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Do German Works Councils Counter or Foster the Implementation of Digital Technologies?

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ABSTRACT

Do German Works Councils Counter or Foster the Implementation of Digital Technologies?*

As works councils' information, consultation and co-determination rights affect the decision process of the management, works councils play a key role in the implementation of digital technologies in establishments. However, previous research focuses on the potential of digital technologies to substitute for labor and its impact on labor market outcomes of workers. This paper adds the role of industrial relations to existing literature by analyzing the impact of works councils on the implementation of digital technologies. Theoretically, the role of works councils in the digital transformation is ambiguous. Using establishment data from the IAB Establishment Survey of 2016 combined with individual employee data from the Federal Employment Agency and occupational level data about the physical job exposure, empirical evidence indicates an ambivalent position of works councils towards digital technologies. The sole existence of works councils leads to statistically significant lower equipment levels with digital technologies. However, works councils foster the equipment with digital technologies in those establishments, which employ a high share of workers who are conducting physical demanding job activities. Thus, this study highlights the importance of establishment-level workforce representation for the digital adoption process within Germany.

JEL Classification: J50, J53

Keywords: co-determination, digital technologies, works councils, industrial relations, entropy balancing

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1 Introduction

Tremendous technological progress has occurred in the last years in the information and communication sector. Smart factories, big data, industry 4.0, robotic, artificial intelligence and cloud services are typical buzzwords which refer to digital technologies. Modern automation and digital technologies allow new forms of interaction and communication between humans and machines. The capability of this technology to connect facilities, products, workers and customers might substantially change previous working conditions and working environments. Machines might lessen the physical strain of employees by taking over physically demanding activities or monotonous and repetitive tasks (Arnold et al. 2016; Becker 2015; Dombrowski et al. 2014). Technology might contribute to safer working environments due to automated monitoring processes based on real-time responses and the performance of work in hazardous workplace environments (BMAS 2017; Korupp et al. 2006). From the management perspective, digital technologies are beneficial as they potentially increase the level of productivity and profits (Kagermann et al. 2013; Brynjolfsson/McAfee 2012).

Surprisingly, very little is known about the diffusion process of those digital technologies across establishments. Studies which evaluate the digital transformation process are rare as the availability of new technologies is much faster than the disposability of scientific data. We use very recent data of the IAB Establishment Panel, which contains information about the information procurement about modern automation technologies and the equipment with digital technologies. We merge the comprehensive set of information about establishment characteristics of the IAB Establishment Panel with administrative data of the Federal Employment Agency which provides insight in the occupational structure of the workforce. Thus, by providing an analysis of establishment properties which are crucial for the implementation process of digital technologies, we are among the first establishment-level studies which enhance the understanding about the usage of cutting-edge technologies. One of the first studies which captures the usage of digital technologies in Germany is based on the IAB-ZEW-Establishment survey "Working World 4.0" (Arntz et al. 2016a). This study reveals that 31 percent of the establishments have not even considered digital technology yet while 50 percent of the establishments state to already use digital technologies (Arntz et al. 2016a: 3f.). However, the reasons for this disparity in the implementation of digital technologies remain unexplained in the literature up to now. Genz et al. (2018) use the same data set to analyze how digital technology investments affect employees within firms. They find that firm-level investments in new digital technologies positively affect the wage growth of the workforce. Our paper contributes to economic literature by highlighting the role of the institutional framework and the industrial relations, namely the existence of works councils, for the implementation of digital technologies.

Thereby, we provide insight about the implementation process of digital technologies to the industrial relations literature. In Germany, one essential component of industrial relations is the employees' representation via works councils. Traditionally, works councils play an important role in the personnel development and equal employment opportunities of the workforce. Literature has focused on the effect of works councils on establishments' performance and innovation activity (for an overview see Jirjahn 2011; Addison et al. 2004; Frege 2002; Addison et al. 2001). However, this strand

of literature has not yet addressed the crucial advances in digital technologies. Recent technological innovations open up the potential scope of action of co-determination of works councils. On the one hand, works councils represent employees' interests, especially with regards to employment perspectives. On the other hand, they preserve a co-operative relationship with the management, who are focused on efficiency enhancement and investments into digital technologies. The positioning of the works councils is therefore crucial for the implementation process of digital technologies within establishments. Georg et al. (2017) conduct a qualitative study about works councils and digital devices. Up to our knowledge, our paper is the first quantitative study examining the relation between works councils and the implementation of digital technologies.

Furthermore, we apply a novel matching approach for the empirical investigation of the impact of works councils. We are among the first to apply entropy balancing weights in the industrial relations literature to overcome two major challenges in the empirical identification strategy. First, the existence of works councils is strongly correlated with the establishment size. In the majority of large establishments, workers are represented by works councils and large establishments are particularly interested in digital technologies. This might lead to the problem of spurious correlation. Second, an endogeneity problem might distort the results as workers might set up a works council as a reaction to the announcement of future restructuring of the company and the workforce as well as the investment into digital technologies.

The outline of the paper is as follows. Section 2 briefly discusses the usage of digital technologies and the role of works councils in Germany. The section concludes by developing theoretical considerations for the analysis. Section 3 presents the dataset, descriptive statistics and our methodological approach. Section 4 displays our results of the econometric investigation of works councils' role for the implementation of digital technologies in Germany. Eventually, Section 5 concludes.

2 Digital technologies and works councils in Germany

Modern automation and digitization technologies are capable to transform communication and cooperation between employees, facilities, logistics, products and customers. Digital technologies include among others autonomous robotics, smart factories, internet of things, or even analysis tools with big data, cloud services or online platforms. Our understanding of digital technologies follows the definition provided in the IAB Establishment Survey. The exact wording of the IAB Establishment Survey questionnaire can be found in the appendix in Section 7.1.

2.1 Current usage of digital technologies

The impact of new communication and information technology on the labor market is subject of a broad discussion in modern societies. The study by Frey/Osborne (2017) has stimulated the fear about massive employment loss by forecasting that 47 percent of the total employment in the U.S. is at risk to be substituted by robots and computer algorithms

in the next 20 years. This result has been discussed controversially among scientific literature. For instance, this estimate seems to be biased upwards, as this figure downsizes strongly as soon as the possibility of workers to adapt and switch tasks within occupations is taken into account (Arntz et al. 2017). Furthermore, it captures only the theoretical technological potential to substitute occupations and not the resulting employment effects (Autor 2015). Those theoretical potentials are merely partially exploited as for example economic, ethical or legal aspects are limiting the application of latest technologies. Frequently overlooked in the debate about the employment effects of digital technologies is the fact that job profiles may change as for example new tasks in existing occupations are developed and that new occupations are emerging due to cutting-edge technologies (Dengler/Matthes 2018). The calculation of potentials to substitute workers has also been carried out for the German labor market (see for example Arntz et al. 2016b; Bonin et al. 2015; Dengler/Matthes 2015).

Besides of the potentials to substitute workers, there is also a growing strand of literature which investigates the impact of the use of new automation technologies on employment levels. As there is a lack of data which comprises a direct measurement of latest digital technologies, literature has up to now used the diffusion of industrial robots and its impacts on the U.S. labor market (Acemoglu/Restrepo 2017; Graetz/Michaels 2016) as well as for Germany (Dauth et al. 2016). Other threats of an introduction of digital technologies besides the potential unemployment risk are among others increasing mental strain resulting from multitasking and higher pace of work (Arnold et al. 2016; Kraan et al. 2014; Chesley 2014), blurring boundaries between private and working life (Galvin/Schiemann 2012; Chesley 2014) and higher work intensity (Kraan et al. 2014).

Surprisingly, still relatively little is known about the decision processes within establishments about the timing, extend and manner how to adapt their value chain to automation and digital technologies. Early in the distribution process of computers and internet, studies have pointed out heterogeneities in the access of individuals to digital technologies (OECD 2002; OCED 2004). Arntz et al. (2016a) present first insights about the usage of cutting-edge digital technologies in Germany. Their results reveal a heterogeneous distribution of digital equipment across German establishments. While some establishments intensively use digital technologies, one third of the establishments has not yet discussed the potential benefits or the implementation of digital devices. Additionally, Genz et al. (2018) find that technological upgrading of establishments benefits the wage growth of the employees. Thus, heterogeneous diffusion of digital technologies across German establishments might also contribute to divergent wage growth potentials for workers across different establishments. Up to the recent moment, the causes for this disparity in the implementation of digital technologies remain unexplained in literature. Our study contributes to filling this research gap by analyzing differences in the industrial relations of establishments as a potential explanation mechanism for the heterogeneity in the usage of digital equipment in Germany. More specifically, we investigate on establishment-level whether works councils are associated with the knowledge about digital topics and the investment in digital technologies.

