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

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**Abstract**

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

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

**Keywords: social media, knowledge sources, product innovation**

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# 1 Introduction

In today's information-rich environment, a firm's competitive advantage is increasingly determined by the leverage of external knowledge (Tambe et al., 2012). Social media including online social networks and microblogging services, open up new possibilities to exploit this knowledge. As the largest of these platforms, Facebook has about 1.8 billion monthly active users as of the end of September 2016 and is also of great importance with respect to the time spent online by the average user (GlobalWebIndex, 2016).[1] Attracted by the opportunity to access a large user base, firms increasingly adopt a social media presence with Facebook being the favourite platform with more than 60 million business pages in September 2016[2] (Stelzner, 2016).

While the main purpose of social media is marketing, business surveys show that it also relates to other firm operations such as receiving customer feedback in order to improve products and services (German Federal Statistical Office, 2015). Accordingly, it provides faster and less costly access to knowledge thereby facilitating product development and innovation due to users' input (Roberts and Piller, 2016). A study by Bertschek et al. (2015) shows that for firms in the German cultural and creative industries, customers are one of the most important sources of information for realising innovation projects, while for more than half of the firms social media platforms represent an information source and are thus more important than research institutes or consulting firms. As examples show, 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). One particular case is the product line FRITZ!Box by AVM, a major German manufacturer of telecommunication devices for end consumers, which actively seeks user input on its Facebook page and receives a considerable amount of feedback which led to several suggested new features being implemented over the span of a few months. Using Facebook as an information source has been facilitated by the launch of Facebook's Topic Data service, a tool for companies that anonymously gathers information from Facebook users, one purpose of which is to improve the firms' products and services.[3] Beyond anecdotal evidence of sourcing information from social media users, there is, to the best of our knowledge, no large-scale empirical evidence on whether

[1] `https://newsroom.fb.com/company-info`, accessed on 28 January 2016.

[2] `http://venturebeat.com/2016/09/27/facebook-60-million-businesses-have-pages-4-million-actively-advertise/`, accessed on 28 January 2016.

[3] `http://www.wsj.com/articles/facebook-takes-on-new-role-marketing-consultant-1426036185`, accessed on 28 January 2016.

or not firms' external focus in the form of a social media presence significantly enables corporate innovation.

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

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

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

# 2 Related Literature

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

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

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

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

Aral et al. (2013) argue that social media in general transform firm boundaries, thereby creating a new way to interact with customers. Accordingly, studies focus on marketing outcomes such as user engagement based on firms' social media content and on the targeting of this content (Lee et al., 2016; Miller and Tucker, 2013). Consumers' purchase expenditures or shopping visits are positively affected by targeted content and user engagement (Goh et al., 2013; Rishika et al., 2013). However, the aforementioned advantages of social media not only affect marketing outcomes, but also might increase firm value more generally. Firms' adoption and use of social media might affect firm performance through user engagement and user attention (Chung et al., 2015). Because of the real-time content produced by users, social media can even serve as a predictor of firm value (Luo et al., 2013). However, in order to fully reap the benefits from user-generated information on social media a firm may need complementary data analysis skills (Hitt et al., 2016). This finding implies that absorptive capacity (Cohen and Levinthal, 1989, 1990) is also necessary in the case of social media (Culnan et al., 2010). This is also in line with Aral et al. (2013), who state that it is necessary to account for organisational characteristics such as the interdepartmental coordination when looking at the transformative impact of social media platforms. As a consequence, engaging with customers on social media potentially creates a new channel for (open) innovation. However, there is so far only small-scale evidence of a positive relationship for firms' social media presence and innovation (Roberts et al., 2016; Mount and Garcia Martinez, 2014).

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

# 3 Analytical Framework

Following the evidence provided by the literature outlined above, we employ the concept of the knowledge production function introduced by Griliches (1979) and employed in many empirical (open) innovation studies (see for instance Freel, 2006, Griffith et al., 2006, Laursen and Salter, 2006, and Roper et al., 2008). Accordingly, we assume that a firm's innovation output is determined by both internal as well as external knowledge sources. Therefore, a firm's innovation output (INNO) may depend on knowledge sources directly related to the innovation process, such as internal and external research and development (R&D). Moreover, the firm's social media presence (SM) is considered a medium for externally sourcing ideas and feedback from customers that might help the firm to further improve its products and services or to develop new ones. In our analysis, measures of social media activity comprise the firm's adoption of Facebook, the activity by the firm and the activity by the users on Facebook. Since quantitative Facebook measures cannot inform us about the exact purpose of firms' social media use and about users' actual input, we apply a qualitative analysis of the content provided by firms and users allowing us to dig deeper into the actual activities on firms' Facebook pages. Measures of Facebook activities might also reflect firms' technical affinity and openness more generally. Therefore, in the estimations we control for firms' information technology (IT) intensity, which is determined by the use of enterprise resource planning (ERP) software and the percentage of employees working predominantly with computers. Further control variables (X) account for firm size, qualification and age structure of the workforce, industry-specific effects and firms' export status. Hence, the probability of firm $i$ introducing an innovation can be written as:

