

# DISCUSSION

// NO.17-015 | 08/2020

# DISCUSSION PAPER

// IRENE BERTSCHEK AND REINHOLD KESLER

## Let the User Speak: Is Feedback on Facebook a Source of Firms' Innovation?

# Let the User Speak: Is Feedback on Facebook a Source of Firms' Innovation?<sup>§</sup>

IRENE BERTSCHEK\*      REINHOLD KESLER<sup>†</sup>

First Version: March 2017

This Version: August 2020

## 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. Our results withstand a large set of robustness checks, including estimations that take potential endogeneity of firms' Facebook use into account. Analyzing the content of firm posts and user comments reveals that Facebook adoption is correlated with product innovations only if firms and users actively engage in a discussion.

**JEL classification: D22, L23, O31**

**Keywords: social media, open innovation, feedback, product innovation**

---

<sup>§</sup>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 Universities of Ulm, Giessen, Münster, Kassel, and Bochum, as well as the participants of the annual conferences at IIOC 2016 in Philadelphia, EARIE 2016 in Lisbon, and the VfS 2016 in Augsburg for their helpful comments. We thank Niklas Gösser and Florian Schoner for their outstanding research assistance, as well as Erin Goldfinch for proof reading the paper. An earlier version of this paper is available as a CRE8TV Project Deliverable DEL: 4.2.4-R titled 'Social Media as a Source of Creativity: Hype or a Serious Strategy?.'

\*Corresponding author: ZEW – Leibniz Centre for European Economic Research and University of Giessen, Digital Economy Research Department, P.O. Box 103443, D-68034 Mannheim, Germany, [irene.bertschek@zew.de](mailto:irene.bertschek@zew.de);

<sup>†</sup>University of Zurich, Department of Business Administration, Plattenstrasse 14, CH-8032 Zurich, Switzerland, [reinhold.kesler@business.uzh.ch](mailto:reinhold.kesler@business.uzh.ch).

# 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, such as online social networks and microblogging services, open up new possibilities to gather this information. As the largest of these platforms, Facebook has more than two billion monthly active users as of the end of December 2019<sup>1</sup> and is also of great importance with respect to the time spent online by the average user.<sup>2</sup> Attracted by the opportunity to access a large user base, firms increasingly adopt a social media presence with Facebook being the favourite platform comprising more than 140 million business pages in 2020.<sup>3</sup>

While the main objective of social media is marketing, surveys among companies show that it also serves other purposes such as receiving customer feedback in order to improve products and services (Bertschek and Erdsiek, 2020; German Federal Statistical Office, 2017). Accordingly, it provides faster and cheaper access to knowledge, thereby facilitating product development and innovation due to users’ input. As a result, 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 media,<sup>4</sup> Tesla improving the company’s app based on CEO Elon Musk reading a complaint from a customer on Twitter,<sup>5</sup> and Airbnb CEO Brian Chesky asking on Twitter what the company should launch in 2017.<sup>6</sup> Beyond this 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 through a social media presence on a platform like Facebook significantly enables corporate innovation.

In this paper, we examine the role that social media, specifically Facebook, plays for firms’ innovation activity measured by the realization of newly developed or significantly improved products or services (‘product innovation’). We use a unique and rich data set of 2,932 German

---

<sup>1</sup><https://newsroom.fb.com/company-info>, accessed on 25 April 2020.

<sup>2</sup><https://www.emarketer.com/content/average-social-media-time-spent>, accessed on 25 April 2020.

<sup>3</sup><https://newsroom.fb.com/company-info>, accessed on 25 April 2020.

<sup>4</sup><http://www.pgnewsroom.co.uk/blog/innovation-en/gillette-treo-first-product-ever-designed-assisted-shaving>, accessed on 25 April 2020.

<sup>5</sup><https://www.inc.com/justin-bariso/elon-musk-takes-customer-complaint-on-twitter-from-idea-to-execution-in-6-days.html>, accessed on 25 April 2020.

<sup>6</sup><https://twitter.com/bchesky/status/813219932087390208>, accessed on 25 April 2020.

manufacturing and service firms collected in 2015 and supplemented by information from firms' Facebook pages available from 2010 until the end of 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 platform to engage with users with low barriers to entry, social media might be particularly relevant for small and medium-sized enterprises.

We find that both the adoption of and user activity on a firm's Facebook page is positively and significantly correlated with the probability to introduce a product innovation.

A large set of robustness checks supports these results. These checks comprise considering Facebook activity from earlier periods, employing different innovation and social media measures, controlling for further sourcing channels as well as digital capabilities, matching firms with and without Facebook, 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 with the instruments also allowing to model a selection of Facebook adoption that leaves user activity to be a significant determinant of product innovation. Analyzing the content of posts and comments on a firm's Facebook page in multiple ways reveals that only through the engagement by the firm and by the users a firm's Facebook page is positively and significantly related to product innovation output. Engagement in this case means asking questions or using relevant keywords as well as conducting polarised discussions with a positive or negative sentiment of user comments.

Thus, a firm's Facebook presence and the information from users are 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. By creating an interactive environment that allows engagement and discussions by the users, firms may benefit particularly from polarised content.

## 2 Related Literature

According to the open innovation paradigm, firms' boundaries open up to include external knowledge into the innovation process, thereby taking into account that relevant knowledge might not exclusively reside with individuals inside the firm (Chesbrough, 2003).

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. In light of new measures of open innovation (West et al., 2014), Dahlander and Piezunka (2014) study online suggestions from external contributors of 23,809 organisations, which are found to be elicited by both proactive and reactive engagement by the firm.

Two further strands of literature are addressed by our study comprising the literature on user innovation (Bogers et al., 2010) and on firms' use of online communities for inducing ideas by the crowd (Lakhani, 2016). The former strand provides evidence on users of a product or service themselves being the innovator as they have superior information about needs as well as preferences and derive own benefits from innovations (Baldwin and von Hippel, 2011; Bogers et al., 2010), with Chatterji and Fabrizio (2014) as an 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.

In general, Aral et al. (2013) argue that social media transform firm boundaries, thereby creating new ways to interact with customers. As a result, corresponding research especially studies marketing aspects and considers, for example, the user engagement based on firms' social media content and the targeting of this content (Lee et al., 2018; Miller and Tucker, 2013). This targeted content and user engagement in turn affects consumers' purchase expenditures or shopping visits (Goh et al., 2013; Rishika et al., 2013). However, the aforementioned benefits of social media do not only include marketing outcomes, but also may involve the firm value

more generally. The firm’s adoption and use of social media affects firm performance through user engagement and user attention as suggested by Chung et al. (2015). Similarly, social media can serve as a predictor of firm value due to the real-time content provided (Luo et al., 2013). Regarding the content on social media, Gans et al. (Forthcoming) consider such a platform enabling customers’ voice (based on the concept by Hirshman, 1970). They point out that as the cost of raising voice reduces significantly online, firms migrate their customer service activities to get in touch with users directly, a phenomenon important in many markets. Accordingly, ‘voice’ is analyzed through customers’ complaints on Twitter about shocks in airline service quality, thereby disciplining firms for low quality, where especially airlines with higher market shares respond. In a similar vein, Ananthakrishnan et al. (2019) find that voice or feedback through online customer reviews improves quality in the hotel industry.

In our study, we look at ‘voice’ more generally across several industries and relate it to firms’ product innovation output as engaging with customers on social media not only improves quality, but potentially also creates a new channel for (open) innovation through major improvements and new products and services. However, there is, so far, mostly qualitative and only small-scale quantitative evidence of a positive relationship between a firm’s social media presence and innovation (Bhimani et al., 2019; de Zubieta et al., 2019; 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. 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 advancing open innovation research with respect to the role of customers.

### **3 Analytical Framework**

Following 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). 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 di-

rectly 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 as a new way 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.

However, 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 ( $\mathbf{X}$ ) 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.<sup>7</sup>

We assume Facebook activity to play a significant role for realizing 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:

---

<sup>7</sup>This definition follows the Oslo Manual (OECD and Eurostat, 2005) and is a well-established measure of innovation output in the innovation economics literature. It also corresponds to the definition used in the Eurostat’s Community Innovation Survey (CIS), see also section 4.1.

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

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

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

In order to test this, we analyze whether a firm's Facebook presence as well as the amount of firm posts and user comments are in fact determinants of product innovation success.

In order to check the robustness of our results, we employ a large set of further analyses: (i) Facebook activity dating back further than 2013 (to the periods from 2010 to 2012) is considered for a better match with the period covering the innovation measure and to account for lags in the innovation process. (ii) Alternative innovation measures are employed that better reflect the innovation success through the sales from product innovation, while the realization of a process innovation serves as a placebo test. (iii) Alternative measures of social media activity are taken both from the survey to cover other social networks and from the Facebook pages to better account for the firm size. (iv) Both customer attention and firm attention are considered as additional explanatory variables to control for further sourcing channels and to account for firms' openness. (v) The firm's digital capabilities are controlled for by a broad range of alternative IT variables. (vi) Firms with and without Facebook are compared following a propensity score matching routine. (vii) Path dependency of innovation implying that success breeds success (Peters, 2009; Flaig and Stadler, 1994) is taken into account by including the lagged product innovation outcome approximating a cumulation of prior innovation activities as another explanatory variable for a subsample of firms. (viii) 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 instruments indicating a firm's business-to-consumer (B2C) focus and the industry average of Facebook adoption (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 a social media platform such as Facebook. Hence, a variable indicating the firm's market focus predicts the likelihood of a Facebook presence, which has also been suggested by prior research and business surveys (Culnan et al., 2010). 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. Similarly, industry-level information of Facebook adoption as an alternative instrument correlates well with a firm's decision to adopt, while it is not predictive for the single firm's probability to innovate. (ix) Finally, the selection of a Facebook adoption is taken into account through a Heckman sample selection model based on the two instruments and baseline covariates. For the selected sample, we then run our main regression with firm and user activity as our explanatory variables.