2.2 Works councils and technological change

Works councils are an important element of the industrial relations in Germany. If an establishment has more than five permanent employees, workers have the right to elect a works council which represents their interests towards the management or owner of the establishment. This formation right, as well as their information, consultation and co-determination rights, are set out in the Works Constitution Act ("Betriebsverfassungsgesetz", BetrVG; in the following abbreviated with WCA). Traditionally, works councils play an important role for the personnel development and their existence improves communication, loyalty and trust at the establishment level (Müller/Stegmeier 2017a; Jirjahn/Kraft 2011; Askildsen et al. 2006). A more detailed overview of the election process of works councils, their rights and their duties can be found for example in Addison et al. (2001). The majority of rights are granted to every elected works council. However, the scope of action for works councils expands with increasing number of employees. For example, the right to obtain complete information about changing work methods at an early stage must be given to works councils in establishments with more than 21 employees (Section 111 WCA). If the workforce exceeds the threshold of 100 employees, works councils may set up additional committees to assign them specific tasks and councils have the right to delegate certain tasks to working groups (Section 28 WCA). Furthermore, the number of employees normally employed in the establishment determines the amount of works council members to be released from their work duties (Section 38(1) WCA). If the establishment employs between 200 and 500 persons, one member of the works council shall be freed from their original tasks. For establishments with 501 to 900 employees the amount increases by one additional works council and so on (Section 38(1) WCA). The release from work duties allows works councils to concentrate on their responsibilities to represent and foster the interests of the workforce. Therefore, the effectiveness of works councils might increase if the number of employees in the establishment exceeds the thresholds for works council releases. However, a recent study has demonstrated that works councils do not utilize their scope of action for the co-determination in training programs grounded in the WCA (Iller et al. 2016). Thus, the rights as set out in the WCA and the real scope of action of works councils might diverge.

A comprehensive picture about the presence of works councils in Germany can be found in Ellguth/Kohaut (2017). In 9 percent of German establishments eligible to establish works councils, that is those who employ more than 5 permanent employees, this employee representation is constituted in the year 2016. The pattern of the existence of works councils does not show regional differences between Western and Eastern Germany. However, the coverage of works councils which is defined by the industrial relations literature as the proportion of employees working in establishments with works councils is higher in West Germany (43 percent) than in East Germany (34 percent). One important factor which determines the presence of works councils is the establishment size. Very few exceptions of small establishments have a works council while the majority of the large establishments is characterized by the presence of works councils (Ellguth/Kohaut 2017: 282f.). However, works councils are not existing in all eligible establishments since the formation of works councils is voluntary and depends on employees' initiative (Askildsen et al. 2006).

The importance of industrial relations is a well-established research field. Literature focuses on the effect of works councils on establishments' performance and productivity as well as on the employees' wages (for an overview see Jirjahn 2011; Addison et al. 2004; Frege 2002; Addison et al. 2001). Regarding the role of works councils for technological change, existing literature has analyzed the impact of works councils on the innovation activity of firms. Addison et al. (2001) present arguments for both negative and positive effects of works councils on innovation activity of establishments. However, the empirical evidence reveals neither convincing positive influence on product or process innovations nor evidence for hindering innovation activities. One theoretical "collective voice" argument asserts that works councils act as a voice instrument which builds trust and enhances communication and information flows between management and employees. Thus, the existence of works councils might lead to higher innovation activity within establishments. Several empirical studies tried to find evidence for this positive relationship. Blume/Gerstelberger (2007) do not find statistically significant results, Jirjahn/Kraft (2011) reveal a positive influence on incremental product innovations, however, no significant influence can be found for process innovation (Askildsen et al. 2006). A recent study finds only a significant positive influence of works councils when collective agreements are present (Addison et al. 2017). However, measuring product and process innovation activities of establishments narrows the analysis to those firms which are developers of modern technology. In contrast, analyzing heterogeneities in establishments' consideration and adaption of latest technologies allows broader conclusions about the relevance of works councils for technological change as every establishment is exposed to the availability of new technological advances within their specific sector. This article enhances, therefore, the existing literature by contributing insight into the role of works councils for the technology adaption within establishments.

Furthermore, the industrial relations literature has not yet focused on the very recent, crucial technical development of digital technologies. Generally, earlier studies presume that the active participation of works councils potentially shapes the use of new technologies within German establishments (such as Pfeiffer 2005). Only recently, a qualitative study has examined the relation between works councils and digital devices (Georg et al. 2017). Interviews with works councils reveal considerable uncertainties and challenges regarding the digital transformation in the majority of German establishments. Works councils doubt whether new technologies might affect the workforce and which role they can take over in the creation of a new work organization. Another works council survey finds, that 40 percent of the works councils asked in the survey associate the use of new digital technologies with potentials to improve employment conditions of the workforce (Ahlers 2018). Our article is the first quantitative study examining the role of works councils on the implementation of cutting-edge digital technologies and thus is closing this research gap.

2.3 Hypotheses for the link between works councils and the implementation of digital technologies

The implementation of digital technologies emphasizes the responsibility of works councils to mediate as a conflict solving institution between employees and management. Recent digital innovations might increase the conflict potential within establishments. For employees, the threat of losing their job and concerns about the privacy of employment data are dominating the discussion about digital technologies. Whereas the management frequently focuses on the benefits

of digital technologies such as efficiency enhancement, increasing productivity and prestige. As there is no theory available concerning works councils' theoretical scope for action with respect to the implementation of digital technologies, we develop in the following three theoretical arguments for the mechanism of action of works councils on the implementation of digital technologies based on the rights of works councils as set out in the WCA.

Literature which analyses the link between works councils and new technology has focused on the impact of works councils on the innovation activity of establishments as previously explained. This literature strand often assumes that works councils' collective voice enhances innovation activities within firms and thus works councils are positively linked with the creation of new technologies. However, our article focuses the implementation of novel digital technologies which are available on the market. This constitutes important new theoretical predictions for the hypothesis how works councils and novel technologies might be associated. A widely held view among managers and employers' associations is that the presence of works councils counters economic activities and technological progress within establishments (Müller/Stegmaier 2017b; Hübler 2003). This argument draws upon the use of wide-ranging co-determination rights of works councils. Changes in workplaces, work operations or working environment enable works councils to verify the impact of the introduction of new technologies on the existing workforce (Section 91 WCA). If a special burden is exposed to the employees, works councils may request appropriate interventions to obviate the burden. Works councils are also allowed to claim compensation for additional physical and psychological strain for the employees. Furthermore, works councils have the right to impede an impersonal and anonymous control of the performance and the behavior of employees by means of technological instruments, as those interventions into the personal rights cannot be observed and averted by the employees themselves (Section 87(1) No. 6 WCA). Thus, works councils have a veto right with respect to the implementation of digital technologies as automation and connectivity between persons and machines necessarily generates such data collecting personal performance information. This substantial scope of action of works councils narrows the freedom of action of the management. Even though the management has taken the decision to invest into digital technology, the process until the investment can be undertaken and the technology can be implemented in the place of work might consume considerably longer time as the works council has not only to be informed but also to be convinced. Thus, we formulate the first hypothesis:

Hypothesis 1: Works councils counter the implementation of digital technologies.

Hypothesis 1a: Establishments with works councils are considering digital topics less intensively.

Hypothesis 1b: Establishments with works councils are poorer equipped with digital technologies.