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

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 both in terms of products and services as well as in terms of processes. We expect Facebook activity to only have an impact on product innovation whereas process innovations should not be influenced. Customers are interested in firms' products and services rather than in their internal processes, while firms also do not usually inform consumers about their processes or workflows. Therefore, our first main hypothesis is that Facebook

activity has a positive impact on the probability of firms realising a product innovation, but has no impact on process innovation.

Both firms and users might engage in social media in various ways. Therefore, it depends on the purpose for which firms use social media and on the quality of users' feedback whether or not firms can realise product innovations. In the case of Facebook, it is unclear from the outset whether firms use it with the purpose of gathering information or for marketing, for example. Similarly, it is unclear, whether users provide feedback that is helpful for improving products and services, or whether the feedback is generally not informative. Therefore, our second main hypothesis is that the impact of Facebook activity on product innovation depends on the content of firms' and users' activities.

In order to test for the first hypothesis, we analyse whether a firm's Facebook presence is in fact a specific determinant of a product innovation, while a placebo regression is also run with process innovation as the dependent variable. The second hypothesis is tested by employing a content analysis of both user activity and firm activity on firms' Facebook pages in order to see whether length and sentiment of user activity matter as well as to verify whether firms actually use Facebook to actively source information from users. In order to check the robustness of our results, we run a large set of further regressions: (i) Both customer attention and firm attention are considered as additional explanatory variables to control for further sourcing channels and to account for firms' openness. (ii) Several alternative measures of social media activity reflect the interaction between firms and users. (iii) Path dependency of innovation implying that success breeds success (Peters, 2009; Flaig and Stadler, 1994) is taken into account by including the lagged innovation success approximating a cumulation of prior innovation activities as another explanatory variable for a subsample of firms. Finally, (iv) an instrumental variable approach is employed to consider the endogeneity problem resulting from reverse causality with innovative firms being more likely to adopt new technologies such as social media and having a more active presence of both the firm and users on social media, than less innovative firms. Identification relies on a combination of two variables indicating a firm's business-to-consumer (B2C) focus (see also section 4.4). Firms operating in the end consumer market, as opposed to business-to-business (B2B) firms, are more likely to communicate with their customers by means of an external social media platform such as Facebook. Hence, a variable indicating the firm's market focus predicts the likelihood of a Facebook presence and its activity, which has also been suggested by prior research and business surveys (Culnan et al., 2010; Stelzner, 2016). At

the same time, firms being more active in the B2C market do not systematically differ from B2B firms with respect to their innovative output.

# 4 Data and Measures

The data basis used for the empirical analysis is the 2015 wave of the ZEW ICT survey, a business survey carried out by the Centre for European Economic Research (ZEW).[4] The sample is stratified according to 17 manufacturing and service sectors and three size classes with respect to the number of employees. The data set comprises 4,510 firms located in Germany. Detailed information on the use of ICT, innovation activity, size, attributes of employees, and many further firm characteristics are included. After cleaning the data and taking account of item non-response, the estimation sample is reduced to 2,932 observations.[5]

## 4.1 Innovation

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

- *Product Innovation Dummy* is measured by a dummy variable indicating whether or not a firm has introduced new or significantly improved products or services to the market between 2011 and 2013.[6]

For a subsample of firms, information on the lagged realisation of a product innovation is available, which is defined analogously and covers the period from 2007 to 2009. For a placebo regression, realised process innovation is employed as a further measure of innovation output.

- *Process Innovation Dummy* is measured by a dummy variable indicating whether or not a firm has internally introduced new or significantly improved processes between 2011 and 2013.

[4]See Bertschek et al. (2017) for further details. The data is available at the ZEW Data Research Centre (`http://kooperationen.zew.de/en/zew-fdz`, accessed on 28 January 2016).

[5]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 stratification criteria as shown in Table 2, implying that observations are missing at random.

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

## 4.2 Social Media

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

In order to present a more detailed picture of firms' social media activities and of their interaction with users, we enrich the survey data with external information from the firm-initiated 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.[7]

The information regarding a firm's social media presence on Facebook is obtained for the surveyed firms following the standardised procedure outlined in Appendix 7.1. Based on the profile information, the data of the firm's Facebook page activity from the year 2013 is collected[8] 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:

- *Facebook Dummy* is a dummy variable equal to the value one, if the firm has a Facebook page.
- *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.

[7]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.