Both firms and users might engage in social media in various ways. Therefore, it depends on the purpose for which the firms use social media and on the content of users' feedback whether or not firms can realize product innovations. In the special case of Facebook, it is unclear whether firms use it with the purpose of gathering information or rather 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 not informative. Therefore, our second main hypothesis (H2) is that the role of a firm's Facebook page for product innovation depends on the content of both firm and user activity. More precisely, we specify the following two hypotheses:

H2(a): Engagement on a firm's Facebook presence is a prerequisite in order to have a significant role for realizing a product innovation.

H2(b): As the tone of user comments often emphasises the underlying information, the relationship between a firm's Facebook page and product innovation depends on the sentiment.

The second set of hypotheses is tested by first employing a content analysis of both user activity and firm activity on firms' Facebook pages. As a result, the content analysis serves the purpose of getting to the mechanism and having falsification tests, thereby distinguishing, for example, firms on Facebook between those that engage and those that do not. Due to the short text lengths prevalent on Facebook, we focus on a keyword analysis with different themes of keywords enabling us to cross-validate the measures, also when looking at the sentiment. Accordingly, for both firm and user activity, we look for question words as well as for keywords indicating engagement (see section 4.2). The presence of these is then included in our baseline regressions to be interacted with the Facebook dummy variable in order to differentiate firms without Facebook, firms with Facebook but without having relevant keywords, and firms that have both. For firms on Facebook having engagement the indicators can be further distinguished

into below- and above-average engagement. In a similar vein, we include interactions of the Facebook dummy variable with the sentiment of user activity, thereby isolating firms without any positive and negative sentiment. Finally, we can also divide into below- and above-average shares of positive and negative sentiment to spot non-linearities.

## 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 ZEW Mannheim.<sup>8</sup> The sample is stratified according to 17 manufacturing and service sectors as well as three size classes with respect to the number of employees. The data set comprises in total 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.<sup>9</sup>

### 4.1 Innovation

The main dependent variable is realized 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.

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

A follow-up question in the ZEW ICT survey from 2015 concerns the share of sales that can be attributed to the realized product innovation. Besides this, the survey also includes a question on the realization of a process innovation, which is defined analogously to product innovation

---

<sup>8</sup>See Bertschek et al. (2018) for further details. The data is available at the ZEW Data Research Centre (<http://kooperationen.zew.de/en/zew-fdz>, accessed on 25 April 2020).

<sup>9</sup>More 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 industry stratification criteria as shown in Table 2, implying that observations are missing at random.

as new or significantly improved processes introduced by the firm. This variety of measures makes it possible to have a more comprehensive view on firms' innovation output activity.

The definition of product innovation output follows the Oslo manual (OECD and Eurostat, 2005) and corresponds to the well-established definition of product innovation output used in Eurostat's Community Innovation Survey (CIS), a survey on firms' innovation activity conducted in European countries on a yearly basis. Alternative measures of innovation activity comprise patents and citations. There are, however, some limitations of using patents as a measure of innovation output, as patents might be used as a strategic tool and do not necessarily result in a realized innovation (Blind et al., 2006). In a similar vein, citations of patents are employed rather as a measure of knowledge flows or knowledge diffusion than as a measure of innovation output (Roach and Cohen, 2013; Alcacer and Gittelman, 2006; Duguet and MacGarvie, 2005).

## 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 our analysis, we focus on the use of external social networks (see also Table 4).

In order to have 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 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.<sup>10</sup>

The information regarding a firm's social media presence on Facebook is obtained for the sur-

---

<sup>10</sup>Facebook 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.

veyed 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 collected<sup>11</sup> 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 2013<sup>12</sup>:

- *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 pages.

Similar to English, the German language has specific question words (starting with the letter ‘W’), of which there are in total 36.<sup>13</sup> They can be used as a measure of whether the firm or the users initiate or engage in a conversation with the presumable aim of receiving an answer. We consider this as a first measure to reflect the interactive environment on the firm’s Facebook page (that can be important for receiving feedback). Accordingly, all of the firm and user activity is scanned with respect to these question words coming up and thereby giving us:

- *Firms Ask Questions Dummy* is a dummy variable that takes the value one if the firm has at least one post containing question words.
- *Users Ask Questions Dummy* is a dummy variable that takes the value one if there is at least one user comment containing question words.

---

<sup>11</sup>See section 7.1.2 in the Appendix 7.1 for the procedure.

<sup>12</sup>For a series of robustness checks, information on these Facebook variables dating back to the periods from 2010 to 2012 is additionally retrieved, although only a small share of firms had a Facebook page back in 2010 as displayed in Figure 1.

<sup>13</sup>See section 7.1.3 in the Appendix 7.1 for the list of keywords. The list is based on <https://de.wikipedia.org/wiki/W-Wort>, accessed on 25 April 2020.

In order to measure engagement by firms more precisely, we take into account whether firms actually use Facebook to explicitly source information from users by employing another qualitative analysis of the firm posts. For this, 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.<sup>14</sup> Each firm post is analyzed with respect to engaging keywords resulting in the following variables:

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

In order to also measure engagement by users more precisely, we exploit a specificity of the German language called ‘Konjunktiv II,’ which is used if one is talking about something that is currently not possible. Accordingly, it is a verb form that is predominantly used to express ideas and wishes, as well as giving advice and suggestions, but also when stating impossible conditions or polite requests.<sup>15</sup> In order to form the ‘Konjunktiv II’ in German, certain forms of auxiliary and modal verbs are used. An example would be the request ‘could you improve it?’ (‘**Könnten** Sie das verbessern?’ in German with the relevant word in bold). Accordingly, we can look up specific and unique forms of relevant auxiliary and modal verbs in the user comments, thereby concentrating on those conjugations that happen if a user is talking to a firm.<sup>16</sup>

- *Users Engage Dummy* is a dummy variable that takes the value one if there is at least one user comment containing engaging keywords.
- *% Users Engage* is the proportion of user comments that contain engaging keywords.

Besides certain keywords, the content by users can be also analyzed with respect to further dimensions. For example, as an initial quality approximation of user input, the average length of user comments is considered.

---

<sup>14</sup>See section 7.1.4 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.

<sup>15</sup>See, for more information, <https://deutsch.lingolia.com/de/grammatik/verben/konjunktiv>, accessed on 25 April 2020.

<sup>16</sup>See section 7.1.5 in the Appendix 7.1 for the list of keywords. The list is based on <https://deutsch.lingolia.com/de/grammatik/verben/modalverben>, accessed on 25 April 2020.

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

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.<sup>17</sup> Following data processing,<sup>18</sup> 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.

### 4.3 Further Firm Characteristics

Further variables that might be relevant for firms' innovation activity based on previous research are presented in the following.<sup>19</sup> 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 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. These two measures also approximate a stock rather than an idiosyncratic investment, as they are prerequisites for more sophisticated tools like customer relationship management or business analytics. In many firms, an ERP system is the technical backbone for further IT applications. The spread of personal computers among employees is a well-established measure of the basic IT intensity of firms' work processes. 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

---

<sup>17</sup>See Schwaiger et al. (2016) for an exemplary study that uses SentiWS for analyzing Facebook pages of German firms.

<sup>18</sup>Each 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.

<sup>19</sup>A detailed explanation of the variables in the order of appearance is provided in Table 1 in the Appendix 7.2.

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.<sup>20</sup>

#### 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 follow McElheran (2015) and construct the share of output devoted to private consumption on a NACE 2-digit industry level based on the input-output tables published by the German Federal Statistical Office.<sup>21</sup> If this share of output is larger than 30 percent, an industry or the firm belonging to this industry is defined to 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:

---

<sup>20</sup>The 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.

<sup>21</sup>[https://www.destatis.de/DE/Themen/Wirtschaft/Volkswirtschaftliche-Gesamtrechnungen-Inlandsprodukt/Tabellen/\\_tabellen-innen-in-output.html](https://www.destatis.de/DE/Themen/Wirtschaft/Volkswirtschaftliche-Gesamtrechnungen-Inlandsprodukt/Tabellen/_tabellen-innen-in-output.html), accessed on 25 April 2020.

- *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.

We use an additional instrument comprising the industry average of Facebook adoption on a granular level of 51 industries (NACE 2-digit classification). The aggregate measure of Facebook adoption within an industry acts as a valid instrument since it is a good predictor for a firm’s probability to adopt Facebook. However, it does not directly determine a single firm’s innovation success.

## 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.<sup>22</sup> 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 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.<sup>23</sup> 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.

---

<sup>22</sup>This corresponds to the R&D shares as measured for instance by data from the German Community Innovation Survey (CIS) ([http://ftp.zew.de/pub/zew-docs/mip/19/mip\\_2019.pdf](http://ftp.zew.de/pub/zew-docs/mip/19/mip_2019.pdf), accessed on 25 April 2020.)

<sup>23</sup>See 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 provided 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.<sup>24</sup> 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.

Measures from the content analyses show that close to 79 percent of firms ask at least once a question in their posts, whereas 59 percent of the corporate Facebook profiles have at least one user comment including a question word. 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. In contrast, only 38.2 percent of firms on Facebook have at least one user comment that includes an engaging keyword, while the average share of comments containing such is only about 4.3 percent. 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.