As works councils are commissioned to mediate between opposing interest of management and workforce (Section 2 WCA), they might particularly show active participation if one of the two parties is exposed to difficulties and requires the mediating role of works councils. Works councils might fulfill their role as an important channel for bottom-up communication (Müller/Stegmaier 2017a) if the employees are confronted with concerns. Employees might claim such active engagement of works councils if a large proportion of the workforce suffers from high physical strain at the

workplace. Following Kroll (2011) physical strain consists of ergonomically demanding work activities and environmental stress. Ergonomically demanding tasks are for example lifting heavy items, working in forced postures such as bending, kneeling, crouching, as well as occasional overhead work. Environmental stress is imposed by work involving exposure to noises, dusts, fumes, gases, insufficient illumination, shocks, oscillations or vibrations (Schlick et al. 2010). Works councils are explicitly instructed to protect health and safety at work (Section 89 WCA). Works councils might acknowledge the benefit of digital technologies which lessen the physical strain by substituting some of the physically demanding work activities (Arnold et al. 2016; Becker 2015; Dombrowski et al. 2014). Therefore, works councils might use their co-determination rights referring to the design of workplaces, work operations and working environments (Section 91 WCA) in order to enforce an improvement of the working conditions for the employees. Hence, we form our second hypothesis:

Hypothesis 2: Works councils foster the implementation of digital technologies if the workforce is exposed to high physical strain.

Hypothesis 2a: Establishments with works councils are considering digital topics more intensively if the workforce is exposed to high physical strain.

Hypothesis 2b: Establishments with works councils are better equipped with digital technologies if the workforce is exposed to high physical strain.

Works councils might be particularly engaged if the management is confronted with difficulties and requires the mediating role of works councils. Management often relies on works councils' assistance for top-down communication in order to generate larger workforce support for upcoming structural changes within the establishment (Freeman/Lazear 1995; Müller/Stegmaier 2017a). High competition between market competitors has the potential to exert pressure on the profitability of establishments and might endanger the continuing existence of the establishment. This can force the management to undertake substantial restructuring within the establishment. As labor costs constitute a large proportion of the debt on establishments' balance sheets, management might think about layoffs first. Works councils are instructed by law to secure employment and might therefore actively submit proposals to the employer relating to the security and the promotion of employment in order to prevent layoffs in this situation (Section 92a WCA). As it is one of the general duties of works councils to make recommendations to the employer for action benefiting the establishment and the staff (Section 80 WCA), an alternative suggestion to increase profitability and productivity might be to invest into digital technology (Kagermann et al. 2013). The high competitive pressure can also result from the fact that the market competitors already invested into digital technology, whereas the considered establishment has not taken this decision yet. In this case, works councils might contribute to an enlarged approval among the workforce as they can inform the employees about the background of managements' decisions (Müller/Stegmaier 2017a). This might contribute to an accelerated implementation process of new digital technology. Thus, we hypothesize:

Hypothesis 3: Works councils foster the implementation of digital technologies if the establishment is exposed to high competitive pressure.

Hypothesis 3a: Establishments with works councils are considering digital topics more intensively if the establishment is exposed to high competitive pressure.

Hypothesis 3b: Establishments with works councils are better equipped with digital technologies if the establishment is exposed to high competitive pressure.

3 Data, descriptive results and methodological approach

3.1 Data

The main data set for the empirical analysis is the IAB Establishment Panel, which is a large-scale annual establishment-level survey on personnel developments and business policies for Germany. This data comprises German establishments with at least one employee who is liable to social security as of June, 30th of the previous year. The stratified sample is drawn across 10 different establishment sizes, 16 German states (*"Bundesländer"*) and 17 different industries. For more detailed information and comprehensive descriptions see Fischer et al. (2009) and Ellguth et al. (2014). We use data from the latest survey of the year 2016. In this survey, 15,300 German establishments are asked a large number of subjects, including employment and business development, investment activities, innovations in the establishment, personnel structure, wages and salaries, working times in the establishment and general data on the establishment. Additionally to those questions, the focal topic about digital technologies is addressed. A detailed description of the three questions referring to digital technologies can be found in Section 7.1 of the appendix. As Arntz et al. (2016a) highlight the difference between the information about new digital technologies and the actual investment into equipment, the focus in this study lies on two of the three questions. We use the question "How intensively has your establishment dealt with this topic so far?" to measure the establishment's consideration level of digital technologies. We use the question "How well is your establishment equipped with these technologies compared to other establishments in your sector?" to measure the actual state of the digital equipment in the establishment. By contrast, we take the retrieved information of the question "What potential do you see for the application of such technologies in your establishment?" into account to restrict the sample for the estimations of the equipment with digital technologies. In order to analyze the occupational structure of the workforce employed in the surveyed establishments of the IAB Establishment Panel, we merge cross-sectional information of the Employee History (*"Beschäftigtenhistorik"*, *BeH*) to the dataset. The *BeH* combines all of the employment notifications which are stored by the Federal Employment Agency (*"Bundesagentur für Arbeit"*, *BA*) in Germany in accordance with the DEVO (Data Collection Regulation *"Datenerfassungsverordnung"*), DÜVO (Data Transmission Regulation *"Datenübermittlungsverordnung"*) and the DEÜV (Regulation on Data Collection and Transmission *"Datenerfassungs- und Datenübermittlungsverordnung"*). The information in the *BeH* is restricted to workers covered by social security and marginal part-time employees in accordance with

§ 27 SGB III. This data allows insights into more detailed personal information about individuals who have been employed on the 30th June 2015 in one of the establishments surveyed by the IAB Establishment Panel 2016. Additionally, the analysis relies on information about physical job exposure of the Index for Job Demands in Occupations based on KldB-2010 according to Kroll (2011). We rely on an updated version of the index, which is constructed based on data from the BIBB/BAuA Employment Survey 2011, which is a large-scale representative employee survey conducted by the German Federal Institute for Vocational Education and Training (BIBB).² The Index for Job Demands comprises comprehensive scales for physical job demands such as ergonomic strain of the musculoskeletal system due to demanding or one-sided, stressful activities. We merge this index to the occupational information for each employee working in one of the establishments of the IAB Establishment Panel 2016.

3.2 Descriptive statistics

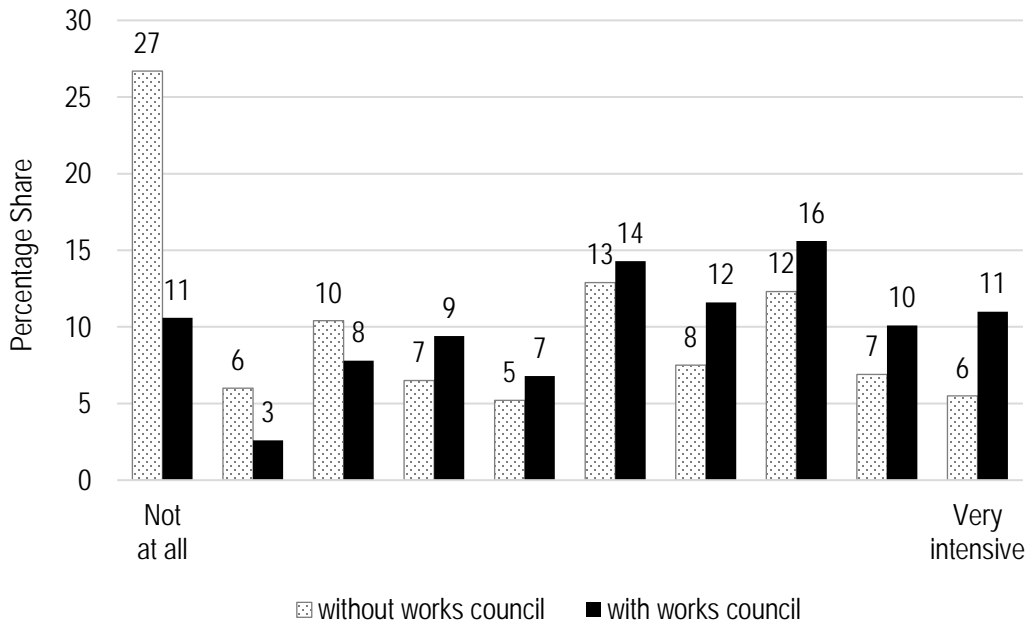
The descriptive analysis takes into account private sector establishments with at least 5 employees, as only those have the right to establish a works council according to the WCA. Following relevant literature, we exclude establishments from the agricultural sector and non-profit organizations. That leaves 9,841 establishments for the analysis. As can be seen in Table A1 in the appendix, on average in 28 percent of the establishments in this sample a works council is present and as known from literature, the share increases with establishment size. In 20 percent of the small establishments, which employ up to 199 employees, works councils represent employees' interests, whereas this fraction increases to 87 percent in large establishments which are considered to have more than 500 employees.³ We did not conduct our study separately for Western and Eastern Germany, as neither Schnabel (2016) detects substantial differences in employees' representation via works councils between Western and Eastern Germany nor reveals previous examination of the IAB Establishment Survey of 2016 differences in the answering behavior for the included questions referring to digital technologies (Müller et al. forthcoming).