[8]See Section 7.1.1 in the Appendix 7.1 for the procedure.

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

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

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.[9] Following data processing[10], every word of a user comment is compared with the dictionary, with the sum of detected weights (of corresponding words) resulting in a score for each user comment.

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

Finally, to take into account whether firms actually use Facebook to explicitly source information from users, a qualitative analysis of the firm posts is employed. 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.[11] Each firm post is analysed with respect to engaging keywords resulting in the following variables:

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

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

[10] 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.

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

## 4.3 Further Firm Characteristics

Further variables that might be relevant for firms' innovation activity based on previous research are presented in the following.[12] 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. We consider firm size as another important determinant of innovation activity (see for example Schumpeter, 1942, and Cohen and Levinthal, 1989) and measure it by the number of employees and gross investments. Furthermore, the qualification and age structure of employees are taken into account. They reflect the internal knowledge of the firms and the openness of the workforce towards new technologies. Additionally, firms' export activity is included as a measure of exposure to international competition, which has been shown to be positively correlated with firm performance (see for instance Wakelin, 1998, and Wagner, 2012). Finally, 17 dummy variables control for industry affiliation.

As a robustness check a variable from the survey is introduced indicating whether firms actually use the Internet as an information sourcing tool, while another control variable approximates the diffusion of Internet among employees. In order to include further channels of customer attention, a variable is created based on data from the Google search volume for the firm.[13]

## 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

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

[13] 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.

firm's B2C focus, which is assumed to be exogenous and to affect firms' innovation success only through their social media presence. We thereby follow McElheran (2015) and construct the share of output devoted to private consumption on a NACE 2-digit industry level based on the latest input-output tables published by the German Federal Statistical Office.[14] 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:

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

# 5 Results

## 5.1 Descriptive Statistics

The descriptive statistics in Table 3 show that on average half of the firms in the estimation sample have introduced at least one product innovation, whereas 60.5 percent have implemented a process 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.[15] 56.8 percent of the firms employ an ERP software system and about 46.1 percent of the employees predominantly work with computers. The sample mainly consists of small and medium-sized enterprises with an average size of 103.1 employees and gross investments of about one million euro. Nearly a quarter of the firms systematically source information online, whereas on average 57.8 percent of the employees have access to the Internet. Google actually tracks the search volume for only 25 percent of the firms, suggesting the estimation sample largely contains lesser known firms (figure not presented), which is also

[14] `https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/VGR/InputOutputRechnung/InputOutputRechnung.html`, accessed on 28 January 2016.

[15] This corresponds to the R&D shares as measured for instance by data from the German CIS (`http://www.zew.de/fileadmin/FTP/mip/16/mip_2016.pdf`, accessed on 28 January 2016.)

evident from the relative search volume of 0.23 for the average firm which corresponds to only a fraction of the benchmark. 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.

[TABLE 3 ABOUT HERE]

Table 4 shows descriptive statistics for the firms' social media presence. On average, 46.4 percent of the firms use social media, i.e. at least one out of the four applications given in the survey. The most popular social media applications are online social networks, which are used by 31 percent of the firms in the sample. They are followed by collaboration platforms (21.8 percent), wikis (14.5 percent) and (micro-)blogs (7.8 percent). Table 4 also shows summary statistics for the 605 firms (20.6 percent) of the estimation sample with a Facebook page.[16] These firms have on average 75.3 firm posts and 150.6 user comments for 2013, while the average firm writes 12.3 comments and receives 8.5 user posts. The average user comment has 40.6 characters. For the average firm, 6 percent of the user comments are classified negative compared to 34.6 percent being positive, while the ratio of the two measures is 15.9 percent. Nearly three out of four firms write posts containing engaging keywords, while on average 18.4 percent firm posts are engaging, thus suggesting that firms are indeed interested in user input on Facebook.

[TABLE 4 ABOUT HERE]

Table 5 compares firms with and without a Facebook page with respect to firm characteristics. Firms using Facebook have a higher rate of product and process innovators and are more IT intensive. They are larger, 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]

[16] 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.

As can be seen in Figure 1, 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 seen in Figure 2. As an example, the average firm in the retail trade sector has 20.9 firm 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 1 user comment, on average.

[FIGURES 1 AND 2 ABOUT HERE]

## 5.2 Econometric Results

Table 6 shows the baseline OLS estimations[17] for product innovation output as the dependent variable and the three Facebook measures along with the outlined covariates as explanatory variables. The coefficient of Facebook adoption indicates a highly significant increase of 5.8 percentage points in the likelihood to introduce a product innovation, while firms' Facebook activity measured by the number of firm posts is insignificant. User activity measured by the number of user comments is significantly and positively correlated with the probability of realising a product innovation with 100 additional user comments (in a year) corresponding to a 0.4 percentage point higher likelihood of realising a product innovation. These effects remain in specifications containing two or three of these measures at once (columns 4 to 6 of Table 6). 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.