The correlations between the measures inferred from the content analyses help to understand the underlying mechanisms. The share of firm posts comprising question words is highly correlated with the share of firm posts having engaging keywords (correlation of about 0.7). This validates the keywords for engaging firm posts as they are often times accompanied by questions, meaning the firm aims at receiving answers. The share of engaging firm posts is also correlated with the variable from the survey on whether firms externally source for information. Regarding the sentiment, for firms on Facebook, the share of negative user comments (compared to the share of positive user comments) is correlated more strongly with the share of user comments having questions, while the share of positive user comments (compared to the share of negative user

---

<sup>24</sup>88.1 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.

comments) is associated more strongly with the share of user comments that contain engaging keywords. The latter relationship validates the measure of engaging keywords by users, as those are often times used in the German language when requesting something in a polite manner. In that sense, the measure would only yield a lower bound estimate of the relationship between user engagement and the realization of a product innovation as impolite requests are not picked up by those keywords.

[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 larger<sup>25</sup>, 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 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]

In Figure 5, the distribution of product innovators by industry is provided. It shows a great heterogeneity ranging from 26 percent of firms in the business services sector realizing product

---

<sup>25</sup>Even 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.

innovations compared to 75 percent for manufacturers of chemicals. However, comparing this to Figure 3 on Facebook adoption by industry does not seem to suggest a clear picture of industries having both rapid innovation cycles and social media profiles.

[FIGURE 5 ABOUT HERE]

## 5.2 Econometric Results

Table 6 shows the baseline OLS estimations<sup>26</sup> 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 realizing a product innovation with 100 additional user comments (in a year) corresponding to a 0.4 percentage point higher likelihood of realizing a product innovation. These estimated coefficients 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 relationship between the quantity of Facebook activity and 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)). We will have a closer look into this in the content analyses.

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 innovation.<sup>27</sup>

---

<sup>26</sup>We 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.

<sup>27</sup>Distinguishing between manufacturing and services firms, we find the relationship only to be present among service firms. As we cover the early stage of having Facebook profiles by firms, this might be evidence for early

Restricting the sample to firms with Facebook profiles in column (7) of Table 6, the quantity of user activity remains significantly and positively correlated with realized product innovations. Other relevant determinants such as R&D expenses, the use of ERP software, and the exporting status are still significant, while the insignificance of other variables can be potentially attributed to a lower number of observations.

The following analysis serves to further verify the generally positive relationship between a firm's Facebook page and the realization of product innovation using quantitative measures.

[TABLE 6 ABOUT HERE]

### **Considering Facebook Activity from 2010 to 2013**

As outlined before, Facebook activity referring to the period 2010 to 2013 is considered both for a better match with the period covering the innovation measure (spanning from 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 A1 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 end of 2012 as well as the firm and user activity taking place in the period from 2010 to 2012. Table A2 reveals the coefficient for the Facebook adoption to be still weakly significant, whereas the user activity is still positively and significantly correlated with the realization of a product innovation.<sup>28</sup>

[TABLES A1 AND A2 ABOUT HERE]

---

returns of those firms with shorter lags, as the provision of services, in general, is related to more interaction with customers than in case of physical products.

<sup>28</sup>If 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).

## **Alternative Measures of Innovation**

We employ alternative measures of innovation. Firstly, we take into account, whether the product innovation resulted in sales, thereby approximating the corresponding success. Based on the attributed revenue share given in the survey, we adjust the previous product innovation variable to be equal to one only if the product innovation resulted in any sales, one percent of sales, and at least five percent of sales (corresponding to the 25th quantile). We also consider the revenue share itself as a dependent variable. The results can be found in Table 7, columns (1) to (4), where the positive relationship especially regarding user activity persists, although at a decreasing level of significance as the threshold for the required revenue share increases. On the one hand, this decreasing level of significance might reflect that feedback on Facebook is particularly helpful if new products or services are still at the very beginning of market entrance or if innovation is only incremental. On the other hand, it might reflect the fact that Facebook usage is highly correlated with firm size, and larger firms usually have a more diverse product portfolio such that one new product or service will not lead to a high share of sales in general. Secondly, we introduce the realization of a process innovation as a dependent variable in a placebo regression, as we assume that feedback from customers is more likely to target products rather than processes. Accordingly, in column (5) of Table 7, we find no significant relationship between the Facebook measures and the realization of a process innovation. This also mitigates the concern that our results are just displaying a relationship between firms using social media and generally being innovative.

[TABLE 7 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 8). 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 and firm activity measured by the amount of firm comments is insignificant. Finally, user posts as an alternative measure of user comments is similarly significantly and positively correlated with product innovation output. All of the

specifications including user and firm activity also include the dummy for the adoption of a Facebook profile that is still positively and significantly correlated with the realization of a product innovation.

[TABLE 8 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 degree of Internet access among employees as control variables in Table A3 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. Google search volume as a further measure of customer attention and the share of employees with Internet access are only of 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 A3 ABOUT HERE]

### **Controlling for Digital Capabilities**

We include a broad range of control variables in our main regression to approximate different digital capabilities of a firm as these might coincide with the adoption and use of social media by a firm. These variables comprise the proportion of employees with mobile Internet access or in IT training, the number of IT specialists, the presence of online sales, as well as the firm's use of cloud computing or big data analytics. All these variables are positively and significantly correlated with product innovation as shown in Table A4, however, they do not alter the main results regarding the Facebook measures. Including all of these IT variables as covariates at once, we still observe the positive relationship between user activity and product innovation to be statistically significant. This resonates well with the evidence in Table A3 showing that other IT variables displaying the capability of firms to gather information from the Internet does not change the results either.

[TABLE A4 ABOUT HERE]

### **Matching Firms with and without Facebook**

As a further robustness check, we employ a propensity score matching routine, essentially matching firms with and without Facebook profile based on all the observed characteristics of the baseline regression (see Table A5). An advantage of the matching approach over simple OLS estimations is that it better balances ‘treatment’ (with Facebook page) and ‘control’ (without Facebook page) group by considering only those observations with common support in the explanatory variables. However, for our sample, there is no statistically significant difference between the two groups after matching (in Table A6) as opposed to the unmatched comparison in Table 5. As a result, we find in Table A7 a positive relationship of adopting Facebook and the realization of a product innovation, though still relying on selection on observables.

[TABLE A5-A7 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 the surveys take place several years apart, there is considerable panel attrition reducing the sample heavily. Table 9 shows that the lagged innovation variable is positively and significantly correlated with the current innovation output, while both estimated coefficients of the firm’s Facebook adoption and user activity remain significant, though at a lower level. This finding remains, when we include all three Facebook measures as explanatory variables at once.

[TABLE 9 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 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 is instrumented both by a variable displaying the firm’s focus on end consumers and an industry average of Facebook adoption. Table 10 presents the results. The

first stages show that both instruments alone are positively and significantly correlated with the firm's Facebook adoption with the industry average being statistically more significant. The F-test values suggest both instruments to be relevant. Considering both instrumental variables in the first stage regression, only the industry average of Facebook adoption remains significant. The F-test with a value of 57 as well as the Hansen J-test indicate the relevance of the instruments for explaining Facebook usage at the firm-level. 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. In the second stage estimations, the coefficient of a firm's Facebook adoption is still positive and statistically significant.<sup>29</sup> The results of the instrumental variable analysis are in favor of a causal and positive effect of Facebook adoption 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 10 ABOUT HERE]

### Selecting into Facebook

In a further step, we revisit the firms having adopted a Facebook profile. To take account of a possible selection sample selection, we apply a Heckman two-step procedure. In the first stage, we use both instruments (on top of our usual covariates) as exclusion restrictions to model firms' adoption of a Facebook profile. For the selected sample of Facebook adopters, we then run our baseline regression model with firm and user activity on the firm's Facebook profile as additional explanatory variables. Analogously to the IV estimations, both exclusion restrictions are significant when entering the first stage regression separately. If both exclusion restrictions are considered jointly, it is only the industry average of Facebook adoption that is statistically significant. The results, shown in Table 11, suggest user comments to be positively and significantly correlated with the realization of a product innovation. The coefficient lambda is weakly significant indicating a sample selection with respect to the adoption of Facebook.

[TABLE 11 ABOUT HERE]

---

<sup>29</sup>The 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.



## **Incorporating Content Analyses**

Concerning our second main hypothesis (H2), qualitative Facebook measures of firm and user activity inferred from content analyses are considered as explanatory variables and included in our baseline regressions. Specifically, we interact these measures with the Facebook dummy variable to differentiate firms on Facebook having such textual characteristics in their firm or user content to those without. The reference category are firms without a Facebook page.

First, we look at measures for the engagement on a firm's Facebook page both by the firm and users as displayed in Table 12. Accordingly, we only find a positive and significant relationship for the interaction between the different engagement measures and the Facebook presence, whereas there is no significant correlation for the Facebook dummy variable alone. This pattern is observed independently of whether firms or users ask questions or employ engaging keywords. However, larger coefficients for user activity seem to suggest a more important role being attributed to users engaging in a conversation on the corporate profile and potentially leaving feedback. Interestingly, companies with engagement shares above the average over all firms on Facebook are more likely to benefit translating to a higher probability of realizing a product innovation. This result is especially pronounced for the firm engagement.

[TABLE 12 ABOUT HERE]

Thus, in line with hypothesis H2(a), engagement is a prerequisite in order to have a Facebook presence to be significantly related with the realization of a product innovation. The results also suggest that solely having a Facebook page does not lead to product innovation, thereby mitigating endogeneity concerns.

This result is strengthened when users' engagement is crossed by firms' engagement (see Table A8). Including interactions between the variables for firms and users asking questions or engaging gives a positive and significant relationship only for those firms on Facebook that have both users and firms engaging at least once.