Across this sample, a disparity between establishments with and without works councils with regards to the two states of implementation of digital practices can be noticed. As can be seen in Figure 1, 27 percent of the establishments without works councils indicate that they do not consider digital technologies at all. The fraction of establishments where the workers are represented by works councils giving the same answer is considerably lower with only 11 percent. The share of establishments considering themselves to have an above average information level is higher among those establishments with a works council established. Almost the same picture arises for the answers to the question about the equipment with digital technology, as can be seen in Figure 2. The fraction of establishments stating to be badly equipped with new digital technologies is higher among establishments without works councils. In contrast, the majority

² For a profound understanding of the index, see also the general description of Kroll, available at: <http://dx.doi.org/10.7802/1102>.

³ Those shares result from the unweighted analysis of the sample. The calculations for weighted data are attached in the appendix in Table A2.

Figure 1: Consideration of digital technologies – Survey answers

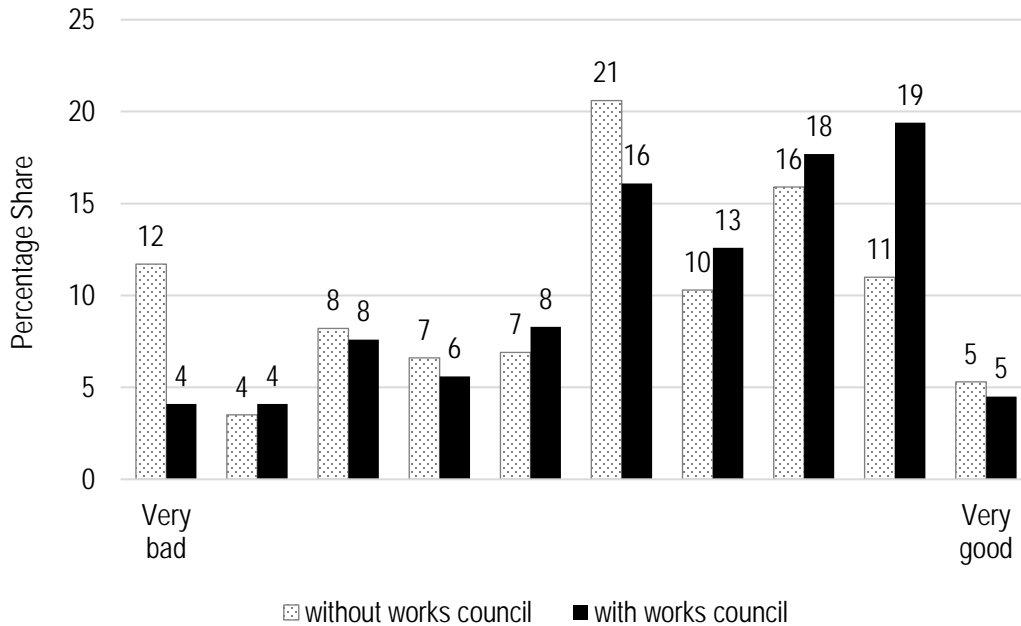


Sample: private sector establishments with at least 5 employees, without establishments in agriculture and non-profit organizations; establishments with missings and answer category “do not know” are excluded.

Note: The answers above have a basis in weighted data.

Source: IAB-Establishment Panel 2016, own calculations

Figure 2: Equipment with digital technologies - Survey answers



Sample: private sector establishments with at least 5 employees, without establishments in agriculture and non-profit organizations; establishments with missings and answer category “do not know” are excluded.

Note: The answers above have a basis in weighted data.

Source: IAB-Establishment Panel 2016, own calculations

of the establishments with works councils assess themselves to be better equipped with digital devices than other establishments within their sector.

The affiliation to different industries is an important aspect of the analysis. On the one hand, previous literature has shown that the potential availability of digital technologies across sectors is very heterogeneous (Arnold et al. 2016; Arntz et al. 2016a). The differentiation between sectors for the consideration and the equipment with digital technologies in our sample is shown in the appendix in Table A3 and Table A4. On the other hand, the industrial relations literature has demonstrated that the existence works councils is not evenly distributed across sectors and works councils' negotiating power varies across sectors due to historical reasons (see for example Addison et al. 2003). Therefore, we incorporate the sectoral affiliation in our empirical strategy.

3.3 Methodological approach

The first step in order to analyze the relation between works councils and the implementation of digital equipment within German establishments, we estimate separate ordinary least squares models for the two outcomes of interest. First, we examine link between the existence of works councils and the consideration of digital technologies. Second, we analyze the role of works councils for the equipment with digital technologies within the establishment in comparison to other establishments within the same sector. We estimate the following ordinary least squares model:

$$Digi_i = \beta_0 + \beta_1 WoCo_i + \beta_2 Est_i + \beta_3 Emp_i + \beta_4 Sec_i + \beta_5 Reg_i + \varepsilon_i \quad (1)$$

with $Digi_i$ being a measure for digital involvement within establishment i , that is in the first model the consideration of digital topics and in the second model the equipment with digital technologies. $WoCo_i$ denotes the presence of a works councils in establishment i , which is a dummy variable taking on the value one if a works council exists in the establishment and zero otherwise. Est_i comprises establishment characteristics of establishment i and Emp_i summarizes information about the workforce composition of establishment i . Furthermore, Sec_i captures the sectoral affiliation of the establishment i and Reg_i controls for the regional location within Germany for each establishment i . The estimation strategy contains a large number of observable control variables which influence the implementation of digital technologies and the presence of works councils in order to minimize the concern of an endogeneity bias due to omitted variables (for a more detailed explanation of endogeneity problems in cross-sectional data see Wooldridge 2002: 51). Several important observable establishment features such as *establishment size*, *establishment age*, dummies for the *coverage by a collective agreement* on establishment- and industry-level, *competitive pressure*, *profit situation* and *state of technology* within the establishment enter the model. Further establishment control variables in Est_i are dummies for the *branch plant* status, the *legal form* of the establishment and for the *membership in a chamber of crafts and trades*. Emp_i includes the shares of *workers exposed to high physical strain* at the workplace, *routine workers*, *qualified workers* and *commercial workers*. The sectoral controls Sec_i consist of a set of 8 *industry* dummies. The regional controls Reg_i include a *Western Germany* dummy taking on the value one if the establishment is located in West

Germany, as well as four *urban location* dummies. For the first step, we estimate the empirical model across all establishments in the private sector, excluding agricultural establishments and non-profit organizations, with five or more employees for which information on each variable is available. For the investigation of the equipment with digital technologies, we further restrict the sample to those establishments which have answered to see a potential for the use of digital technologies.

However, the identification of an association between works councils and the implementation of digital devices raises a major challenge with regards to the size of establishments. Previous studies have demonstrated that works councils are more likely to exist in large establishments (Addison et al. 2001; Bellmann/Ellguth 2006; Mohrenweiser et al. 2012; Müller 2012). Indeed, works councils are established in the majority of large establishments (for a recent analysis, see Ellguth/Kohaut 2017). Additionally, large establishments are more likely to be better informed and equipped with digital technologies as otherwise comparable small establishments. This confronts the analysis with the problem of spurious correlation. An association between works councils and the implementation of digital equipment might artificially arise due to the fact that works councils exist in large establishments and large establishments are more involved with digital advances. In the cross-sectional estimation approach, it is therefore of vital importance to take this concern into account by controlling for the establishment size. Thus, we include the number of employees as control variable.

The inclusion of the number of employees in order to control for establishment size might be associated with a concern related to the right that exempts works councils from their regular work duties (Section 38(1) WCA). The release from work duties allows works councils to concentrate on the representation of workers' interests. Therefore, the effectiveness of works councils might increase with increasing number of employees in the establishment. Consequently, in the second step of the econometric strategy we split the sample into three different subgroups along the establishment size. We estimate equation (1) for the subgroup of establishments with 5 to 199 employees, 200 to 500 and more than 501 employees respectively. In the first subgroup the WCA grants the right to establish a works council, however, the works council may not be exempted from work duties. In the second subgroup one works council shall be released and in the third subgroup two or more works councils might be exempted from their original work tasks.

