, EXPECTATION, EXTEND, IMAGINATION, CONCLUSION, FEEDBACK, ERROR, DETERMINE, RESEARCH, THOUGHT, LIKE, TASTE, DESIGN, HELP, HINT, IDEA, IMPRESSION, IMPULSE, INITIATIVE, INNOVATION, INSPIRE, INTEREST, INTUITION, CREATIVITY, CRITIQUE, PRAISE, SOLUTION, FLAW, OPINION, COLLABORATION, INFORM, CONTRIBUTE, MODIFICATION, DEMAND, NOVELTY, GRADE, PERSPECTIVE, TRIAL, PROBLEM, ADVICE, REACTION, FEEDBACK, REVIEW, FEEDBACK, IMPORTANCE, VOICE, PARTICIPATION, PARTICIPATION, TEST, TIP, CONSIDER, CONVINCED, SURVEY, SUPPORT, STUDY, JUDGEMENT, IMPROVE, DESIRE, ATTEMPT, PREFERENCE, SUGGESTION, IMAGINATION, VOTE, CHOICE, PERCEPTION, VALUATION, WISH, TESTIMONY, SATISFACTION]

7.2 Firm Characteristics

Table 1: Detailed Explanation of Firm Characteristics

% R&D Expenses	firm expenditure on internal and external R&D activities as a share of sales.
ERP Software Dummy	a dummy variable that takes the value one if a firm uses an enterprise resource planning software for planning, coordination and controlling.
% Employees using PC	percentage share of employees working predominantly with computers.
Number of Employees	yearly average measure excluding marginal employment.
Gross Investment	gross addition to fixed and financial assets in million €.
% High-skilled Employees	proportion of employees with a degree from university, university of applied sciences or university of cooperative education.
% Medium-skilled Employees	proportion of master craftsmen, technicians and persons having successfully completed vocational training.
% Employees < age 30	proportion of employees who are younger than thirty years.
% Employees ≥ age 50	proportion of employees who are fifty years or older.
Export Dummy	a dummy variable that takes the value one if a firm exports its products or services.
Online Sourcing Dummy	a dummy variable that takes the value one if a firm systematically searches for information about the firm or its products and services on the Internet, e.g. in blogs.
% Employees with Internet	percentage share of employees with an Internet connection at the workplace.
Google Trends	the firm's average search volume divided by the average search volume of the benchmark firm ²⁷ worldwide for Google web search in 2013.

²⁷Since Google Trends only shows a relative search volume, all firms are compared with the same benchmark firm, which has a medium search volume when compared to more well-known firms.

7.3 Tables & Figures

Table 2: Industry Distribution

	Estimation Sample		Full Sample	
	N	%	N	%
Manufacture of Consumer Goods	482	16.44	607	15.75
Manufacture of Chemicals	102	3.48	140	3.63
Manufacture of Basic Materials	260	8.87	329	8.54
Manufacture of Metals	208	7.09	279	7.24
Manufacture of Electronics	186	6.34	237	6.15
Manufacture of Machinery	175	5.97	231	6.00
Manufacture of Motor Vehicles	84	2.86	110	2.85
Retail Trade	173	5.90	228	5.92
Wholesale Trade	145	4.95	193	5.01
Transport Services	162	5.53	217	5.63
Media Services	135	4.60	164	4.26
ICT Services	167	5.70	223	5.79
Financial Services	150	5.12	231	6.00
Consulting, Advertising	180	6.14	231	6.00
Technical Services	145	4.95	191	4.96
Business Services	178	6.07	242	6.28
N	2932	100	3853	100

The full sample is displayed without the firms affiliated with none of the considered industries or with the very heterogeneous industry "Other Manufacturing".

Source: ZEW ICT survey 2015.

Table 3: Summary Statistics

	Mean	SD	Min	Max	N
Product Innovation Dummy	0.496	0.500	0	1	2932
Product Innovation 2010 Dummy	0.539	0.499	0	1	888
% R&D Expenses	0.051	0.113	0	1	2932
ERP Software Dummy	0.568	0.495	0	1	2932
% Employees using PC	0.461	0.347	0	1	2932
Number of Employees	103.090	294.561	5	4500	2932
Gross Investment	0.990	4.863	0	130	2932
% High-skilled Employees	0.196	0.245	0	1	2932
% Medium-skilled Employees	0.626	0.269	0	1	2932
% Employees < age 30	0.238	0.175	0	1	2932
% Employees \geq age 50	0.271	0.185	0	1	2932
Export Dummy	0.458	0.498	0	1	2932
Online Sourcing Dummy	0.237	0.426	0	1	2932
% Employees with Internet	0.578	0.372	0	1	2932
Google Trends	0.227	2.335	0	77	2932
B2C Dummy	0.411	0.492	0	1	2932
% B2C Industry Output	0.213	0.239	0	1	2932
B2C Indicator	0.519	0.820	0	2	2932

Source: ZEW ICT survey 2015/2010.