[TABLE A8 ABOUT HERE]

Second, we distinguish user activity by its sentiment in Table 13 and include interactions with the Facebook dummy variable. As a consequence, we can differentiate between firms with and

without any positive and negative sentiment. The results suggest that only firms with at least one user comment having any sentiment are more likely to realize a product innovation. By contrast, the others do not benefit, possibly because there is no (polarising) discussion taking place on their Facebook page. The relationship is more pronounced for negative sentiment, whereas for positive sentiment, the Facebook dummy variable is close to the 10 % significance level. Distinguishing firms on Facebook with below- or above-average shares of comments being positive or negative, one can observe a kind of non-linearity. While only an above-average share of positive sentiment is positively and significantly correlated with product innovation (Table 13, column (2)), the coefficient for below-average shares of negative sentiment is larger and has a higher level of significance (Table 13, column (4)). In line with hypothesis H2(b), we find that the sentiment of user comments is a significant determinant for the probability to realize a product innovation.

[TABLE 13 ABOUT HERE]

Thus, the results support our second main hypothesis (H2) implying that both the engagement and the sentiment of content on a firm's Facebook page matter for product innovation output.

## 6 Discussion and Conclusion

We examine the role of firms' social media presence for their product innovation success. We focus on Facebook because it is the social media channel by which firms can reach a huge user base. 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. taking account of Facebook activity that dates back further than the innovation activity, considering alternative measures of social media activity and innovation, controlling for further sourcing channels and additional variables capturing firms' IT intensity, matching firms with and without Facebook, 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 and the industry average of Facebook adoption. These instruments are also employed as exclusion restrictions in a sample selection model still revealing a positive and significant relationship between user activity and product innovation for the reduced sample of firms on Facebook.

Analyzing the content on firms' Facebook pages, we find that engagement is a prerequisite for Facebook activity in order to be significantly related with the realization of a product innovation. Thus, from a firm's perspective, instead of posting generic information, explicitly encouraging users to provide their feedback and make them engage in a conversation is crucial for the firm's innovation success. Moreover, regarding the content of user feedback, we find only in case of user comments with either a positive or a negative sentiment that Facebook adoption is a significant determinant for realizing a product innovation. This relationship is even more pronounced in case of user comments with a negative sentiment. These comments might help 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 complementing 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.

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, and in particular with respect to the adoption of social media,<sup>30</sup> we expect that the role of social media is even 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 expect that other social media platforms play minor roles for firms' innovation output, though, firms' primary purpose on Facebook is marketing. Hence, future studies might include different social media channels. Thirdly, the analysis is based on a data base that

---

<sup>30</sup>According to the Digital Economy and Society Indicator of the European Union (2019), Germany ranks 20th with respect to using social media in enterprises. See [https://ec.europa.eu/newsroom/dae/document.cfm?doc\\_id=59893](https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=59893), accessed on 25 April 2020.

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 basically 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

- Alcacer, J. and Gittelman, M. (2006). Patent Citations as a Measure of Knowledge Flows: The Influence of Examiner Citations, *The Review of Economics and Statistics* **88**(4): 774–779.
- Ananthakrishnan, U. M., Proserpio, D. and Sharma, S. (2019). I Hear You: Does Quality Improve with Customer Voice?, [https://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=3467236](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3467236).
- 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 Erdsiek, D. (2020). Die Kunden stehen im Fokus von Social Media, ZEW Branchenreport Informationswirtschaft, Februar 2020.
- Bertschek, I., Ohnemus, J. and Viete, S. (2018). The ZEW ICT Survey 2002 to 2015: Measuring the Digital Transformation in German Firms, *Journal of Economics and Statistics* **238**(1): 87–99.
- Bhimani, H., Mention, A.-L. and Barlatier, P.-J. (2019). Social Media and Innovation: A Systematic Literature Review and Future Research Directions, *Technological Forecasting and Social Change* **144**: 251–269.
- Blind, K., Edler, J., Frietsch, R. and Schmoch, U. (2006). Motives to Patent: Empirical Evidence from Germany, *Research Policy* **35**(5): 655–672.
- 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*, 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.
- 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.
- Dahlander, L. and Piezunka, H. (2014). Open to Suggestions: How Organizations Elicit Suggestions Through Proactive and Reactive Attention, *Research Policy* **43**(5): 812–827.
- de Zubieta, G. C., Fryges, H. and Jones, J. (2019). Social Media, Open Innovation & HRM: Implications for Performance, *Technological Forecasting and Social Change* **144**: 334–347.
- 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.
- Duguet, E. and MacGarvie, M. (2005). How Well Do Patent Citations Measure Flows of Technology? Evidence from French Innovation Surveys, *Economics of Innovation and New Technology* **14**(5): 375–393.

- Flaig, G. and Stadler, M. (1994). Success Breeds Success. The Dynamics of the Innovation Process, *Empirical Economics* **19**(1): 55–68.
- Gallaugh, 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. (Forthcoming). Exit, Tweets, and Loyalty, *American Economic Journal: Microeconomics*.
- German Federal Statistical Office (2017). Nutzung von Informations- und Kommunikationstechnologien in Unternehmen, <https://www.destatis.de/DE/Publikationen/Thematisch/UnternehmenHandwerk/Unternehmen/InformationstechnologieUnternehmen.html>.
- 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.
- 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.
- Lakhani, K. R. (2016). Managing Communities and Contests to Innovate With Crowds, *Revolutionizing Innovation: Users, Communities, and Open Innovation* .
- 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. (2018). Advertising Content and Consumer Engagement on Social Media: Evidence From Facebook, *Management Science* **64**(11): 5105–5131.
- 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 and Eurostat (2005). *Oslo Manual - Guidelines for Collecting and Interpreting Innovation Data*, OECD.
- 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.
- Roach, M. and Cohen, W. M. (2013). Lens or Prism? Patent Citations as a Measure of Knowledge Flows from Public Research, *Management Science* **59**(2): 504–525.
- 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.
- 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*, MIT Press.

## 7 Appendix

### 7.1 Information on Data from Facebook

#### 7.1.1 Finding Surveyed Firms on Facebook

A standardised manual three-step procedure shall imitate the search behaviour of an interested individual. Starting with the company website, direct links to social media profiles are retrieved. 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 an additional keyword. 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 helps to restrict the sample to active profiles before the conducted interviews of the ZEW ICT survey. In case of several accounts, the German main profile of the surveyed firm is chosen, unless both activity and age falls below those of other relevant firm profiles.

#### 7.1.2 Collecting Data from Facebook

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.<sup>31</sup> Every Facebook user has been 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 allowed to access the respective Facebook page and choose which information on the Facebook page to examine. Following this procedure, several tools were used to query the Graph API more systematically, thereby allowing to collect information from all the posts on the firm’s Facebook page.<sup>32</sup>

---

<sup>31</sup><https://developers.facebook.com/docs/graph-api/overview>, accessed on 25 April 2020.

<sup>32</sup>In spring of 2018, Facebook announced to limit this access, making any further data collection in this regard infeasible. For more information, see <https://about.fb.com/news/2018/04/restricting-data-access/>, accessed on 25 April 2020.

### 7.1.3 Question Words

#### in German

[WER, WELCHE, WELCHER, WEM, WEN, WELCHEN, WELCHEM, WESSEN, WAS, WELCHES, WARUM, WESHALB, WESWEGEN, WIESO, WIE, WIEWEIT, WOFÜR, WOZU, WOMIT, WODURCH, WORUM, WORÜBER, WOBEL, WOVON, WORAUS, WO, WOHN, WOHER, WORAN, WORIN, WORAUF, WORUNTER, WOVOR, WOHINTER, WONEBEN, WANN]

#### in English

[WHO, WHICH, WHOM, WHOSE, WHAT, WHY, HOW, WHERE, WHEN]

### 7.1.4 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, ENTSCHIEDEN, 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, CONVINCE, SURVEY, SUPPORT, STUDY, JUDGEMENT, IMPROVE, DESIRE, ATTEMPT, PREFERENCE, SUGGESTION, IMAGINATION, VOTE, CHOICE, PERCEPTION, VALUATION, WISH, TESTIMONY, SATISFACTION]

### **7.1.5 Engaging User Comment Keywords**

## **in German**

[WÄRE, HÄTTE, WÜRDE, KÖNNTE, MÜSSTE, SOLLTE, WOLLTE, DÜRFTTE, MÖCHTE, WÄREN, HÄTTEN, WÜRDEN, KÖNNTEN, MÜSSTEN, SOLLTEN, WOLLTEN, DÜRFTEN, MÖCHTEN, WÄRET, HÄTTET, WÜRDET, KÖNNTET, MÜSSTET, SOLLTET, WOLLTET, DÜRFTET, MÖCHTET]

## **in English**

[THREE CONJUGATIONS EACH IN ‘KONJUNKTIV II’ FOR THREE AUXILIARY VERBS BEING ‘BE,’ ‘HAVE,’ ‘WILL,’ AS WELL AS SIX MODAL VERBS COMPRISING ‘CAN,’ ‘MUST,’ ‘SHALL,’ ‘WANT,’ ‘MAY,’ AND ‘LIKE.’]

## 7.2 Firm Characteristics

Table 1: Detailed Explanation of Firm Characteristics

% R&D Expenses	firm expenditures 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 <sup>33</sup> worldwide for Google web search in 2013.

<sup>33</sup>Since Google Trends only shows a relative search volume, all firms are compared with the same benchmark firm, which has an average search volume when compared to more well-known firms.