Beyond the establishment size, several other establishment characteristics might differ between establishments with and without works councils. The major concern for the empirical analysis is, therefore, the comparability of establishments with (treatment group) and without (control group) works councils. In the final step of the empirical strategy in order to achieve a sufficient similarity between establishments, we apply an econometric specification involving entropy balancing weights. This method can be applied to binary treatments in order to achieve covariate balance (Hainmueller 2012). Entropy balancing weights reweigh establishments without works councils such that the moment conditions are equal across all establishments irrespectively of the treatment status. The econometric specification requires the first and the second moment of all control variables to be the same in the control group as in the treatment

group.⁴ Previous studies trying to isolate an effect of works councils on establishment performance or innovation activity of the establishment rely on methods such as nearest neighbor matching (for example Bellmann/Ellguth 2006). This approach either matches or discards observations in order to achieve a sufficient level of comparability across observations. One of the main benefits of the used entropy balancing method is the higher flexibility with respect to the reweighting procedure. It reweights all units in order to achieve balance without discarding observations and still retains efficiency by closely following the base weights. Another advantage of entropy balancing is that it outperforms standard matching approaches in terms of efficiency. Entropy balancing does not rely on functional form assumptions and is a fully non-parametric approach. Furthermore, this estimator considers selection on time-constant unobserved factors (Hainmueller 2012). Entropy balancing automatically adjusts the weights to pre-specified moment conditions and thereby obviates the need for repeated balance checking and iterative searching over different propensity score specifications that may stochastically balance the covariates (Hainmueller 2012). Variables affecting the treatment (existence of works council) and the outcome (digital variables) should be considered in the reweighting scheme as the entropy balancing also relies on the conditional independence assumption. We chose to include a set of control variables which has been proven to be relevant in the related industrial relations literature (Addison et al. 2003; Addison et al. 2004; Bellmann/Ellguth 2006). The empirical estimation uses the weights obtained from entropy balancing and controls for the equation (1) described set of variables. By applying this novel matching estimator, the paper refines the works council literature by using latest econometric methods.

4 Empirical results

4.1 Do works councils counter the implementation of digital technologies?

As explained in Section 2.3, works councils and the implementation of digital devices might be negatively related as works councils have several information and veto rights with regards to the introduction of new technologies.

The relation between works councils' presence and the consideration of digital technologies

In the first step to find empirical evidence for this hypothesis, we estimate the association between works councils' presence and the consideration of digital technologies with an ordinary least squares model. As can be seen in Table 1, in the baseline model controlling for a large set of establishment level characteristics, workforce characteristics, sectoral affiliation and regional characteristics, the presence of a works council is on average associated with a 0.2 lower consideration level of digital technologies on a 10-point scale. However, this link is not statistically significant on a conventional significance level and the magnitude of the coefficient is small. In order to reveal differences in the effectiveness

⁴ We use the Stata package EBALANCE within Stata 14 to implement entropy balancing following Hainmueller/Xu (2013). We repeat the estimations requiring only the first moment of all control variables to be the same in the control group as in the treatment group as a robustness check for the entropy balancing specification. However, this release of the moment conditions does not change the interpretation of the results, which are available from the authors on request.

of works councils depending on the establishment size, in the subsequent step, three separate models are estimated. Interestingly, compared to the other two groups the effect of works councils increases in magnitude and gains statistical significance for the subgroup of establishments with 200 to 500 employees. In those establishments, one works council shall be released from regular work duties in order to fully conduct tasks and duties with respect to their function as workforce representation. The negative association suggests that establishments with works councils in this establishment size group are considering less digital topics than comparable establishments without works councils.

Table 1: Consideration of digital technologies - Summary of the ordinary least squares regressions

	Baseline	Establishment size intervals			After entropy balancing
No. of employees	≥ 5	5-199	200-500	≥ 501	≥ 5
Works council (1=yes)	-0.156 (-1.54)	-0.126 (-1.12)	-0.663** (-2.38)	-0.062 (-0.11)	-0.041 (0.01)
No. observations	6,777	5,987	543	247	3,436
Adj. R ²	0.160	0.139	0.122	0.073	0.161

Sample: private sector establishments, without establishments in agriculture and non-profit organizations

Note: The set of control variables and their estimated coefficients can be found in the appendix in Table A5.

t-statistics in parentheses; ***, **, * indicate statistical significance at the 1%-/5%-/10% level

Source: IAB-Establishment Panel 2016, own calculations

Interestingly, the application of entropy balancing weights in order to achieve a sufficient similarity between establishments, does not considerably change the obtained results of the baseline model. The resulting coefficient after using this novel matching approach, again indicates a negative but statistically insignificant association between works councils and the consideration of digital topics in German establishments.

The relation between works councils presence' and the equipment with digital technologies

In the next step to find an empirical relation between works councils and the implementation of digital practices, we estimate the association between works councils and the equipment with digital technologies with an ordinary least squares model. As can be seen in Table 2, holding all other variables constant, the presence of works councils is associated with a 0.3 point decrease in the scale from 1 to 10. If all other characteristics are hold constant at their means, establishments without works councils answer to be above average equipped with digital technologies (6.1 on the scale of 1 to 10), while establishments with works councils answer to be averagely well equipped with these technologies compared to other establishments (5.8 on the scale of 1 to 10).

The differentiation across different establishment size groups shows, that this pattern remains relatively stable for small and medium sized establishments. The only exception are large establishments with more than 500 regular employed employees. For this subsample the magnitude of the coefficient is close to zero and it is not statistically significant at any conventional significance level. One might expect that the effect of works councils is most pronounced within large establishments as the scope of action for works councils widens with increasing numbers of employees. However, for this subsample the number of observed establishments is very small. The considerable reduction in the number of

establishments might be responsible for the raise in standard errors. As before, the application of entropy balancing weights in order to counter endogeneity concerns, does not considerably change the results of the baseline model. Again evidence is found, that works councils presence in establishments is associated with less equipment with digital technologies.

Table 2: Equipment with digital technologies - Summary of ordinary least squares regressions

	Baseline	Establishment size intervals			After entropy balancing
	≥ 5	5-199	200-500	≥ 501	≥ 5
Works council (1=yes)	-0.314*** (-3.72)	-0.321*** (-3.39)	-0.398* (-1.74)	0.005 (0.01)	-0.302** (-2.28)
No. observations	3,529	2,987	369	173	2,188
Adj. R ²	0.138	0.132	0.213	0.193	0.195

Sample: private sector establishments, without establishments in agriculture and non-profit organizations, which see a potential to use digital technologies.

Note: The set of control variables and their estimated coefficients can be found in the appendix in Table A6. t-statistics in parentheses; ***, **, * indicate statistical significance at the 1%/-5%/-10% level

Source: IAB-Establishment Panel 2016, own calculations

The relation between works councils' presence and the implementation of digital technologies

To summarize, no results are found that indicate a robust relation between the presence of works councils and the consideration of digital topics within German establishments. However, we find a robust negative relation between works councils and the equipment with digital technologies. This might be in line with the presumption, that works councils use their effective rights with respect to the introduction of new technologies. Works councils are allowed to co-determine how workplaces and internal processes are restructured and improved when new technologies have to be applied by the workforce. Due to the unavailability of longitudinal data of the information about digital technologies in the IAB Establishment and the empirical strategy which allows to control for observables, the concern about an endogeneity bias is reduced but not fully ruled out. Therefore, this article refrains from drawing any causal conclusions.⁵

⁵ This general pattern remains stable even for a number of robustness checks, which results are available from the authors on request. One possible concern which might be raised is the concern about endogeneity due to reverse causality. Workers might choose to establish a works council in order to formally represent their interests as soon as it is speculated or announced that the management board is planning to invest into digital technology. This is reasonable as the broad general debate in German media underlines the fear of the society that digital devices impose drastic employment losses. Previous studies indicate that one of the driving factors for the constitution of works councils are concerns of the workforce about their job stability and security of the workplace (Kraft/Lang 2008; Mohrenweiser et al. 2012). Alternatively, digital technologies might lead to establishment foundations as new technological possibilities yield scope for innovative business ideas. The causal relationship would go in those cases in the opposite direction. Therefore, the analysis comprises as a robustness check only those establishments which are founded before 1996. With respect to the workforce representation, those establishments enter the analysis which do not have a works council as well as those establishment with a works council established already before 1996. The basic patterns of the results remain unchanged. As one might argue that this restriction is too conservative as digital equipment is a very recent technology, the same restriction is applied with respect to the year 2010. Again, the basic patterns of the results remain unchanged.