Table 4: Summary Statistics, Social Media

	Mean	SD	Min	Max	N
Social Media Dummy	0.464	0.499	0	1	2932
External Social Media Dummy	0.319	0.466	0	1	2932
– Social Network Dummy	0.310	0.463	0	1	2932
– Blog Dummy	0.078	0.267	0	1	2932
Internal Social Media Dummy	0.305	0.460	0	1	2932
– Wiki Dummy	0.145	0.352	0	1	2932
– Collaboration Dummy	0.218	0.413	0	1	2932
Facebook Dummy	0.206	0.405	0	1	2932
Facebook Dummy (2013)	0.166	0.372	0	1	2932
Firm Posts	75.311	210.547	0	3194	605
Firm Posts (2010-2013)	145.089	267.448	0	3194	605
Firm Posts (2010-2012)	86.686	143.327	0	1184	487
Firm Comments	12.374	39.529	0	395	605
User Comments	150.600	831.990	0	12983	605
User Comments (2010-2013)	254.362	1249.343	0	16565	605
User Comments (2010-2012)	128.904	797.415	0	15104	487
User Posts	8.527	42.934	0	634	605
Average User Comment Length	40.638	39.577	0	244	605
% Negative User Comments	0.060	0.114	0	1	605
% Positive User Comments	0.346	0.314	0	1	605
Ratio Negative/Positive User Comments	0.159	0.316	0	3	605
Engaging Firm Post Dummy	0.744	0.437	0	1	605
% Engaging Firm Posts	0.184	0.184	0	1	605

Source: ZEW ICT survey 2015 & Facebook.

Table 5: Summary Statistics by Facebook Adoption

	w/ Facebook			w/o Facebook		
	Mean	SD	N	Mean	SD	N
Product Innovation Dummy	0.592	0.492	605	0.471***	0.499	2327
Product Innovation 2010 Dummy	0.606	0.490	165	0.524*	0.500	723
% R&D Expenses	0.049	0.092	605	0.051	0.118	2327
ERP Software Dummy	0.663	0.473	605	0.544***	0.498	2327
% Employees using PC	0.536	0.355	605	0.441***	0.343	2327
Number of Employees	181.069	459.612	605	82.816***	229.101	2327
Gross Investment	1.772	7.750	605	0.787***	3.743	2327
% High-skilled Employees	0.221	0.257	605	0.190***	0.242	2327
% Medium-skilled Employees	0.596	0.258	605	0.633***	0.271	2327
% Employees < age 30	0.289	0.196	605	0.225***	0.166	2327
% Employees ≥ age 50	0.227	0.160	605	0.282***	0.190	2327
Export Dummy	0.498	0.500	605	0.448***	0.497	2327
Online Sourcing Dummy	0.380	0.486	605	0.200***	0.400	2327
% Employees with Internet	0.659	0.363	605	0.556***	0.372	2327
Google Trends	0.818	5.023	605	0.074***	0.451	2327
B2C Dummy	0.463	0.499	605	0.397***	0.489	2327
% B2C Industry Output	0.243	0.260	605	0.205***	0.233	2327
B2C Indicator	0.669	0.891	605	0.480***	0.796	2327

Source: ZEW ICT survey 2015/2010 & Facebook.

Mean differences significant at *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Facebook Adoption Over Time