### 7.3 Figures & Tables

Figure 1: Facebook Adoption Over Time

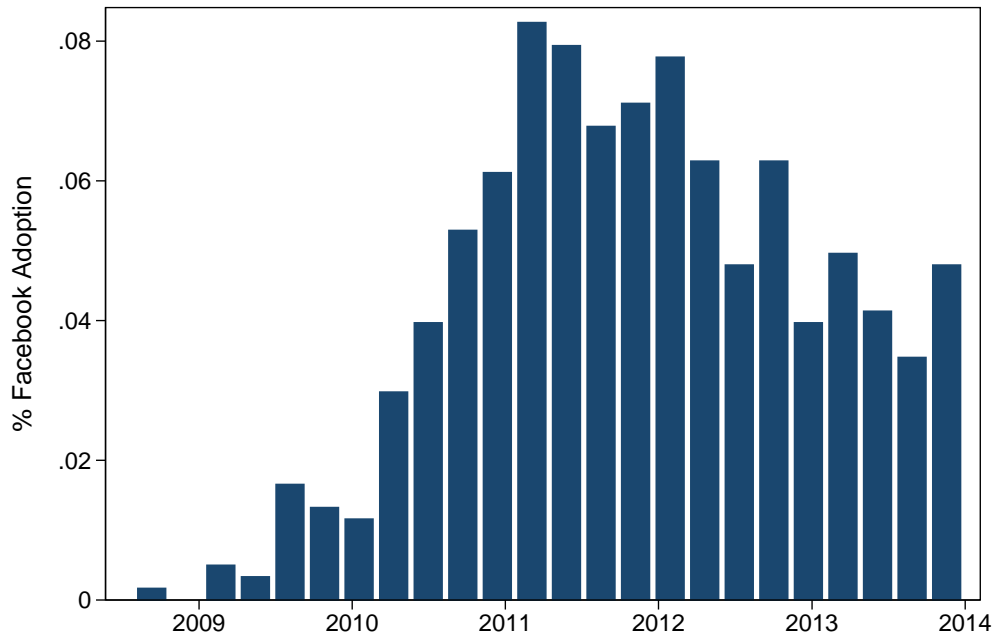


Figure 2: Facebook Adoption by Size (Number of Employees)

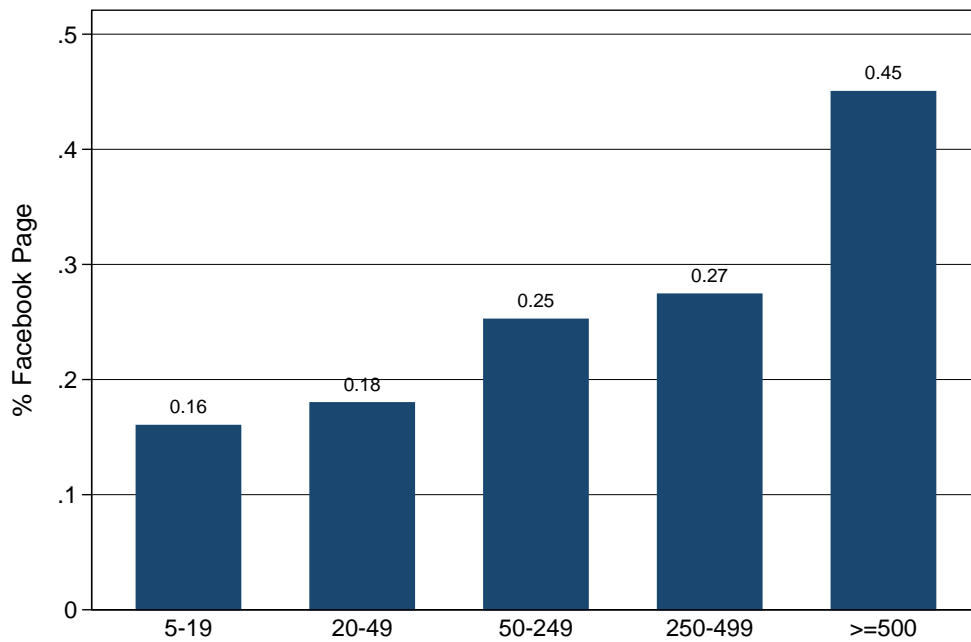


Figure 3: Facebook Adoption by Industry

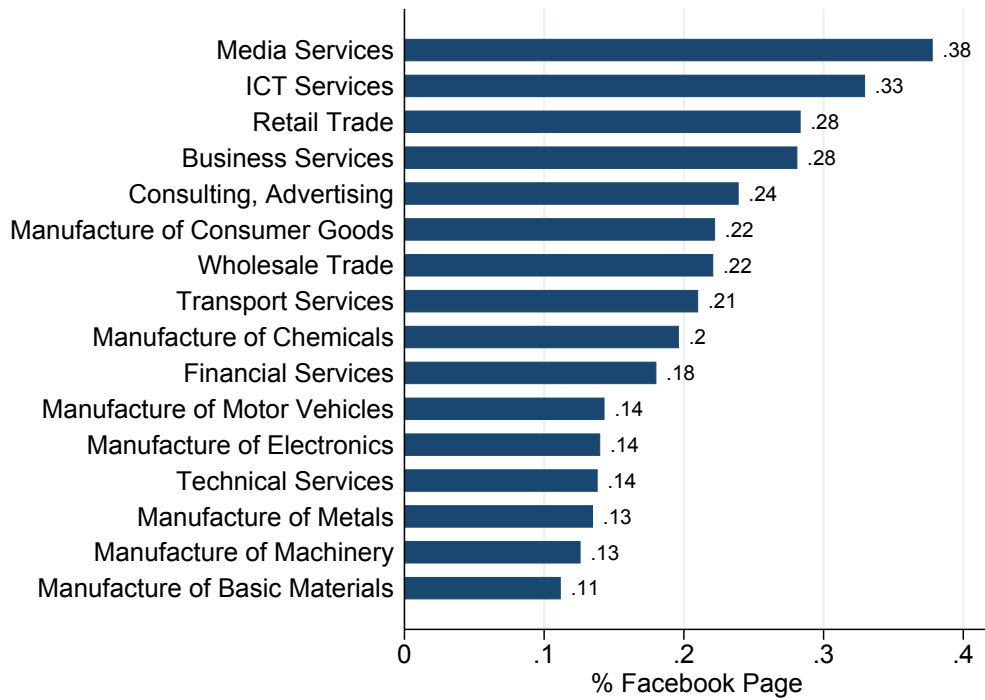


Figure 4: Average Facebook Activity by Industry

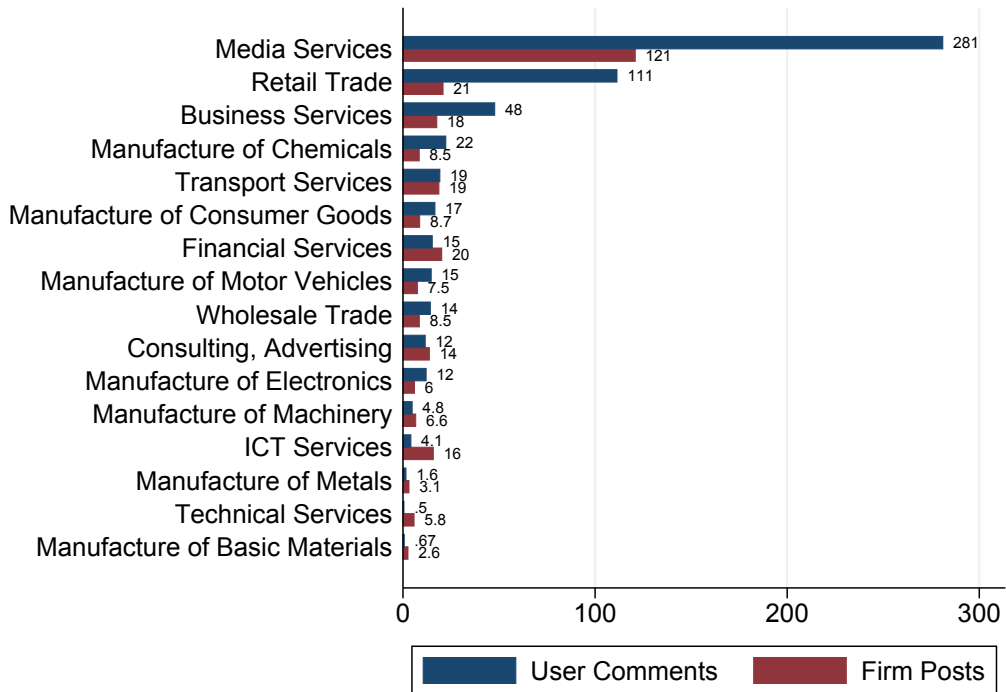


Figure 5: Share of Product Innovators by Industry

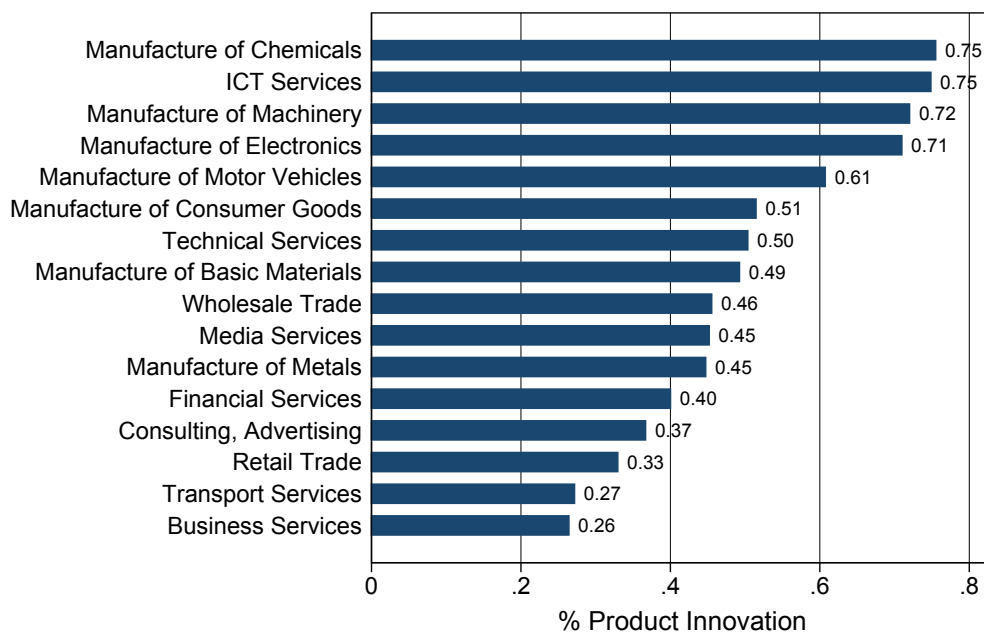




Table 2: Industry Distribution

	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 on 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
Firms Ask Questions Dummy	0.787	0.410	0	1	605
Users Ask Questions Dummy	0.590	0.492	0	1	605
Firms Engage Dummy	0.744	0.437	0	1	605
% Firms Engage	0.184	0.184	0	1	605
Users Engage Dummy	0.382	0.486	0	1	605
% Users Engage	0.043	0.094	0	1	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