This is line with our two main hypotheses: Facebook activity has a positive impact on product innovation, however, firms' and users' activities show different effects. The following analysis

[17]We run 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.

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

[TABLE 6 ABOUT HERE]

**Placebo Regressions**

In order to show that a firm's Facebook presence is specifically a determinant of product innovation output, a placebo regression is conducted with the implementation of a process innovation as an alternative innovation output for which the Facebook presence is arguably irrelevant. Table 7 shows that neither the firm's Facebook adoption nor firms' or users' activities on the firm's Facebook page are significantly correlated with the probability to implement a process innovation, thereby confirming our first hypothesis. In contrast, the share of sales spent for R&D, the use of ERP software, the share of employees using a computer, gross investments, export activity and the age structure of the employees are also significant determinants in the case of process innovation.

[TABLE 7 ABOUT HERE]

**Content Analysis**

Concerning our second main hypothesis, as a next step, qualitative Facebook measures are considered as explanatory variables (Table 8). The average user comment length as a first proxy of quality is positively and significantly correlated with the probability of realising a product innovation. When distinguishing the user input by its sentiment, only the share of negative user comments is significant, suggesting a higher share of negative user comments to be correlated with a higher probability to develop new products and services or to improve existing ones. This is reflected by a significant coefficient with respect to the ratio of negative user comments for a positive user comment. Furthermore, the results show that firms using keywords that encourage users to leave feedback, are significantly more likely to realise a product innovation, surpassing the size of the coefficient for firm's Facebook adoption. Accordingly, an increase in the share of firm posts that contain engaging keywords correlates with a higher probability of a product innovation. Thus, the results support our second hypothesis that it is the content of firms' and users' Facebook activities that matters with respect to product innovation output.

[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 level of Internet access among employees as control variables (Table 9) does not alter the findings of the baseline estimations. However, the coefficients of both Facebook adoption and user activity are smaller when online sourcing is considered as a control variable. Google search results as a further measure of customer attention and the share of employees with Internet access are of only weak significance, which is also due to a high correlation with firm size and IT intensity, respectively. In contrast, online sourcing is highly significant and positively correlated with the probability of introducing a product innovation, suggesting that the systematic search of external information on the Internet is relevant for product innovation.

[TABLE 9 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 10). Specifically, the firm's social network adoption variable from the ZEW ICT survey 2015 is significantly and positively correlated with the probability to introduce a product innovation. Similarly, the sign and significance of the coefficients for the number of firm posts and the number of user comments do not change considerably if the Facebook measures are rescaled by the number of employees, while user comments per firm post as a further rescaling is also significant. Interestingly, firm activity measured by the amount of firm comments is weakly significant and positively correlated with the probability to introduce a product innovation, suggesting that firms' additional interaction with users is another determinant. Finally, user posts as an alternative measure of user comments is similarly significantly and positively correlated with product innovation output.

[TABLE 10 ABOUT HERE]

**Taking Account of Path Dependency of Innovation**

Accounting for the hypothesis that (innovation) success breeds (innovation) success, the lagged innovation output is included as a further explanatory variable for a subsample. As Table 11

shows the lagged innovation variable is positively and significantly correlated with the current innovation output, while both effects of the firm's Facebook adoption and user activity remain, though with a lower level of significance.

[TABLE 11 ABOUT HERE]

**Instrumenting Social Media**

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

Table 12 presents the results. In the first stage, the B2C indicator is, as expected, positively and significantly correlated with all three variables: the firm's Facebook adoption, firm activity and user activity. The F-test values of the first stage suggest that the instruments are relevant, with the magnitude being larger than 10. Other factors explaining Facebook adoption are the share of employees working with computers, firm size measured by the number of employees, age structure of employees and export status. Similar determinants are significant for both the firm activity and user activity, except for the age structure. Instead, the qualification structure of employees plays a significant role for the two measures of activity. In the second stage estimation, the coefficient of firms' Facebook adoption is now less significant for product innovation, while firms' Facebook activity is now weakly significant. For Facebook user activity, the coefficient for the number of user comments is still significantly positive for the probability of realising a product innovation, yet of less significance compared to the OLS estimation.[18] The results of the instrumental variable analysis are in favour of a causal and positive effect of Facebook activity on product innovation output. Firms seem to benefit from their users' feedback on Facebook in terms of a higher probability of introducing a product innovation.

[18]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.