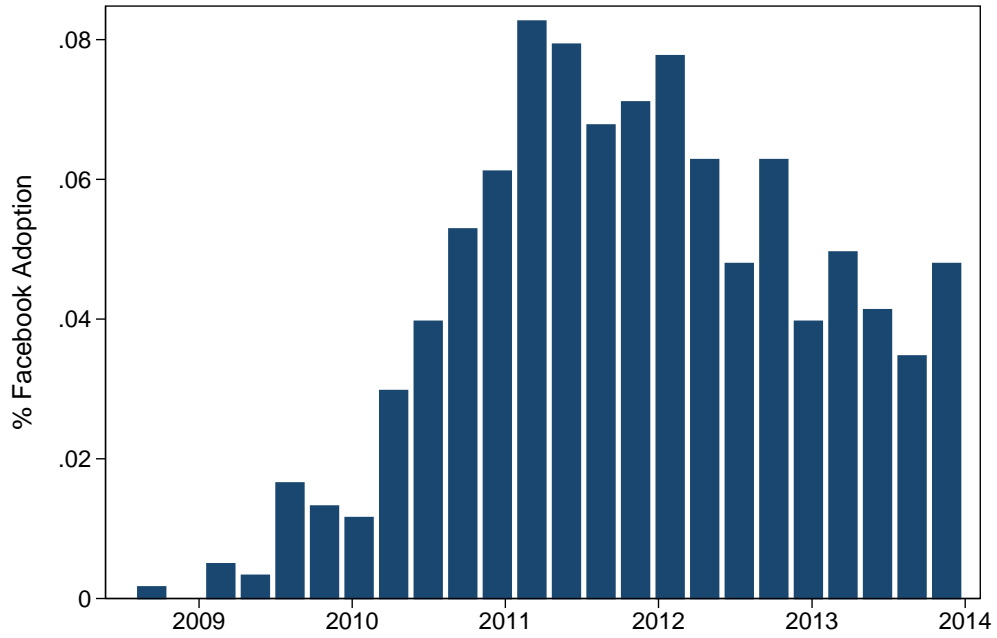


Figure 2: Facebook Adoption by Size (Number of Employees)