4.2 Do works councils foster digital technologies in the presence of high physical strain?

According to the WCA, works councils are commissioned to protect safety and health of employees at work as they for example have co-determination rights regarding the design of workplaces, work operations and working environments. As we explained in Section 2.3, works councils might acknowledge the potentials of digital technologies to lessen the physical strain of employees who are conducting ergonomically demanding tasks in dangerous working environments. This suggests that works councils might foster the implementation of digital technologies.

The relation between works councils' presence and the consideration of digital technologies

To find empirical evidence for this hypothesis, the association between works councils' presence and the consideration of digital technologies is estimated in an ordinary least squares model including an interaction between works councils and the share of workers who suffer from high physical strain.

Table 3: Implementation of digital technologies in the presence of high physical strain - Summary of ordinary least squares regressions

	Consideration of digital technologies		Equipment with digital technologies	
	Baseline	After entropy balancing	Baseline	After entropy balancing
No. of employees	≥ 5	≥ 5	≥ 5	≥ 5
Works council (1=yes)	-0.331*** (-2.77)	-0.340 (-1.63)	-0.417*** (-4.25)	-0.335* (-1.93)
Interaction	0.747*** (2.83)	1.349** (2.05)	0.491* (1.91)	0.165 (0.41)
Works council * share physical strain				
Share of workers with physical strain (%)	-1.348*** (-9.47)	-2.078*** (-2.91)	-0.719*** (-4.59)	-0.280 (-0.74)
No. observations	6,777 [†]	3,436 [†]	3,529 [‡]	2,188 [‡]
Adj. R ²	0.161	0.165	0.139	0.195

Sample: [†]private sector establishments, without establishments in agriculture and non-profit organizations

[‡]private sector establishments, without establishments in agriculture and non-profit organizations, which see potentials to apply digital technologies

Note: The set of control variables and their estimated coefficients can be found in the appendix in Table A7.

t-statistics in parentheses; ***, **, * indicate statistical significance at the 1%-/5%-/10% level

Source: IAB-Establishment Panel 2016, own calculations

As can be seen in Table 3, the baseline model which controls for a large set of establishment level characteristics, workforce characteristics, sectoral affiliation and regional characteristics, yields a negative coefficient for the presence of works councils for those establishments which have no workers who are suffering under physical strain. If all other characteristics are hold constant at their means, establishments without works councils answer to consider digital technologies more intensively than comparable establishments with works councils (4.7 compared to 4.4 on the scale of 1 to 10). This is true for approximately 33% establishments in the sample, as 2,220 establishments do not have workers who are conducting high physically demanding work activities. For establishments where a share of workers is con-

ducting high physical demanding work tasks, the presence of works councils is positively associated with the consideration of digital technologies. The predictive margins for the consideration of digital technologies along the distribution of different shares of employees working in the presence of high physical strain can be found in the appendix in Figure A1. In those 167 establishments which only employ workers who have to conduct high physical demanding tasks, the establishments with works councils indicate to consider digital technologies to some extent (3.8 on the scale of 1 to 10), whereas those establishments without the workforce representation are considering digital topics less intensively (3.3 on the scale of 1 to 10). In order to reduce endogeneity concerns, we conducted entropy balancing weights to this specification. In this case, the magnitude of the interaction term between works councils' presence and the physical strain of employees as well as the negative coefficient of the share of workers conducting physical demanding tasks are increasing. However, we have to point out that the sample size is considerably reduced.

The relation between works councils' presence and the equipment with digital technologies

In the next step, we analyze the relation between works councils and the equipment with digital technologies by estimating an ordinary least squares model including an interaction between works councils and the share of workers who suffer from high physical strain. As can be seen in Table 3, the association between works councils and the equipment with digital technologies is statistically significant negative for those establishments which have no workers who are suffering under physical strain. As this question has been answered by the surveyed establishments less frequently, the underlying sample size decreases. In this smaller sample, 1,226 establishments do not employ any worker who has to conduct physical demanding work. In this case, establishments with works councils are slightly less intensively equipped with digital technologies than comparable establishments without works councils (5.9 compared to 6.3 on the scale of 1 to 10). In contrast, 46 establishments exclusively employ workers with high physical demands on their workplaces. In those establishments the presence of works council goes along with slightly better equipment with digital technologies (5.6 on the scale of 1 to 10 for establishments without works councils compared to 5.7 on the scale of 1 to 10 for establishments with works councils). In Figure A2 of the appendix, we show the predictive margins for the equipment with digital technologies along the distribution of different shares of employees working in the presence of high physical strain. In the next step, we again use entropy balancing weights. The basic pattern of the association between works councils and the equipment with digital technologies remains stable, only the magnitude of the effects decrease and the statistical significance declines as the sample size again decreases.

The relation between works councils' presence and the implementation of digital technologies

To summarize, we find empirical evidence in favor of our second hypothesis, that works councils support the implementation of digital technologies in those establishments, which employ a high share of workers who have to conduct physical demanding job activities. This might suggest that works councils recognize the potentials of digital technologies to ease working tasks carried out by employees if they so far had to suffer under physical strain on their work places.

4.3 Do works councils foster digital technologies in the presence of high competitive pressure?

Works councils are instructed by the WCA to secure employment and actively submit proposals to the employer relating to the security and the promotion of employment. In Section 2.3, we formulated the hypothesis that works councils might foster the implementation of digital technologies in establishments which are under high competitive pressure.

The relation between works councils' presence and the consideration of digital technologies

In order to verify this hypothesis, we conduct an ordinary least squares regression which covers the relation between works councils and the implementation of digital technologies in establishments suffering from competition pressure with an interaction term between works councils and a dummy variable capturing the high competitive pressure. As can be seen in Table 4, the baseline model which estimates the consideration of digital devices controlling for a large set of control variables, yields a negative, statistically significant coefficient for the presence of works councils in those establishments which are not considering themselves to be under strong market competition. In this case, establishments with works councils answer to consider less digital topics than comparable establishments without works councils (4.0 compared to 4.3 on the scale of 1 to 10). This is true for a majority of 64 percent establishments in the sample, as 4,303 establishments do not state to be under high competition.

Table 4: Implementation of digital technologies in the presence of high competitive pressure - Summary of ordinary least squares regressions

	Consideration of digital technologies		Equipment with digital technologies	
	Baseline	After entropy balancing	Baseline	After entropy balancing
No. of employees	≥ 5	≥ 5	≥ 5	≥ 5
Works council (1=yes)	-0.309** (-2.54)	0.125 (0.52)	-0.305*** (-2.95)	-0.158 (-0.91)
Interaction Works council * competition pressure	0.357** (2.47)	-0.365 (-1.08)	-0.0216 (-0.17)	-0.298 (-1.17)
Competition pressure (1=high)	0.148* (1.76)	0.870*** (2.71)	0.126 (1.61)	0.417* (1.86)
No. observations	6,777 [†]	3,436 [†]	3,529 [‡]	2,188 [‡]
Adj. R ²	0.161	0.162	0.138	0.197

Sample: [†]private sector establishments, without establishments in agriculture and non-profit organizations

[‡]private sector establishments, without establishments in agriculture and non-profit organizations, which see potentials to apply digital technologies.

Note: The set of control variables and their estimated coefficients can be found in the Appendix in Table A8.

t-statistics in parentheses, ***, **, * indicate statistical significance at the 1%/-5%/-10% level

Source: IAB-Establishment Panel 2016, own calculations

In contrast, for those 36 percent of the establishments which consider the market competition to be very strong, the presence of works councils is positively associated with the consideration of digital technologies (4.4 on the scale of 1 to 10 for establishments without works councils compared to 4.5 on the scale of 1 to 10 for establishments with works councils). We include an illustrative figure for the resulting coefficients in the appendix in Figure A3. The application of

entropy balancing weights achieves a better comparability between different establishments. The estimated coefficients indicate, that the establishment characteristics are the driving factors for differences in the consideration level of digital technologies as in this specification, the presence of high competitive pressure gains importance.