[TABLE 12 ABOUT HERE]

# 6 Discussion and Conclusion

We examine the role of firms' social media presence, specifically on Facebook, in firms' product innovation success. Firms can use this channel to communicate with their customers, to receive their feedback and their ideas in order to improve existing products and services or to develop new ones. Our results suggest that the probability of introducing a product innovation is positively and significantly correlated with firms' adoption of Facebook and user feedback. Information gathered from users' comments seems to be channelled in a way that helps firms to improve or further develop their products and services or to create new products and services. Our results withstand a large set of robustness checks, i.e. controlling for further sourcing channels, considering alternative measures of social media activity, taking previous innovation success into account and running placebo regressions with process innovation as the dependent variable. 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.

The results are in line with our two main hypotheses. First, firms' Facebook adoption and user activity on firms' Facebook pages are relevant for firms' product innovation but not for their process innovation. Since firms communicate with users about their products and services and not about their internal processes this result is plausible. It is supported by placebo regressions with process innovation as the dependent variable revealing insignificant coefficients of Facebook measures. Second, when analysing the activity and the content provided on Facebook by firms and by users, the analysis shows that firms benefit from their Facebook activity not by the quantity of posts but rather from actively encouraging users to give feedback. Thus, from a firm's perspective, instead of posting generic information, sending information that encourages users to provide their feedback is crucial for innovation success. With respect to the content of user feedback, the results show that, besides the length of user comments, in particular negative user comments are associated with firms' innovation success. This result does not necessarily imply that positive user feedback is useless for firms at all, but maybe it rather matters from a marketing perspective; users who buy the firms' products and like them are more likely to provide positive comments and contribute to firms' sales but not to their innovation output. By contrast, negative feedback helps firms to identify problems and to improve their products

and services. Firms might even feel urged to improve their products and services if they are publicly criticised on their Facebook page. The results of our analysis are also in line with the concept of open innovation in the sense that they highlight the importance of customers or users in the innovation process, an aspect that has so far been under-researched in the open innovation literature.

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

Our analysis has some limitations. Firstly, it is focussed on mainly small and medium-sized enterprises located in Germany, so the results can only generally be applied to countries with a similar industry structure. Since German firms are rather conservative with respect to the adoption of new technologies, however, we might expect that the role of social media is rather more important in countries where firms and users are more open towards the adoption of new technologies. Secondly, our analysis is focussed on Facebook as the social media platform of interest. Due to the high proliferation rate of Facebook we might expect that different platforms play minor roles for firms' innovation output. Future studies might include different social media channels. Thirdly, the analysis is based on a data base that is unique with respect to its combining comprehensive information from a firm survey with information from firms' Facebook pages. Although this way of combining different data sets might be a guiding approach for future research, the data set at hand is a cross section and we are thus unable to account for unobserved heterogeneity. The availability of panel data with comparable information should provide further evidence on the role of social media in firms' innovation success.

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# 7 Appendix

## 7.1 Facebook Data

### 7.1.1 Facebook Profile Research

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

### 7.1.2 Facebook Data Collection

Facebook provides an application programming interface (Graph API) to request data directly from the platform with requests ranging from objects, information about objects to connections between objects, where an object might, for example, correspond to a profile or post.[19] Every Facebook user is able to collect publicly available information from Facebook profiles, as is the case with firms' Facebook pages by means of the Graph API Explorer. Having an access token allows to access the respective Facebook page and choose which information on the Facebook page to examine. Following this procedure, several tools are used to query the Graph API more systematically, such as the Python software development kit for Facebook with a script collecting information from all the posts on the firm's Facebook page.

[19] `https://developers.facebook.com/docs/graph-api/overview`, accessed on 28 January 2016.

### 7.1.3 Engaging Firm Post Keywords

[Ändern, Angabe, Anklang, Anliegen, Anmerkung, Anregung, Ansicht, Anspruch, Antwort, Aufschluss, Auskunft, Äussern, Austausch, Beanstandung, Bedarf, Bedeutung, Befund, Beitragen, Beobachtung, Bericht, Beteiligen, Bitte, Defekt, Denkanstoss, Eindruck, Einfall, Einsatz, Einschätzung, Einwand, Einwurf, Empfehlen, Empfinden, Engagement, Entdecken, Entfalten, Entscheiden, Entwickeln, Entwurf, Erfinden, Ergebnis, Erhebung, Erkenntnis, Ermessen, Erwartung, Erweitern, Fantasie, Fazit, Feedback, Fehler, Feststellen, Forschen, Gedanke, Gefallen, Geschmack, Gestalten, Hilfe, Hinweis, Idee, Impression, Impuls, Initiative, Innovation, Inspirieren, Interesse, Intuition, Kreativität, Kritik, Lob, Lösung, Mängel, Meinung, Mitarbeit, Mitteilen, Mitwirken, Modifikation, Nachfrage, Neuerung, Note, Perspektive, Probe, Problem, Rat, Reaktion, Resonanz, Rezension, Rückmeldung, Stellenwert, Stimme, Teilhabe, Teilnahme, Test, Tipp, Überlegen, Überzeugen, Umfrage, Unterstützen, Untersuchen, Urteil, Verbessern, Verlangen, Versuch, Vorliebe, Vorschlag, Vorstellung, Vote, Wahl, Wahrnehmung, Wertung, Wunsch, Zeugnis, Zufrieden]