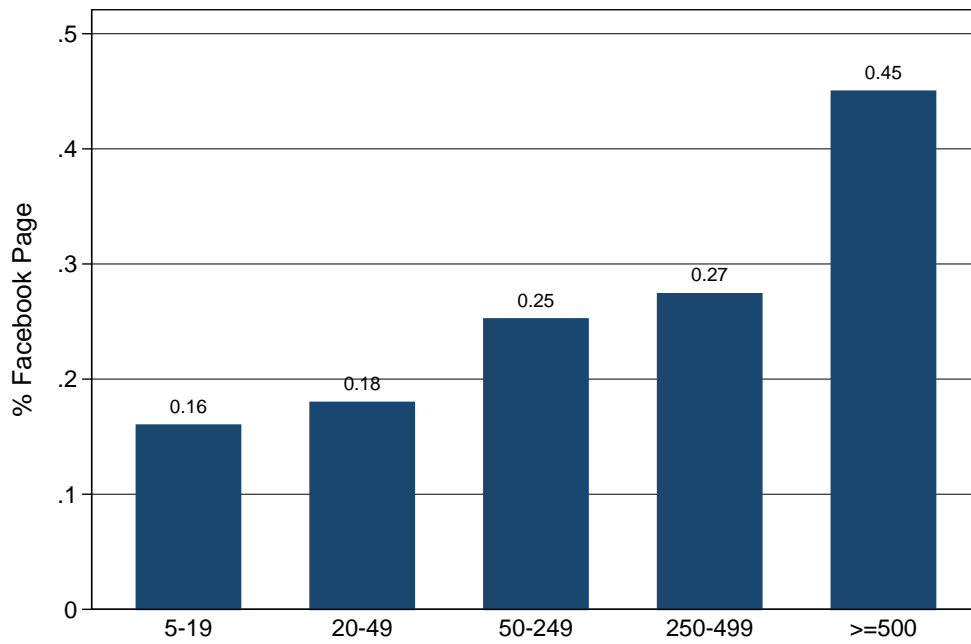


Figure 3: Facebook Adoption by Industry

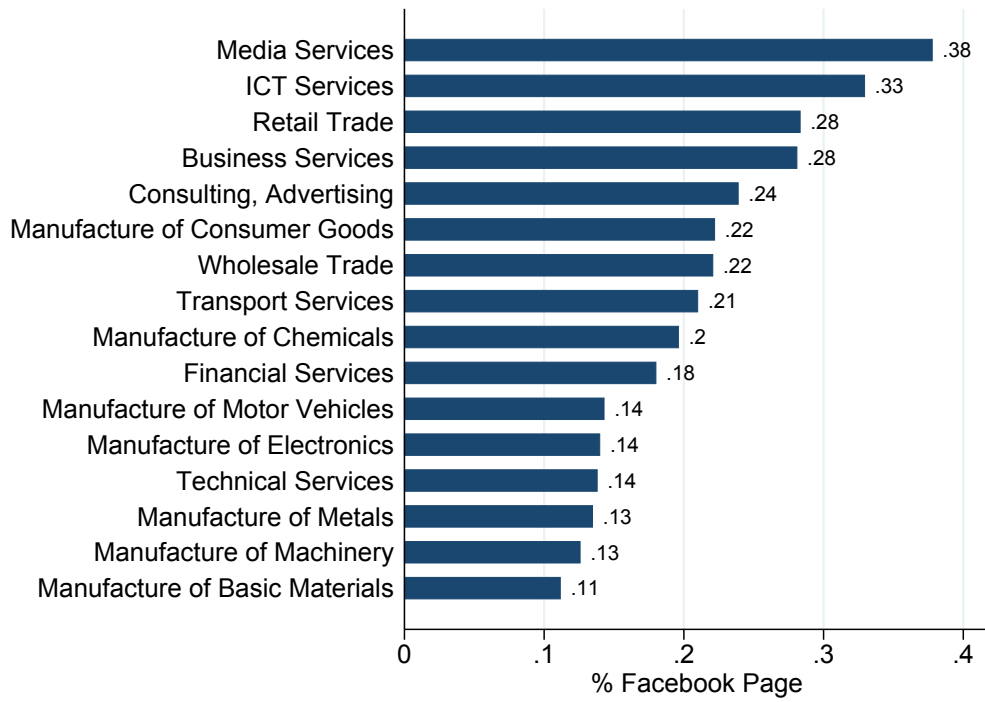


Figure 4: Average Facebook Activity by Industry

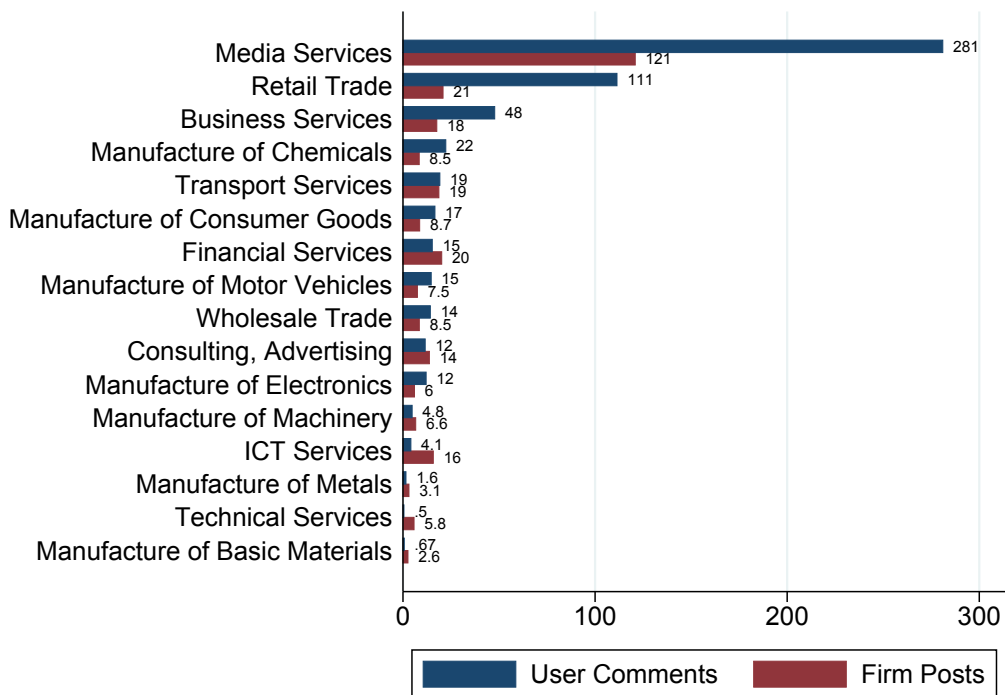


Table 6: OLS, Baseline

	Product Innovation					
	(1)	(2)	(3)	(4)	(5)	(6)
Facebook Dummy	0.058*** (0.02)			0.054** (0.02)	0.054** (0.02)	0.055** (0.02)
Firm Posts		0.013 (0.01)		0.007 (0.01)		-0.002 (0.01)
User Comments			0.004*** (0.00)		0.003*** (0.00)	0.004** (0.00)
% R&D Expenses	0.674*** (0.07)	0.672*** (0.08)	0.668*** (0.07)	0.675*** (0.07)	0.673*** (0.07)	0.672*** (0.07)
ERP Software Dummy	0.107*** (0.02)	0.108*** (0.02)	0.109*** (0.02)	0.107*** (0.02)	0.108*** (0.02)	0.108*** (0.02)
% Employees using PC	0.091** (0.04)	0.096*** (0.04)	0.096*** (0.04)	0.089** (0.04)	0.088** (0.04)	0.088** (0.04)
Number of Employees (in logs)	0.026*** (0.01)	0.027*** (0.01)	0.027*** (0.01)	0.026** (0.01)	0.025** (0.01)	0.026** (0.01)
Gross Investment (in logs)	0.024*** (0.01)	0.025*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)
% High-skilled Employees	0.172*** (0.06)	0.165*** (0.06)	0.167*** (0.06)	0.167*** (0.06)	0.167*** (0.06)	0.168*** (0.06)
% Medium-skilled Employees	-0.035 (0.04)	-0.036 (0.04)	-0.036 (0.04)	-0.035 (0.04)	-0.036 (0.04)	-0.035 (0.04)
% Employees < age 30	-0.007 (0.05)	0.007 (0.05)	0.006 (0.05)	-0.005 (0.05)	-0.006 (0.05)	-0.007 (0.05)
% Employees ≥ age 50	-0.045 (0.05)	-0.051 (0.05)	-0.052 (0.05)	-0.044 (0.05)	-0.045 (0.05)	-0.045 (0.05)
Export Dummy	0.178*** (0.02)	0.182*** (0.02)	0.182*** (0.02)	0.179*** (0.02)	0.179*** (0.02)	0.179*** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.239	0.237	0.237	0.239	0.239	0.239
N	2932	2932	2932	2932	2932	2932

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Firm Posts and User Comments are measured in hundreds.