The relation between works councils' presence and the equipment with digital technologies

In the next step, we analyze the relation between works councils and the equipment with digital technologies by estimating an ordinary least squares model including an interaction term between works councils and high competition pressure. Figure A4 in the appendix again summarizes again the obtained coefficients graphically. The majority of the establishments, with 61 percent in the sample, state to not be allocated in a highly competitive market. In this case, establishments with works councils answer to be averagely equipped with digital technologies (5.8 on the scale of 1 to 10), whereas comparable establishments without works councils indicate to be slightly better equipped than the average (6.1 on the scale of 1 to 10). Thus, the baseline model indicates a statistically significant, negative relation between the presence of works councils and the equipment with digital technologies. We find this pattern also for those 1,378 establishments which are under high pressure. Establishments with works councils are slightly less intensively equipped with digital technologies than comparable establishments without works councils (5.9 compared to 6.2 on the scale of 1 to 10). As before, the estimated coefficients after the application of entropy balancing weights indicate, that the establishment characteristics are the driving factors for differences in the equipment with digital technologies. The coefficient for the presence of high competitive pressure after using entropy balancing weights increases in magnitude and gains statistical significance while the coefficient for the works council presence decreases in magnitude and is not statistically significant anymore. This might suggest that establishment heterogeneities are more important than the presence of works councils in order to understand heterogeneous equipment with digital technologies.

The relation between works councils' presence and the implementation of digital technologies

We find first empirical evidence in favor of the hypothesis that works councils contribute to higher consideration levels of digital topics in establishments which are operating under high competitive pressure. However, we are unable to find this association robust across different specifications. Furthermore, we find no evidence for the hypothesis that works councils foster the equipment with digital technologies in establishments in a high competitive market. To summarize, the role of works councils and their active participation in the implementation of digital technologies seems not to be related to the competition the establishment is confronted with.

5 Conclusions

Advances in modern automation technologies, robotics, sensor technology, big data and cloud services have contributed to an increasing diffusion of digital technologies across developed industries and societies. Interestingly, very little is known about the implementation mechanism in establishments and possible reasons for heterogeneities across German establishments. We use the IAB Establishment Panel and administrative German labor market data in order to examine the role of works councils for the implementation of digital technologies within German establishments.

Our results suggest a robust negative relation between works councils and the equipment with digital technologies. In contrast, we find no evidence that works councils presence is systematically related to the consideration of digital technologies. Furthermore, our results suggest that works councils support the implementation of digital technologies in those establishments, which employ a high share of workers who conduct physical demanding job activities. In contrast, the presence of works councils in establishments with high competition pressure seems not to be an important driver for heterogeneities in the implementation of digital devices in establishments. The results of this study should be interpreted as first evidence for the existence of a relation between works councils presence and heterogeneities with respect to the implementation level of digital technologies in German establishments. However, limitations in the data and the empirical identification strategy do not allow to fully rule out endogeneity concerns and we therefore refrain from drawing any causal conclusions.

Works councils are one of the main pillars of the industrial relation system in Germany and have the opportunity to shape employees' working conditions in the digitalized economy. The positive association between works councils presence and the equipment with digital technologies in those establishments where a high share of workers have previously conducted high physical demanding work activities might suggest, that works councils play an important role for the design and regulation of new work requirements resulting from technological upgrading. This is in line with recent literature which highlights the importance of works councils as representor of workers' interests in the digital world (Ahlers 2018). Works councils should exploit their co-determination rights in the transformation process towards a digitalized world and make active use of their information and veto rights granted in the WCA. However, a recent study has demonstrated that works councils do not utilize their scope of action for the co-determination in training programs grounded in the WCA (Iller et al. 2016). Thus, the self-understanding of works councils and their willingness to cooperate with the management will be of crucial importance for the effectiveness of works councils in the digital transformation process.

Further research is therefore needed, which allows to measure the relevance of works councils for the decision making process within establishments and the general relation between management and works councils. This information about the trust relation and the type of co-operation should then supplemented with the degree of digital equipment in German establishments in order to be able to reveal a more differentiated relation between works councils and the implementation of digital technologies in Germany.

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7 Appendix

7.1 IAB Establishment Questions related to digital technologies

Modern automation and digitalisation technologies can revolutionise communication and cooperation between employees, facilities, logistics, products and costumers. These technologies include autonomous robotics, smart factories, the Internet of Things as well as analysis tools with big data, cloud services or online platforms, among other things.

Please answer the following 3 sub-questions using a scale from 1 to 10!

- How intensively has your establishment dealt with this topic so far?
- What potential do you see for the application of such technologies in your establishment?
- How well is your establishment equipped with these technologies compared to other establishments in your sector?

7.2 Descriptive statistics

Table A1: Presence of works councils in the sample

Establishment Size Intervals (no. of employees)	Without Works Council		With Works Council		Total
	Absolute (no. of establishments)	Relative (in %)	Absolute (no. of establishments)	Relative (in %)	Absolute (no. of establishments)
5-199	6,860	80	1,695	20	8,555
200-500	203	24	653	76	856
501 and more	54	13	376	87	430
Total	7,117	72	2,724	28	9,841

Sample: private sector establishments with at least 5 employees, without establishments in agriculture and non-profit organizations

Source: IAB-Establishment Panel 2016, own calculations

Table A2: Presence of works councils

Establishment Size Intervals (no. of employees)	Without Works Council		With Works Council		Total
	Absolute (no. of establishments)	Relative (in %)	Absolute (no. of establishments)	Relative (in %)	Absolute (no. of establishments)
5-199	8,839	91	839	9	9,678
200-500	35	29	85	71	120
501 and more	7	16	36	84	43
Total	8,881	90	960	10	9,841

Sample: private sector establishments with at least 5 employees, without establishments in agriculture and non-profit organizations

Note: The calculations above have a basis in weighted data.

Source: IAB-Establishment Panel 2016, own calculations

Table A3: Consideration of digital technologies across sectors

Answer Categories	Works Council (No. establishments)	Manu- facturing (%)	Construc- tion (%)	Trade (%)	Transport (%)	Finance (%)	Service activities (%)	Other services (%)
<i>Not at all</i>	No 1,655	29	37	23	31	14	14	28
	Yes 60	6	25	11	15	1	2	19
<i>Few</i>	No 1,428	27	22	24	22	13	17	25
	Yes 110	28	15	18	4	15	16	20
<i>Average</i>	No 1,586	28	23	29	17	27	27	26
	Yes 183	35	23	35	15	27	42	33
<i>Very Intensive</i>	No 1,529	16	18	24	30	46	42	20
	Yes 205	30	37	36	66	56	39	29
No. observations 6,756		2,580	604	1,225	514	216	417	1,200

Sample: private sector establishments with at least 5 employees, without establishments in agriculture and non-profit organizations; establishments with missings and answer category "do not know" are excluded

Note: The answers above have a basis in weighted data.

Source: IAB-Establishment Panel 2016, own calculations

Table A4: Equipment with digital technologies across sectors

Answer Categories	Works Council (No. establishments)	Manu- facturing (%)	Construc- tion (%)	Trade (%)	Transport (%)	Finance (%)	Service activities (%)	Other services (%)
<i>Very poor</i>	No 529	12	19	8	16	6	6	12
	Yes 20	6	6	3	0	0	0	8
<i>Fair</i>	No 823	25	17	20	18	9	11	19
	Yes 83	22	11	18	5	11	23	15
<i>Average</i>	No 1,709	42	32	45	37	31	30	38
	Yes 177	45	21	38	32	42	36	28
<i>Very good</i>	No 1,459	21	33	27	29	53	53	31
	Yes 199	28	62	40	63	48	40	50
No. observations 4,999		1,857	431	937	383	177	340	874

Sample: private sector establishments with at least 5 employees, without establishments in agriculture and non-profit organizations; establishments with missings and answer category "do not know" are excluded

Note: The answers above have a basis in weighted data.