## 7.2 Firm Characteristics

Table 1: Detailed Explanation of Firm Characteristics

| | |
|---|---|
| % R&D Expenses | firm expenditure on internal and external R&D activities as a share of sales. |
| ERP Software Dummy | a dummy variable that takes the value one if a firm uses an enterprise resource planning software for planning, coordination and controlling. |
| % Employees using PC | percentage share of employees working predominantly with computers. |
| Number of Employees | yearly average measure excluding marginal employment. |
| Gross Investment | gross addition to fixed and financial assets in million €. |
| % High-skilled Employees | proportion of employees with a degree from university, university of applied sciences or university of cooperative education. |
| % Medium-skilled Employees | proportion of master craftsmen, technicians and persons having successfully completed vocational training. |
| % Employees $<$ age 30 | proportion of employees who are younger than thirty years. |
| % Employees $\geq$ 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[20]worldwide for Google web search in 2013. |

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

## 7.3 Tables & Figures

Table 2: Industry Distribution

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

The full sample is displayed without the firms affiliated with none of the considered industries or with the very heterogeneous industry "Other Manufacturing".
Source: ZEW ICT survey 2015.

Table 3: Summary Statistics

| | **Mean** | **SD** | **Min** | **Max** | **N** |
|---|---|---|---|---|---|
| Product Innovation Dummy | 0.496 | 0.500 | 0 | 1 | 2932 |
| Process Innovation Dummy | 0.605 | 0.489 | 0 | 1 | 2932 |
| Product Innovation 2010 Dummy | 0.539 | 0.499 | 0 | 1 | 888 |
| % R&D Expenses | 0.051 | 0.113 | 0 | 1 | 2932 |
| ERP Software Dummy | 0.568 | 0.495 | 0 | 1 | 2932 |
| % Employees using PC | 0.461 | 0.347 | 0 | 1 | 2932 |
| Number of Employees | 103.090 | 294.561 | 5 | 4500 | 2932 |
| Gross Investment | 0.990 | 4.863 | 0 | 130 | 2932 |
| % High-skilled Employees | 0.196 | 0.245 | 0 | 1 | 2932 |
| % Medium-skilled Employees | 0.626 | 0.269 | 0 | 1 | 2932 |
| % Employees $<$ age 30 | 0.238 | 0.175 | 0 | 1 | 2932 |
| % Employees $\geq$ age 50 | 0.271 | 0.185 | 0 | 1 | 2932 |
| Export Dummy | 0.458 | 0.498 | 0 | 1 | 2932 |
| Online Sourcing Dummy | 0.237 | 0.426 | 0 | 1 | 2932 |
| % Employees with Internet | 0.578 | 0.372 | 0 | 1 | 2932 |
| Google Trends | 0.227 | 2.335 | 0 | 77 | 2932 |
| B2C Dummy | 0.411 | 0.492 | 0 | 1 | 2932 |
| % B2C Industry Output | 0.213 | 0.239 | 0 | 1 | 2932 |
| B2C Indicator | 0.519 | 0.820 | 0 | 2 | 2932 |

Source: ZEW ICT survey 2015/2010.

Table 4: Summary Statistics, Social Media

| | **Mean** | **SD** | **Min** | **Max** | **N** |
|---|---|---|---|---|---|
| Social Media Dummy | 0.464 | 0.499 | 0 | 1 | 2932 |
| External Social Media Dummy | 0.319 | 0.466 | 0 | 1 | 2932 |
| – Social Network Dummy | 0.310 | 0.463 | 0 | 1 | 2932 |
| – Blog Dummy | 0.078 | 0.267 | 0 | 1 | 2932 |
| Internal Social Media Dummy | 0.305 | 0.460 | 0 | 1 | 2932 |
| – Wiki Dummy | 0.145 | 0.352 | 0 | 1 | 2932 |
| – Collaboration Dummy | 0.218 | 0.413 | 0 | 1 | 2932 |
| Facebook Dummy | 0.206 | 0.405 | 0 | 1 | 2932 |
| Firm Posts | 75.311 | 210.547 | 0 | 3194 | 605 |
| Firm Comments | 12.374 | 39.529 | 0 | 395 | 605 |
| User Comments | 150.600 | 831.990 | 0 | 12983 | 605 |
| User Posts | 8.527 | 42.934 | 0 | 634 | 605 |
| Average User Comment Length | 40.638 | 39.577 | 0 | 244 | 605 |
| % Negative User Comments | 0.060 | 0.114 | 0 | 1 | 605 |
| % Positive User Comments | 0.346 | 0.314 | 0 | 1 | 605 |
| Ratio Negative/Positive User Comments | 0.159 | 0.316 | 0 | 3 | 605 |
| Engaging Firm Post Dummy | 0.744 | 0.437 | 0 | 1 | 605 |
| % Engaging Firm Posts | 0.184 | 0.184 | 0 | 1 | 605 |

Source: ZEW ICT survey 2015 & Facebook.