Source: ZEW ICT survey 2015 & Facebook.

Table 7: OLS, Facebook Activity 2010-2013

	Product Innovation					
	(1)	(2)	(3)	(4)	(5)	(6)
Facebook Dummy	0.058*** (0.02)			0.051** (0.02)	0.053** (0.02)	0.053** (0.02)
Firm Posts (2010-2013)		0.012* (0.01)		0.006 (0.01)		-0.000 (0.01)
User Comments (2010-2013)			0.003*** (0.00)		0.003*** (0.00)	0.003*** (0.00)
% R&D Expenses	0.674*** (0.07)	0.674*** (0.08)	0.669*** (0.07)	0.676*** (0.07)	0.674*** (0.07)	0.674*** (0.07)
ERP Software Dummy	0.107*** (0.02)	0.108*** (0.02)	0.109*** (0.02)	0.107*** (0.02)	0.107*** (0.02)	0.107*** (0.02)
% Employees using PC	0.091** (0.04)	0.094*** (0.04)	0.096*** (0.04)	0.089** (0.04)	0.088** (0.04)	0.088** (0.04)
Number of Employees (in logs)	0.026*** (0.01)	0.026*** (0.01)	0.027*** (0.01)	0.026** (0.01)	0.025** (0.01)	0.025** (0.01)
Gross Investment (in logs)	0.024*** (0.01)	0.025*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)
% High-skilled Employees	0.172*** (0.06)	0.163*** (0.06)	0.167*** (0.06)	0.167*** (0.06)	0.166*** (0.06)	0.166*** (0.06)
% Medium-skilled Employees	-0.035 (0.04)	-0.036 (0.04)	-0.035 (0.04)	-0.035 (0.04)	-0.035 (0.04)	-0.035 (0.04)
% Employees < age 30	-0.007 (0.05)	0.005 (0.05)	0.005 (0.05)	-0.006 (0.05)	-0.007 (0.05)	-0.007 (0.05)
% Employees ≥ age 50	-0.045 (0.05)	-0.049 (0.05)	-0.052 (0.05)	-0.044 (0.05)	-0.045 (0.05)	-0.045 (0.05)
Export Dummy	0.178*** (0.02)	0.182*** (0.02)	0.182*** (0.02)	0.179*** (0.02)	0.180*** (0.02)	0.180*** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.239	0.237	0.238	0.239	0.239	0.239
N	2932	2932	2932	2932	2932	2932

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Firm Posts and User Comments are measured in hundreds.

Source: ZEW ICT survey 2015 & Facebook.