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

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

Source: ZEW ICT survey 2015/2010 & Facebook.

Table 6: Baseline

	Product Innovation						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
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)	-0.002 (0.01)
User Comments			0.004*** (0.00)		0.003*** (0.00)	0.004** (0.00)	0.005** (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)	0.818*** (0.18)
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)	0.096** (0.05)
% 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)	0.109 (0.08)
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)	0.032 (0.02)
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)	0.015 (0.02)
% 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)	0.124 (0.13)
% 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)	-0.107 (0.11)
% 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)	-0.095 (0.11)
% 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)	-0.099 (0.14)
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)	0.104** (0.04)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.239	0.237	0.237	0.239	0.239	0.239	0.211
N	2932	2932	2932	2932	2932	2932	605

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

Columns (1) to (6) refer to the whole sample, column (7) to the subsample of firms having a Facebook page.

Firm Posts and User Comments are measured in hundreds.

Source: ZEW ICT survey 2015 & Facebook.

Table 7: Alternative Innovation Measures

	Sales from Product Innovation				Process
	> 0%	> 1%	≥ 5%	Share	Innovation
	(1)	(2)	(3)	(4)	(5)
Facebook Dummy	0.051** (0.02)	0.047** (0.02)	0.023 (0.02)	0.008 (0.01)	0.001 (0.02)
Firm Posts	-0.001 (0.01)	0.001 (0.01)	-0.011 (0.01)	-0.004* (0.00)	0.000 (0.01)
User Comments	0.004** (0.00)	0.004** (0.00)	0.003* (0.00)	0.001** (0.00)	-0.001 (0.00)
% R&D Expenses	0.677*** (0.09)	0.672*** (0.09)	0.673*** (0.10)	0.433*** (0.05)	0.277*** (0.08)
ERP Software Dummy	0.104*** (0.02)	0.112*** (0.02)	0.097*** (0.02)	0.019*** (0.01)	0.154*** (0.02)
% Employees using PC	0.068* (0.04)	0.072* (0.04)	0.086** (0.04)	0.015 (0.01)	0.175*** (0.04)
Number of Employees (in logs)	0.021** (0.01)	0.012 (0.01)	-0.012 (0.01)	-0.012*** (0.00)	0.007 (0.01)
Gross Investment (in logs)	0.023*** (0.01)	0.025*** (0.01)	0.026*** (0.01)	0.007*** (0.00)	0.033*** (0.01)
% High-skilled Employees	0.182*** (0.06)	0.185*** (0.06)	0.172*** (0.06)	0.050** (0.02)	-0.050 (0.06)
% Medium-skilled Employees	-0.039 (0.04)	-0.036 (0.04)	-0.080* (0.04)	-0.018 (0.01)	-0.082* (0.04)
% Employees < age 30	-0.037 (0.05)	-0.019 (0.05)	0.014 (0.05)	0.016 (0.02)	0.226*** (0.05)
% Employees ≥ age 50	-0.061 (0.05)	-0.056 (0.05)	-0.081* (0.05)	-0.016 (0.01)	-0.129*** (0.05)
Export Dummy	0.181*** (0.02)	0.178*** (0.02)	0.168*** (0.02)	0.027*** (0.01)	0.058*** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.231	0.227	0.199	0.207	0.130
N	2804	2804	2804	2804	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: Alternative Social Media Measures

	<b>Product Innovation</b>				
	(1)	(2)	(3)	(4)	(5)
Social Network Dummy	0.087*** (0.02)				
Facebook Dummy		0.059** (0.02)	0.056** (0.02)	0.053** (0.02)	0.054** (0.02)
Firm Posts/No. of Employees		-0.001 (0.01)			
User Comments/No. of Employees		0.001* (0.00)			
User Comments per Firm Post			0.003* (0.00)		
Firm Comments				0.001 (0.00)	
User Posts					0.001** (0.00)
% R&D Expenses	0.660*** (0.07)	0.674*** (0.07)	0.673*** (0.07)	0.675*** (0.07)	0.670*** (0.07)
ERP Software Dummy	0.104*** (0.02)	0.107*** (0.02)	0.108*** (0.02)	0.107*** (0.02)	0.108*** (0.02)
% Employees using PC	0.080** (0.04)	0.090** (0.04)	0.090** (0.04)	0.089** (0.04)	0.089** (0.04)
Number of Employees (in logs)	0.024** (0.01)	0.026*** (0.01)	0.026*** (0.01)	0.025** (0.01)	0.026*** (0.01)
Gross Investment (in logs)	0.025*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)
% High-skilled Employees	0.171*** (0.06)	0.172*** (0.06)	0.171*** (0.06)	0.167*** (0.06)	0.170*** (0.06)
% Medium-skilled Employees	-0.034 (0.04)	-0.035 (0.04)	-0.035 (0.04)	-0.035 (0.04)	-0.035 (0.04)
% Employees < age 30	-0.016 (0.05)	-0.005 (0.05)	-0.008 (0.05)	-0.006 (0.05)	-0.007 (0.05)
% Employees ≥ age 50	-0.038 (0.05)	-0.045 (0.05)	-0.044 (0.05)	-0.044 (0.05)	-0.045 (0.05)
Export Dummy	0.177*** (0.02)	0.178*** (0.02)	0.178*** (0.02)	0.179*** (0.02)	0.179*** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.242	0.239	0.239	0.239	0.239
N	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 9: Lagged Product Innovation

	<b>Product Innovation</b>			
	(1)	(2)	(3)	(4)
Facebook Dummy	0.068*			0.083**
	(0.04)			(0.04)
Firm Posts		0.015		-0.044
		(0.01)		(0.03)
User Comments			0.005**	0.013*
			(0.00)	(0.01)
Product Innovation 2010	0.262***	0.263***	0.264***	0.266***
	(0.03)	(0.03)	(0.03)	(0.03)
% R&D Expenses	0.608***	0.608***	0.603***	0.594***
	(0.10)	(0.10)	(0.10)	(0.10)
ERP Software Dummy	0.077**	0.076**	0.076**	0.076**
	(0.03)	(0.03)	(0.03)	(0.03)
% Employees using PC	0.060	0.072	0.072	0.060
	(0.06)	(0.06)	(0.06)	(0.06)
Number of Employees (in logs)	0.042**	0.043**	0.043**	0.042**
	(0.02)	(0.02)	(0.02)	(0.02)
Gross Investment (in logs)	0.002	0.003	0.002	0.001
	(0.01)	(0.01)	(0.01)	(0.01)
% High-skilled Employees	0.154	0.144	0.143	0.153
	(0.10)	(0.10)	(0.10)	(0.10)
% Medium-skilled Employees	-0.050	-0.056	-0.057	-0.051
	(0.09)	(0.09)	(0.09)	(0.09)
% Employees < age 30	0.175*	0.189*	0.191**	0.178*
	(0.10)	(0.10)	(0.10)	(0.10)
% Employees ≥ age 50	0.020	0.015	0.015	0.020
	(0.08)	(0.08)	(0.08)	(0.08)
Export Dummy	0.142***	0.145***	0.146***	0.145***
	(0.04)	(0.04)	(0.04)	(0.04)
Industry	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.342	0.340	0.340	0.343
N	888	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 10: Instrumental Variable