Table 5: Summary Statistics by Facebook Adoption

| | **w/ Facebook** | | | **w/o Facebook** | | |
|---|---|---|---|---|---|---|
| | Mean | SD | N | Mean | SD | N |
| Product Innovation Dummy | 0.592 | 0.492 | 605 | 0.471*** | 0.499 | 2327 |
| Process Innovation Dummy | 0.669 | 0.471 | 605 | 0.588*** | 0.492 | 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 $\geq$ age 50 | 0.227 | 0.160 | 605 | 0.282*** | 0.190 | 2327 |
| Export Dummy | 0.498 | 0.500 | 605 | 0.448*** | 0.497 | 2327 |
| Online Sourcing Dummy | 0.380 | 0.486 | 605 | 0.200*** | 0.400 | 2327 |
| % Employees with Internet | 0.659 | 0.363 | 605 | 0.556*** | 0.372 | 2327 |
| Google Trends | 0.818 | 5.023 | 605 | 0.074*** | 0.451 | 2327 |
| B2C Dummy | 0.463 | 0.499 | 605 | 0.397*** | 0.489 | 2327 |
| % B2C Industry Output | 0.243 | 0.260 | 605 | 0.205*** | 0.233 | 2327 |
| B2C Indicator | 0.669 | 0.891 | 605 | 0.480*** | 0.796 | 2327 |

Source: ZEW ICT survey 2015/2010 & Facebook.
Mean differences significant at *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Facebook Adoption by Industry