Table 8: OLS, Lagged Facebook Activity

	Product Innovation					
	(1)	(2)	(3)	(4)	(5)	(6)
Facebook Dummy (2013)	0.045*			0.038	0.041*	0.040
	(0.02)			(0.03)	(0.02)	(0.03)
Firm Posts (2010-2012)		0.018		0.009		0.002
		(0.01)		(0.01)		(0.02)
User Comments (2010-2012)			0.004***		0.004***	0.003***
			(0.00)		(0.00)	(0.00)
% R&D Expenses	0.674***	0.673***	0.671***	0.675***	0.675***	0.675***
	(0.07)	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)
ERP Software Dummy	0.107***	0.108***	0.108***	0.108***	0.107***	0.107***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
% Employees using PC	0.093**	0.096***	0.098***	0.092**	0.092**	0.092**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Number of Employees (in logs)	0.027***	0.027***	0.028***	0.027***	0.027***	0.026***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Gross Investment (in logs)	0.024***	0.024***	0.025***	0.024***	0.024***	0.024***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
% High-skilled Employees	0.169***	0.169***	0.171***	0.168***	0.167***	0.167***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
% Medium-skilled Employees	-0.036	-0.035	-0.034	-0.036	-0.036	-0.036
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
% Employees < age 30	-0.002	0.005	0.006	-0.002	-0.002	-0.002
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
% Employees ≥ age 50	-0.048	-0.049	-0.052	-0.047	-0.048	-0.047
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Export Dummy	0.179***	0.181***	0.181***	0.180***	0.180***	0.180***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.237	0.237	0.237	0.238	0.238	0.238
N	2932	2932	2932	2932	2932	2932

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Firm Posts and User Comments are measured in hundreds.

Source: ZEW ICT survey 2015 & Facebook.

Table 9: OLS, Content Analysis

	Product Innovation					
	(1)	(2)	(3)	(4)	(5)	(6)
Engaging Firm Post Dummy	0.073*** (0.02)					
% Engaging Firm Posts		0.162** (0.08)				
Average User Comment Length			0.001*** (0.00)			
% Negative User Comments				0.316** (0.16)		
% Positive User Comments					0.049 (0.04)	
Ratio Negative/Positive User Comments						0.126*** (0.05)
% R&D Expenses	0.676*** (0.07)	0.673*** (0.07)	0.676*** (0.07)	0.669*** (0.08)	0.672*** (0.07)	0.670*** (0.08)
ERP Software Dummy	0.107*** (0.02)	0.107*** (0.02)	0.108*** (0.02)	0.107*** (0.02)	0.108*** (0.02)	0.108*** (0.02)
% Employees using PC	0.089** (0.04)	0.094*** (0.04)	0.087** (0.04)	0.093** (0.04)	0.097*** (0.04)	0.093** (0.04)
Number of Employees (in logs)	0.025** (0.01)	0.027*** (0.01)	0.025** (0.01)	0.027*** (0.01)	0.027*** (0.01)	0.027*** (0.01)
Gross Investment (in logs)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.025*** (0.01)	0.025*** (0.01)
% High-skilled Employees	0.169*** (0.06)	0.171*** (0.06)	0.167*** (0.06)	0.171*** (0.06)	0.172*** (0.06)	0.170*** (0.06)
% Medium-skilled Employees	-0.038 (0.04)	-0.036 (0.04)	-0.036 (0.04)	-0.035 (0.04)	-0.035 (0.04)	-0.037 (0.04)
% Employees < age 30	-0.007 (0.05)	-0.000 (0.05)	-0.001 (0.05)	0.003 (0.05)	0.002 (0.05)	0.004 (0.05)
% Employees ≥ age 50	-0.043 (0.05)	-0.051 (0.05)	-0.044 (0.05)	-0.049 (0.05)	-0.050 (0.05)	-0.047 (0.05)
Export Dummy	0.179*** (0.02)	0.180*** (0.02)	0.181*** (0.02)	0.182*** (0.02)	0.180*** (0.02)	0.181*** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.239	0.238	0.239	0.238	0.237	0.238
N	2932	2932	2932	2932	2932	2932

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: ZEW ICT survey 2015 & Facebook.