Stage	Face- book 1st	Product Innovation 2nd	Face- book 1st	Product Innovation 2nd	Face- book 1st	Product Innovation 2nd
Facebook Dummy		0.543* (0.30)		0.327*** (0.11)		0.338*** (0.11)
% R&D Expenses	-0.098 (0.06)	0.717*** (0.08)	-0.083 (0.06)	0.698*** (0.07)	-0.087 (0.06)	0.699*** (0.07)
ERP Software Dummy	0.018 (0.02)	0.097*** (0.02)	0.021 (0.02)	0.102*** (0.02)	0.020 (0.02)	0.101*** (0.02)
% Employees using PC	0.166*** (0.03)	0.013 (0.06)	0.111*** (0.03)	0.047 (0.04)	0.115*** (0.03)	0.046 (0.04)
Number of Employees (in logs)	0.032*** (0.01)	0.009 (0.02)	0.031*** (0.01)	0.017 (0.01)	0.030*** (0.01)	0.016 (0.01)
Gross Investment (in logs)	0.010 (0.01)	0.020** (0.01)	0.010 (0.01)	0.022*** (0.01)	0.010* (0.01)	0.022*** (0.01)
% High-skilled Employees	0.020 (0.05)	0.157** (0.06)	-0.044 (0.05)	0.164*** (0.06)	-0.046 (0.05)	0.163*** (0.06)
% Medium-skilled Employees	-0.003 (0.03)	-0.036 (0.05)	-0.014 (0.03)	-0.035 (0.04)	-0.015 (0.03)	-0.035 (0.04)
% Employees < age 30	0.232*** (0.05)	-0.118 (0.09)	0.213*** (0.05)	-0.069 (0.06)	0.214*** (0.05)	-0.071 (0.06)
% Employees ≥ age 50	-0.139*** (0.04)	0.020 (0.07)	-0.127*** (0.04)	-0.009 (0.05)	-0.129*** (0.04)	-0.007 (0.05)
Export Dummy	0.050*** (0.02)	0.160*** (0.03)	0.044*** (0.02)	0.168*** (0.02)	0.048*** (0.02)	0.168*** (0.02)
B2C Indicator	0.059*** (0.01)				0.023 (0.01)	
Facebook Dummy Industry Avg.			0.912*** (0.09)		0.882*** (0.09)	
Industry	Yes	Yes	Yes	Yes	Yes	Yes
F-Test	16.93		112.46		57.04	
Hansen J-Test P-value						0.4364
Endogeneity Test P-value		0.0782		0.0066		0.0043
Centered R <sup>2</sup>		0.100		0.196		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.

Table 11: Heckman Selection Model

Stage	Face-	Product	Face-	Product	Face-	Product
	book	Innovation	book	Innovation	book	Innovation
	1st	2nd	1st	2nd	1st	2nd
Firm Posts		-0.002 (0.01)		-0.004 (0.01)		-0.005 (0.01)
User Comments		0.005* (0.00)		0.005* (0.00)		0.005* (0.00)
% R&D Expenses	-0.328 (0.28)	0.833*** (0.22)	-0.261 (0.29)	0.863*** (0.22)	-0.274 (0.29)	0.862*** (0.22)
ERP Software Dummy	0.094 (0.06)	0.090** (0.05)	0.109* (0.07)	0.089** (0.04)	0.108* (0.07)	0.089** (0.04)
% Employees using PC	0.567*** (0.12)	0.080 (0.11)	0.378*** (0.12)	0.047 (0.08)	0.390*** (0.12)	0.048 (0.08)
Number of Employees (in logs)	0.114*** (0.03)	0.026 (0.03)	0.110*** (0.03)	0.019 (0.02)	0.107*** (0.03)	0.019 (0.02)
Gross Investment (in logs)	0.039 (0.02)	0.013 (0.02)	0.043* (0.02)	0.010 (0.02)	0.044* (0.02)	0.010 (0.02)
% High-skilled Employees	0.000 (0.19)	0.123 (0.13)	-0.235 (0.20)	0.102 (0.13)	-0.241 (0.20)	0.104 (0.13)
% Medium-skilled Employees	-0.032 (0.15)	-0.105 (0.11)	-0.079 (0.15)	-0.115 (0.11)	-0.083 (0.15)	-0.114 (0.11)
% Employees < age 30	0.808*** (0.17)	-0.136 (0.16)	0.757*** (0.17)	-0.192 (0.12)	0.761*** (0.17)	-0.191 (0.12)
% Employees ≥ age 50	-0.662*** (0.18)	-0.063 (0.17)	-0.661*** (0.18)	-0.036 (0.13)	-0.669*** (0.18)	-0.035 (0.13)
Export Dummy	0.210*** (0.07)	0.094* (0.05)	0.195*** (0.07)	0.086** (0.04)	0.210*** (0.07)	0.086* (0.04)
B2C Indicator	0.215** (0.05)				0.080 (0.06)	
Facebook Dummy Industry Avg.			2.900*** (0.29)		2.789*** (0.30)	
Industry	Yes	Yes	Yes	Yes	Yes	Yes
Lambda	-0.073		-0.156*		-0.156*	
N	2932	605	2932	605	2932	605

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 12: Content Analysis of Engagement

	<b>Product Innovation</b>					
	(1)	(2)	(3)	(4)	(5)	(6)
Facebook Dummy	0.032 (0.04)	0.016 (0.04)	0.016 (0.04)	0.036 (0.03)	0.030 (0.03)	0.030 (0.03)
× Firms Ask Questions Dummy	0.066*** (0.02)					
× Firms Engage Dummy		0.074*** (0.02)				
× I[Firms Engage $\leq \emptyset$ ]			0.064* (0.03)			
× I[Firms Engage $> \emptyset$ ]			0.083*** (0.03)			
× Users Ask Questions Dummy				0.075*** (0.03)		
× Users Engage Dummy					0.109*** (0.03)	
× I[Users Engage $\leq \emptyset$ ]						0.109** (0.06)
× I[Users Engage $> \emptyset$ ]						0.109*** (0.04)
% R&D Expenses	0.674*** (0.07)	0.676*** (0.07)	0.676*** (0.07)	0.675*** (0.07)	0.679*** (0.07)	0.679*** (0.07)
ERP Software Dummy	0.107*** (0.02)	0.107*** (0.02)	0.107*** (0.02)	0.107*** (0.02)	0.108*** (0.02)	0.108*** (0.02)
% Employees using PC	0.090** (0.04)	0.088** (0.04)	0.088** (0.04)	0.088** (0.04)	0.085** (0.04)	0.085** (0.04)
Number of Employees (in logs)	0.026*** (0.01)	0.025** (0.01)	0.025** (0.01)	0.025** (0.01)	0.024** (0.01)	0.024** (0.01)
Gross Investment (in logs)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)
% High-skilled Employees	0.170*** (0.06)	0.169*** (0.06)	0.169*** (0.06)	0.170*** (0.06)	0.169*** (0.06)	0.169*** (0.06)
% Medium-skilled Employees	-0.035 (0.04)	-0.037 (0.04)	-0.037 (0.04)	-0.035 (0.04)	-0.036 (0.04)	-0.036 (0.04)
% Employees < age 30	-0.007 (0.05)	-0.008 (0.05)	-0.007 (0.05)	-0.007 (0.05)	-0.007 (0.05)	-0.007 (0.05)
% Employees $\geq$ age 50	-0.044 (0.05)	-0.043 (0.05)	-0.044 (0.05)	-0.043 (0.05)	-0.044 (0.05)	-0.044 (0.05)
Export Dummy	0.178*** (0.02)	0.179*** (0.02)	0.179*** (0.02)	0.179*** (0.02)	0.180*** (0.02)	0.180*** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.239	0.239	0.239	0.239	0.240	0.240
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 13: Content Analysis of Sentiment

	<b>Product Innovation</b>			
	(1)	(2)	(3)	(4)
Facebook Dummy	0.051 (0.03)	0.051 (0.03)	0.025 (0.03)	0.025 (0.03)
× Positive User Comments Dummy	0.063** (0.03)			
× I[Positive User Comments ≤ ∅]		0.043 (0.05)		
× I[Positive User Comments > ∅]		0.068** (0.03)		
× Negative User Comments Dummy			0.109*** (0.03)	
× I[Negative User Comments ≤ ∅]				0.204*** (0.05)
× I[Negative User Comments > ∅]				0.083** (0.03)
% R&D Expenses	0.675*** (0.07)	0.674*** (0.07)	0.676*** (0.07)	0.676*** (0.07)
ERP Software Dummy	0.107*** (0.02)	0.107*** (0.02)	0.107*** (0.02)	0.107*** (0.02)
% Employees using PC	0.090** (0.04)	0.091** (0.04)	0.085** (0.04)	0.085** (0.04)
Number of Employees (in logs)	0.026*** (0.01)	0.026*** (0.01)	0.024** (0.01)	0.024** (0.01)
Gross Investment (in logs)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)
% High-skilled Employees	0.171*** (0.06)	0.172*** (0.06)	0.165*** (0.06)	0.164*** (0.06)
% Medium-skilled Employees	-0.035 (0.04)	-0.035 (0.04)	-0.036 (0.04)	-0.036 (0.04)
% Employees < age 30	-0.007 (0.05)	-0.007 (0.05)	-0.009 (0.05)	-0.010 (0.05)
% Employees ≥ age 50	-0.044 (0.05)	-0.045 (0.05)	-0.042 (0.05)	-0.043 (0.05)
Export Dummy	0.178*** (0.02)	0.179*** (0.02)	0.180*** (0.02)	0.180*** (0.02)
Industry	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.239	0.239	0.240	0.241
N	2932	2932	2932	2932

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

Source: ZEW ICT survey 2015 & Facebook.