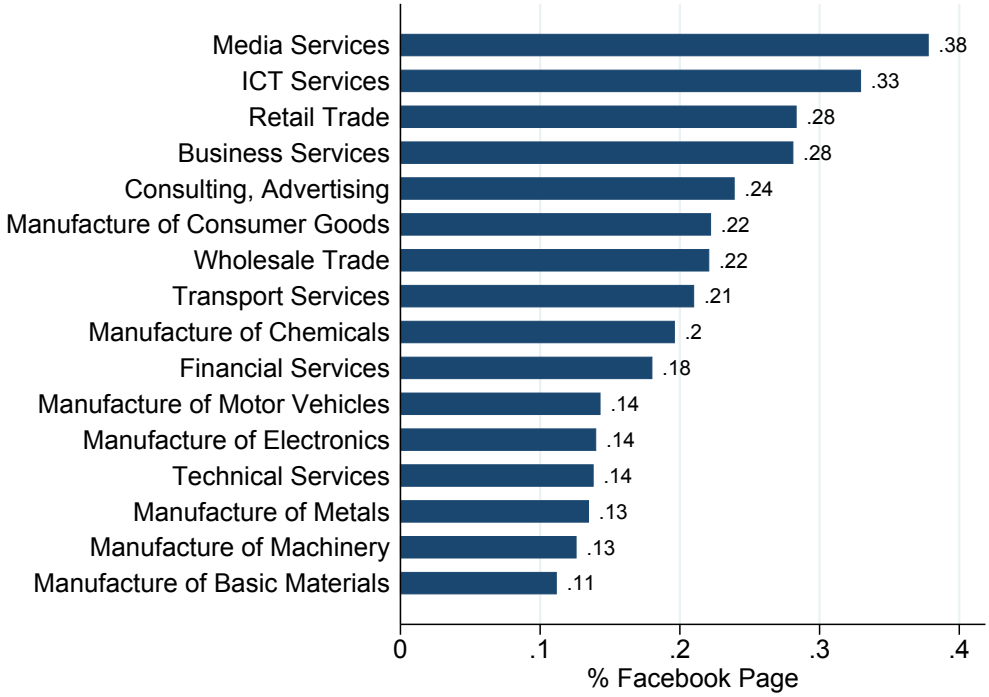


Figure 2: Facebook Activity by Industry

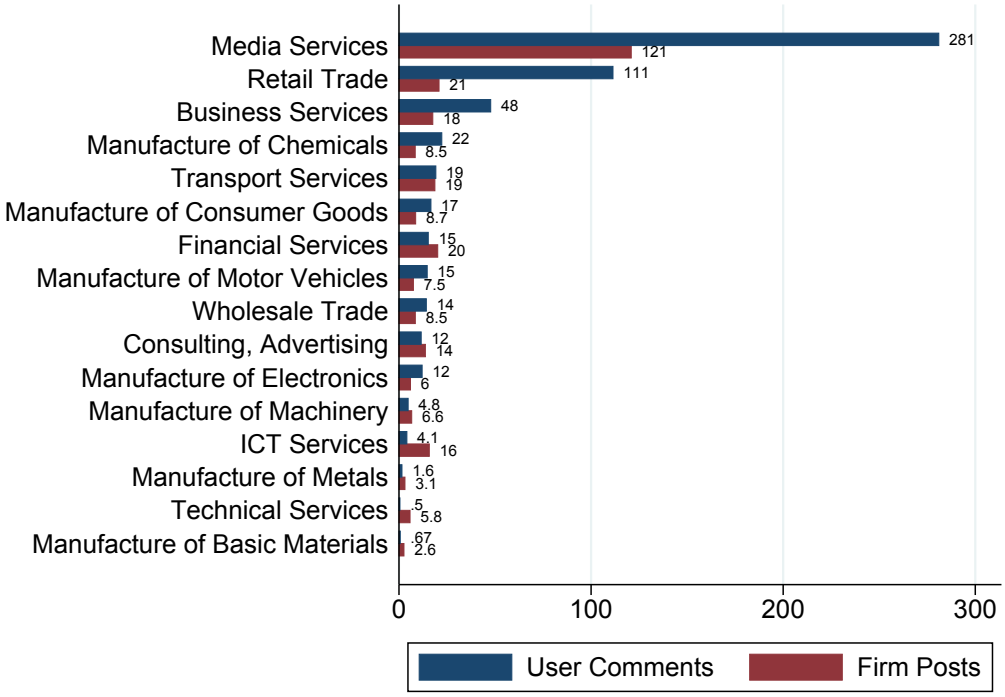

Table 6: OLS, Baseline

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

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Firm Posts and User Comments are measured in hundreds.
Source: ZEW ICT survey 2015 & Facebook.

Table 7: OLS, Process Innovation

| | **Process Innovation** | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| Facebook Dummy | 0.000 | | |
| | (0.02) | | |
| Firm Posts | | -0.002 | |
| | | (0.01) | |
| User Comments | | | -0.001 |
| | | | (0.00) |
| % R&D Expenses | 0.277*** | 0.277*** | 0.277*** |
| | (0.08) | (0.08) | (0.08) |
| ERP Software Dummy | 0.154*** | 0.154*** | 0.154*** |
| | (0.02) | (0.02) | (0.02) |
| % Employees using PC | 0.175*** | 0.175*** | 0.175*** |
| | (0.04) | (0.04) | (0.04) |
| Number of Employees (in logs) | 0.007 | 0.007 | 0.007 |
| | (0.01) | (0.01) | (0.01) |
| Gross Investment (in logs) | 0.033*** | 0.033*** | 0.033*** |
| | (0.01) | (0.01) | (0.01) |
| % High-skilled Employees | -0.052 | -0.050 | -0.050 |
| | (0.06) | (0.06) | (0.06) |
| % Medium-skilled Employees | -0.082* | -0.082* | -0.082* |
| | (0.04) | (0.04) | (0.04) |
| % Employees $<$ age 30 | 0.226*** | 0.226*** | 0.226*** |
| | (0.05) | (0.05) | (0.05) |
| % Employees $\geq$ age 50 | -0.129*** | -0.130*** | -0.129*** |
| | (0.05) | (0.05) | (0.05) |
| Export Dummy | 0.058*** | 0.058*** | 0.058*** |
| | (0.02) | (0.02) | (0.02) |
| Industry | Yes | Yes | Yes |
| $R^2$ | 0.130 | 0.130 | 0.130 |
| N | 2932 | 2932 | 2932 |

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Firm Posts and User Comments are measured in hundreds.
Source: ZEW ICT survey 2015 & Facebook.

Table 8: OLS, Content Analysis

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

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Source: ZEW ICT survey 2015 & Facebook.

Table 9: OLS, Customer and Firm Attention

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

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Firm Posts and User Comments are measured in hundreds.
Source: ZEW ICT survey 2015 & Facebook.

Table 10: OLS, Alternative Social Media Measures

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

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Source: ZEW ICT survey 2015 & Facebook.

Table 11: OLS, Lagged Product Innovation

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

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Firm Posts and User Comments are measured in hundreds.
Source: ZEW ICT survey 2015/2010 & Facebook.

Table 12: Instrumental Variable

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

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Firm Posts and User Comments are measured in hundreds.
Source: ZEW ICT survey 2015 & Facebook.