Table 10: OLS, Customer and Firm Attention

	Product Innovation					
	(1)	(2)	(3)	(4)	(5)	(6)
Facebook Dummy	0.057*** (0.02)			0.044** (0.02)		
Firm Posts		0.012 (0.01)			0.010 (0.01)	
User Comments			0.004*** (0.00)			0.004*** (0.00)
% R&D Expenses	0.673*** (0.07)	0.671*** (0.07)	0.667*** (0.07)	0.651*** (0.07)	0.648*** (0.07)	0.645*** (0.07)
ERP Software Dummy	0.107*** (0.02)	0.108*** (0.02)	0.109*** (0.02)	0.102*** (0.02)	0.103*** (0.02)	0.104*** (0.02)
% Employees using PC	0.090** (0.04)	0.096*** (0.04)	0.096*** (0.04)	0.047 (0.04)	0.049 (0.04)	0.048 (0.04)
Number of Employees (in logs)	0.026*** (0.01)	0.026*** (0.01)	0.027*** (0.01)	0.027*** (0.01)	0.027*** (0.01)	0.028*** (0.01)
Gross Investment (in logs)	0.024*** (0.01)	0.025*** (0.01)	0.024*** (0.01)	0.023*** (0.01)	0.023*** (0.01)	0.023*** (0.01)
% High-skilled Employees	0.170*** (0.06)	0.164*** (0.06)	0.166*** (0.06)	0.152*** (0.06)	0.145** (0.06)	0.146** (0.06)
% Medium-skilled Employees	-0.035 (0.04)	-0.036 (0.04)	-0.036 (0.04)	-0.044 (0.04)	-0.045 (0.04)	-0.045 (0.04)
% Employees < age 30	-0.006 (0.05)	0.007 (0.05)	0.006 (0.05)	-0.008 (0.05)	0.002 (0.05)	0.001 (0.05)
% Employees ≥ age 50	-0.045 (0.05)	-0.052 (0.05)	-0.052 (0.05)	-0.038 (0.05)	-0.042 (0.05)	-0.043 (0.05)
Export Dummy	0.178*** (0.02)	0.182*** (0.02)	0.181*** (0.02)	0.173*** (0.02)	0.175*** (0.02)	0.175*** (0.02)
Google Trends	0.002* (0.00)	0.003* (0.00)	0.002* (0.00)	0.002 (0.00)	0.002* (0.00)	0.002 (0.00)
Online Sourcing Dummy				0.077*** (0.02)	0.081*** (0.02)	0.082*** (0.02)
% Employees with Internet				0.057 (0.04)	0.060* (0.04)	0.061* (0.04)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.239	0.237	0.238	0.243	0.243	0.243
N	2932	2932	2932	2932	2932	2932

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Firm Posts and User Comments are measured in hundreds.

Source: ZEW ICT survey 2015 & Facebook.

Table 11: OLS, Alternative Social Media Measures

	Product Innovation					
	(1)	(2)	(3)	(4)	(5)	(6)
Social Network Dummy	0.087*** (0.02)					
Firm Posts/No. of Employees		0.005 (0.00)				
Firm Comments			0.001* (0.00)			
User Comments per Firm Post				0.005* (0.00)		
User Comments/No. of Employees					0.001*** (0.00)	
User Posts						0.001*** (0.00)
% R&D Expenses	0.660*** (0.07)	0.672*** (0.08)	0.670*** (0.08)	0.667*** (0.08)	0.670*** (0.08)	0.665*** (0.07)
ERP Software Dummy	0.104*** (0.02)	0.108*** (0.02)	0.109*** (0.02)	0.109*** (0.02)	0.108*** (0.02)	0.109*** (0.02)
% Employees using PC	0.080** (0.04)	0.097*** (0.04)	0.096*** (0.04)	0.098*** (0.04)	0.099*** (0.04)	0.097*** (0.04)
Number of Employees (in logs)	0.024** (0.01)	0.029*** (0.01)	0.027*** (0.01)	0.028*** (0.01)	0.029*** (0.01)	0.027*** (0.01)
Gross Investment (in logs)	0.025*** (0.01)	0.025*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.025*** (0.01)	0.024*** (0.01)
% High-skilled Employees	0.171*** (0.06)	0.169*** (0.06)	0.167*** (0.06)	0.173*** (0.06)	0.172*** (0.06)	0.171*** (0.06)
% Medium-skilled Employees	-0.034 (0.04)	-0.034 (0.04)	-0.035 (0.04)	-0.034 (0.04)	-0.035 (0.04)	-0.035 (0.04)
% Employees < age 30	-0.016 (0.05)	0.005 (0.05)	0.006 (0.05)	0.004 (0.05)	0.008 (0.05)	0.005 (0.05)
% Employees ≥ age 50	-0.038 (0.05)	-0.049 (0.05)	-0.050 (0.05)	-0.052 (0.05)	-0.052 (0.05)	-0.052 (0.05)
Export Dummy	0.177*** (0.02)	0.180*** (0.02)	0.182*** (0.02)	0.180*** (0.02)	0.180*** (0.02)	0.181*** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
R ²	0.242	0.237	0.237	0.237	0.237	0.237
N	2932	2932	2932	2932	2932	2932

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: ZEW ICT survey 2015 & Facebook.