## 7.4 Online Appendix

Table A1: Facebook Activity 2010-2013

	<b>Product Innovation</b>					
	(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 <sup>2</sup>	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 A2: Lagged Facebook Activity

	<b>Product Innovation</b>					
	(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 <sup>2</sup>	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 A3: Customer and Firm Attention

	<b>Product Innovation</b>			
	(1)	(2)	(3)	(4)
Facebook Dummy	0.055** (0.02)	0.045** (0.02)	0.053** (0.02)	0.043* (0.02)
Firm Posts	-0.002 (0.01)	-0.003 (0.01)	-0.002 (0.01)	-0.003 (0.01)
User Comments	0.004** (0.00)	0.004** (0.00)	0.004** (0.00)	0.004** (0.00)
% R&D Expenses	0.672*** (0.07)	0.653*** (0.07)	0.669*** (0.07)	0.649*** (0.07)
ERP Software Dummy	0.108*** (0.02)	0.104*** (0.02)	0.106*** (0.02)	0.103*** (0.02)
% Employees using PC	0.088** (0.04)	0.079** (0.04)	0.052 (0.04)	0.045 (0.04)
Number of Employees (in logs)	0.025** (0.01)	0.025** (0.01)	0.028*** (0.01)	0.027*** (0.01)
Gross Investment (in logs)	0.024*** (0.01)	0.023*** (0.01)	0.023*** (0.01)	0.022*** (0.01)
% High-skilled Employees	0.167*** (0.06)	0.165*** (0.06)	0.151*** (0.06)	0.149*** (0.06)
% Medium-skilled Employees	-0.036 (0.04)	-0.035 (0.04)	-0.045 (0.04)	-0.044 (0.04)
% Employees < age 30	-0.006 (0.05)	-0.005 (0.05)	-0.010 (0.05)	-0.008 (0.05)
% Employees ≥ age 50	-0.045 (0.05)	-0.042 (0.05)	-0.041 (0.05)	-0.038 (0.05)
Export Dummy	0.179*** (0.02)	0.175*** (0.02)	0.177*** (0.02)	0.173*** (0.02)
Google Trends	0.002 (0.00)			0.002 (0.00)
Online Sourcing Dummy		0.078*** (0.02)		0.077*** (0.02)
% Employees with Internet			0.062* (0.04)	0.058 (0.04)
Industry	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.239	0.243	0.240	0.244
N	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 A4: Controlling for Digital Capabilities

	Product Innovation						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Facebook Dummy	0.052** (0.02)	0.056** (0.02)	0.055** (0.02)	0.042* (0.02)	0.051** (0.02)	0.053** (0.02)	0.036 (0.02)
Firm Posts	-0.002 (0.01)	-0.002 (0.01)	-0.004 (0.01)	0.006 (0.01)	-0.002 (0.01)	-0.002 (0.01)	0.007 (0.01)
User Comments	0.004** (0.00)	0.004** (0.00)	0.004** (0.00)	0.003** (0.00)	0.004** (0.00)	0.004** (0.00)	0.002* (0.00)
% R&D Expenses	0.685*** (0.07)	0.675*** (0.08)	0.653*** (0.07)	0.697*** (0.08)	0.654*** (0.07)	0.653*** (0.07)	0.659*** (0.08)
ERP Software Dummy	0.105*** (0.02)	0.104*** (0.02)	0.109*** (0.02)	0.097*** (0.02)	0.101*** (0.02)	0.102*** (0.02)	0.083*** (0.02)
% Employees using PC	0.079** (0.04)	0.068* (0.04)	0.069* (0.04)	0.082** (0.04)	0.079** (0.04)	0.079** (0.04)	0.029 (0.04)
Number of Employees (in logs)	0.031*** (0.01)	0.025** (0.01)	0.011 (0.01)	0.033*** (0.01)	0.025** (0.01)	0.022** (0.01)	0.021* (0.01)
Gross Investment (in logs)	0.022*** (0.01)	0.023*** (0.01)	0.022*** (0.01)	0.022*** (0.01)	0.024*** (0.01)	0.023*** (0.01)	0.019*** (0.01)
% High-skilled Employees	0.130** (0.06)	0.155*** (0.06)	0.146** (0.06)	0.169*** (0.06)	0.162*** (0.06)	0.172*** (0.06)	0.112* (0.06)
% Medium-skilled Employees	-0.044 (0.04)	-0.039 (0.04)	-0.038 (0.04)	-0.032 (0.04)	-0.032 (0.04)	-0.033 (0.04)	-0.040 (0.04)
% Employees < age 30	-0.009 (0.05)	-0.004 (0.05)	-0.008 (0.05)	-0.006 (0.05)	-0.014 (0.05)	-0.005 (0.05)	-0.012 (0.05)
% Employees ≥ age 50	-0.041 (0.05)	-0.036 (0.05)	-0.051 (0.05)	-0.040 (0.05)	-0.044 (0.05)	-0.042 (0.05)	-0.028 (0.05)
Export Dummy	0.177*** (0.02)	0.177*** (0.02)	0.179*** (0.02)	0.177*** (0.02)	0.178*** (0.02)	0.178*** (0.02)	0.172*** (0.02)
% Employees with Mobile Internet	0.097*** (0.03)						0.078** (0.04)
% Employees in IT Training		0.156*** (0.05)					0.108** (0.05)
Number of IT Specialists (in logs)			0.041*** (0.01)				0.033** (0.01)
Online Sales Dummy				0.036* (0.02)			0.031 (0.02)
Cloud Computing Dummy					0.070*** (0.02)		0.054** (0.02)
Big Data Analytics Dummy						0.061*** (0.02)	0.052** (0.02)
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.241	0.241	0.242	0.241	0.242	0.242	0.250
N	2926	2898	2930	2837	2908	2922	2773

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 A5: Propensity Score

	<b>Facebook Dummy</b>	
% R&D Expenses	-0.290	(0.28)
ERP Software Dummy	0.094	(0.06)
% Employees using PC	0.550***	(0.12)
Number of Employees (in logs)	0.126***	(0.03)
Gross Investment (in logs)	0.037	(0.02)
% High-skilled Employees	0.050	(0.19)
% Medium-skilled Employees	-0.010	(0.15)
% Employees < age 30	0.800***	(0.17)
% Employees ≥ age 50	-0.636***	(0.18)
Export Dummy	0.161**	(0.07)
Industry		Yes
Pseudo R <sup>2</sup>	0.097	
N	2,932	

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Source: ZEW ICT survey 2015 & Facebook.

Table A6: Summary Statistics by Facebook Adoption After Matching

	w/ Facebook	w/o Facebook
% R&D Expenses	0.049	0.043
ERP Software Dummy	0.663	0.641
% Employees using PC	0.536	0.520
Number of Employees (in logs)	3.90	3.846
Gross Investment (in logs)	-1.52	-1.504
% High-skilled Employees	0.221	0.201
% Medium-skilled Employees	0.596	0.604
% Employees < age 30	0.289	0.286
% Employees ≥ age 50	0.227	0.225
Export Dummy	0.498	0.456

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

Source: ZEW ICT survey 2015/2010 & Facebook.

Table A7: Propensity Score Matching

	<b>Product Innovation</b>			
	w/ Facebook	w/o Facebook	Difference	t-Statistic
Unmatched	0.592	0.471	0.121	5.32
ATT	0.592	0.522	0.069	2.04

Source: ZEW ICT survey 2015/2010 & Facebook.

Table A8: Content Analysis of Engagement, Interactions

	Product Innovation			
	(1)	(2)	(3)	(4)
Facebook Dummy	0.014 (0.05)	0.029 (0.04)	0.012 (0.04)	0.018 (0.04)
× Users Ask Questions Dummy	0.159 (0.12)			
× Firms Ask Questions Dummy	0.055 (0.04)			
× Firms Ask Questions Dummy × Users Ask Questions Dummy	0.071*** (0.03)			
× Users Engage Dummy		0.079 (0.19)		
× Firms Ask Questions Dummy		0.031 (0.03)		
× Firms Ask Questions Dummy × Users Engage Dummy		0.110*** (0.03)		
× Users Ask Questions Dummy			0.040 (0.09)	
× Firms Engage Dummy			0.064 (0.04)	
× Firms Engage Dummy × Users Ask Questions Dummy			0.078*** (0.03)	
× Users Engage Dummy				-0.041 (0.19)
× Firms Engage Dummy				0.039 (0.03)
× Firms Engage Dummy × Users Engage Dummy				0.113*** (0.03)
% R&D Expenses	0.675*** (0.07)	0.679*** (0.07)	0.676*** (0.07)	0.679*** (0.07)
ERP Software Dummy	0.108*** (0.02)	0.108*** (0.02)	0.107*** (0.02)	0.108*** (0.02)
% Employees using PC	0.088** (0.04)	0.085** (0.04)	0.088** (0.04)	0.084** (0.04)
Number of Employees (in logs)	0.026** (0.01)	0.024** (0.01)	0.025** (0.01)	0.024** (0.01)
Gross Investment (in logs)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)	0.024*** (0.01)
% High-skilled Employees	0.171*** (0.06)	0.168*** (0.06)	0.169*** (0.06)	0.168*** (0.06)
% Medium-skilled Employees	-0.037 (0.04)	-0.036 (0.04)	-0.037 (0.04)	-0.036 (0.04)
% Employees < age 30	-0.005 (0.05)	-0.008 (0.05)	-0.008 (0.05)	-0.007 (0.05)
% Employees ≥ age 50	-0.041 (0.05)	-0.044 (0.05)	-0.043 (0.05)	-0.043 (0.05)
Export Dummy	0.178*** (0.02)	0.180*** (0.02)	0.179*** (0.02)	0.180*** (0.02)
Industry	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.239	0.240	0.239	0.240
N	2932	2932	2932	2932

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

Source: ZEW ICT survey 2015 & Facebook.





Download ZEW Discussion Papers from our ftp server:

<http://ftp.zew.de/pub/zew-docs/dp/>

or see:

<https://www.ssrn.com/link/ZEW-Ctr-Euro-Econ-Research.html>

<https://ideas.repec.org/s/zbw/zewdip.html>



**IMPRINT**

**ZEW – Leibniz-Zentrum für Europäische  
Wirtschaftsforschung GmbH Mannheim**

ZEW – Leibniz Centre for European  
Economic Research

L 7,1 · 68161 Mannheim · Germany

Phone +49 621 1235-01

info@zew.de · zew.de

Discussion Papers are intended to make results of ZEW research promptly available to other economists in order to encourage discussion and suggestions for revisions. The authors are solely responsible for the contents which do not necessarily represent the opinion of the ZEW.