Table 12: OLS, Lagged Product Innovation

	Product Innovation		
	(1)	(2)	(3)
Facebook Dummy	0.068*		
	(0.04)		
Firm Posts		0.015	
		(0.01)	
User Comments			0.005**
			(0.00)
Product Innovation 2010	0.262***	0.263***	0.264***
	(0.03)	(0.03)	(0.03)
% R&D Expenses	0.608***	0.608***	0.603***
	(0.10)	(0.10)	(0.10)
ERP Software Dummy	0.077**	0.076**	0.076**
	(0.03)	(0.03)	(0.03)
% Employees using PC	0.060	0.072	0.072
	(0.06)	(0.06)	(0.06)
Number of Employees (in logs)	0.042**	0.043**	0.043**
	(0.02)	(0.02)	(0.02)
Gross Investment (in logs)	0.002	0.003	0.002
	(0.01)	(0.01)	(0.01)
% High-skilled Employees	0.154	0.144	0.143
	(0.10)	(0.10)	(0.10)
% Medium-skilled Employees	-0.050	-0.056	-0.057
	(0.09)	(0.09)	(0.09)
% Employees < age 30	0.175*	0.189*	0.191**
	(0.10)	(0.10)	(0.10)
% Employees ≥ age 50	0.020	0.015	0.015
	(0.08)	(0.08)	(0.08)
Export Dummy	0.142***	0.145***	0.146***
	(0.04)	(0.04)	(0.04)
Industry	Yes	Yes	Yes
R ²	0.342	0.340	0.340
N	888	888	888

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Firm Posts and User Comments are measured in hundreds.

Source: ZEW ICT survey 2015/2010 & Facebook.

Table 13: Instrumental Variable

Stage	Face- book 1st	Product Innovation 2nd	Firm Posts 1st	Product Innovation 2nd	User Comments 1st	Product Innovation 2nd
B2C Indicator	0.059*** (0.01)		0.230*** (0.07)		0.660*** (0.20)	
Facebook Dummy		0.543* (0.30)				
Firm Posts				0.140* (0.08)		
User Comments						0.049* (0.03)
% R&D Expenses	-0.098 (0.06)	0.717*** (0.08)	-0.237* (0.13)	0.697*** (0.08)	0.262 (0.71)	0.651*** (0.08)
ERP Software Dummy	0.018 (0.02)	0.097*** (0.02)	-0.004 (0.04)	0.108*** (0.02)	-0.250 (0.26)	0.120*** (0.02)
% Employees using PC	0.166*** (0.03)	0.013 (0.06)	0.332*** (0.09)	0.056 (0.04)	0.985*** (0.30)	0.055 (0.04)
Number of Employees (in logs)	0.032*** (0.01)	0.009 (0.02)	0.130*** (0.03)	0.008 (0.01)	0.285*** (0.10)	0.013 (0.01)
Gross Investment (in logs)	0.010 (0.01)	0.020** (0.01)	-0.008 (0.02)	0.026*** (0.01)	0.081 (0.07)	0.021*** (0.01)
% High-skilled Employees	0.020 (0.05)	0.157** (0.06)	0.620*** (0.20)	0.081 (0.08)	1.365*** (0.47)	0.101 (0.07)
% Medium-skilled Employees	-0.003 (0.03)	-0.036 (0.05)	0.078* (0.04)	-0.049 (0.04)	0.173 (0.20)	-0.046 (0.04)
% Employees < age 30	0.232*** (0.05)	-0.118 (0.09)	-0.006 (0.08)	0.008 (0.05)	0.216 (0.67)	-0.003 (0.06)
% Employees ≥ age 50	-0.139*** (0.04)	0.020 (0.07)	-0.123* (0.07)	-0.038 (0.05)	-0.118 (0.25)	-0.050 (0.05)
Export Dummy	0.050*** (0.02)	0.160*** (0.03)	-0.103** (0.04)	0.202*** (0.02)	-0.163 (0.22)	0.195*** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
F-Test	16.93		10.82		10.40	
Endogeneity Test P-value		0.0782		0.0709		0.0700
Centered R ²		0.100		0.178		0.126
N	2932	2932	2932	2932	2932	2932

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Firm Posts and User Comments are measured in hundreds.

Source: ZEW ICT survey 2015 & Facebook.