Source: IAB-Establishment Panel 2016, own calculations

7.3 Multivariate Results

Table A5: Consideration of digital technologies - Ordinary least squares regressions

	Baseline	Establishment size intervals			After entropy balancing
	≥ 5	5-199	200-500	≥ 501	≥ 5
No. of employees					
Works council (1=yes)	-0.156 (-1.54)	-0.126 (-1.12)	-0.663** (-2.38)	-0.062 (-0.11)	-0.041 (0.01)
Establishment size (ln(number of employees))	0.394*** (11.79)	0.382*** (8.32)	0.277 (0.70)	0.067 (0.39)	0.286*** (3.62)
Establishment age (1=founded before 1990)	-0.055 (-0.71)	-0.084 (-1.02)	0.312 (1.24)	0.281 (0.73)	0.215 (1.03)
Industry-wide wage agreement (1=yes)	0.162** (1.97)	0.190** (2.13)	-0.067 (-0.28)	0.715 (1.51)	0.045 (0.22)
Establishment wage agreement (1=yes)	0.123 (0.88)	0.027 (0.16)	0.171 (0.57)	1.329** (2.23)	0.297 (1.15)
Competition pressure (1=high)	0.247*** (3.53)	0.220*** (2.88)	0.262 (1.32)	0.684** (2.24)	0.687*** (3.90)
Profit situation (1=good/very good)	0.223*** (3.23)	0.218*** (2.92)	0.263 (1.25)	0.179 (0.60)	0.154 (0.85)
State of technology (1=modern/state of the art)	1.006*** (13.93)	0.965*** (12.37)	1.371*** (6.16)	1.189*** (3.34)	1.152*** (5.86)
Branch plant (1= yes)	0.355*** (3.66)	0.344*** (3.06)	0.504** (2.16)	0.052 (0.16)	0.551*** (2.94)
Legal form of establishment (1=individually-owned firm/partnership)	-0.566*** (-6.03)	-0.575*** (-5.82)	-0.296 (-0.44)	-0.294 (-0.44)	0.169 (0.62)
Member in chamber of crafts/trades (1=yes)	-0.058 (-0.63)	-0.066 (-0.66)	0.040 (0.15)	-0.315 (-0.63)	0.228 (0.94)
Share of workers with physical strain (%)	-1.215*** (-9.18)	-1.275*** (-9.13)	-0.650 (-1.26)	0.033 (0.04)	-1.379*** (-3.11)
Share of routine workers (%)	0.187 (1.13)	0.156 (0.88)	0.479 (0.81)	-0.707 (-0.69)	0.676 (1.17)
Share of qualified workers (%)	1.041*** (6.85)	1.127*** (6.81)	0.847* (1.87)	0.628 (0.85)	1.601** (2.50)
Share of commercial workers (%)	0.385* (1.66)	0.314 (1.29)	2.333* (1.92)	-0.616 (-0.37)	0.203 (0.25)
Industry dummies	Yes***	Yes***	Yes**	Yes***	Yes***
Western Germany dummy	Yes**	Yes*	Yes	Yes	Yes
Urban area dummy	Yes	Yes	Yes	Yes	Yes
No. observations	6,777	5,987	543	247	3,436
Adj. R ²	0.160	0.139	0.122	0.073	0.161

Sample: private sector establishments, without establishments in agriculture and non-profit organization; establishments with missings and answer category "do not know" are excluded

Note: t-statistics in parentheses, ***, **, * indicate statistical significance at the 1%/-5%/-10% level

Source: IAB-Establishment Panel 2016, own calculations

Table A6: Equipment with digital technologies - Ordinary least squares regressions

No. of employees	Baseline	Establishment size intervals			After entropy balancing
	≥ 5	5-199	200-500	≥ 501	≥ 5
Works council (1=yes)	-0.314*** (-3.72)	-0.321*** (-3.39)	-0.398* (-1.74)	0.005 (0.01)	-0.302** (-2.28)
Establishment size (ln(number of employees))	0.085*** (3.00)	0.081** (2.07)	-0.007 (-0.02)	0.140 (0.86)	-0.027 (-0.46)
Establishment age (1=founded before 1990)	-0.123* (-1.72)	-0.179** (-2.34)	0.664*** (2.91)	-0.085 (-0.22)	-0.238* (-1.81)
Industry-wide wage agreement (1=yes)	0.197*** (2.65)	0.192** (2.33)	0.199 (0.98)	0.304 (0.80)	0.284** (2.11)
Establishment wage agreement (1=yes)	0.060 (0.49)	0.030 (0.21)	0.196 (0.69)	0.445 (1.03)	-0.125 (-0.67)
Competition pressure (1=high)	0.119* (1.86)	0.060 (0.85)	0.176 (1.02)	0.742*** (3.00)	0.260** (2.18)
Profit situation (1=good/very good)	0.264*** (4.23)	0.201*** (2.91)	0.839*** (4.59)	0.389 (1.55)	0.271** (2.03)
State of technology (1=modern/state of the art)	1.218*** (17.14)	1.192*** (15.25)	1.386*** (6.64)	1.354*** (4.39)	1.323*** (9.52)
Branch plant (1= yes)	-0.004 (-0.05)	0.088 (0.92)	-0.147 (-0.72)	-0.699** (-2.12)	-0.077 (-0.59)
Legal form of establishment (1=individually-owned firm/partnership)	-0.175** (-1.97)	-0.152* (-1.67)	-0.291 (-0.50)	-0.423 (-1.07)	0.132 (0.32)
Member in chamber of crafts/trades (1=yes)	0.101 (1.19)	0.136 (1.44)	0.003 (0.01)	-0.794 (-0.88)	0.184 (1.16)
Share of workers with physical strain (%)	-0.603*** (-4.18)	-0.678*** (-4.32)	0.118 (0.25)	1.165* (1.88)	-0.188 (-0.72)
Share of routine workers (%)	0.118 (0.68)	0.076 (0.40)	0.662 (1.32)	-1.108 (-1.14)	0.203 (0.55)
Share of qualified workers (%)	0.298** (2.02)	0.310* (1.85)	0.211 (0.58)	1.091 (1.41)	0.342 (1.09)
Share of commercial workers (%)	0.256 (1.15)	0.225 (0.95)	2.398* (1.70)	0.223 (0.15)	0.407 (0.73)
Industry dummies	Yes***	Yes***	Yes**	Yes	Yes**
Western Germany dummy	Yes***	Yes***	Yes	Yes	Yes*
Urban area dummy	Yes	Yes	Yes	Yes*	Yes
No. observations	3,529	2,987	369	173	2,188
Adj. R ²	0.138	0.132	0.213	0.193	0.195

Sample: private sector establishments, without establishments in agriculture and non-profit organizations, which see potentials to apply digital technologies; establishments with missings and answer category "do not know" are excluded

Note: t-statistics in parentheses; ***, **, * indicate statistical significance at the 1%-/5%-/10% level

Source: IAB-Establishment Panel 2016, own calculations

Table A7: Implementation of digital technologies in the presence of high physical strain

	Consideration of digital technologies		Equipment with digital technologies	
	Baseline	After entropy balancing	Baseline	After entropy balancing
No. of employees	≥ 5	≥ 5	≥ 5	≥ 5
Works council (1=yes)	-0.331*** (-2.77)	-0.340 (-1.63)	-0.417*** (-4.25)	-0.335* (-1.93)
Interaction Works council * share physical strain	0.747*** (2.83)	1.349** (2.05)	0.491* (1.91)	0.165 (0.41)
Share of workers with physical strain (%)	-1.348*** (-9.47)	-2.078*** (-2.91)	-0.719*** (-4.59)	-0.280 (-0.74)
Establishment size (ln(number of employees))	0.394*** (11.80)	0.284*** (3.66)	0.086*** (3.01)	-0.028 (-0.49)
Establishment age (1=founded before 1990)	-0.049 (-0.64)	0.180 (0.89)	-0.120* (-1.69)	-0.240* (-1.83)
Industry-wide wage agreement (1=yes)	0.170** (2.06)	0.0479 (0.24)	0.204*** (2.74)	0.286** (2.13)
Establishment wage agreement (1=yes)	0.124 (0.88)	0.285 (1.10)	0.058 (0.47)	-0.128 (-0.68)
Competition pressure (1=high)	0.242*** (3.46)	0.687*** (3.93)	0.114* (1.78)	0.260** (2.19)
Profit situation (1=good/very good)	0.228*** (3.31)	0.175 (0.97)	0.267*** (4.28)	0.275** (2.08)
State of technology (1=modern/state of the art)	1.005*** (13.91)	1.152*** (5.89)	1.217*** (17.13)	1.322*** (9.56)
Branch plant (1= yes)	0.366*** (3.78)	0.537*** (2.86)	0.003 (0.03)	-0.081 (-0.63)
Legal form of establishment (1=individually-owned firm/partnership)	-0.568*** (-6.05)	0.131 (0.49)	-0.177** (-2.00)	0.130 (0.32)
Member in chamber of crafts/trades (1=yes)	-0.041 (-0.45)	0.239 (1.00)	0.110 (1.29)	0.188 (1.18)
Share of routine workers (%)	0.179 (1.08)	0.715 (1.23)	0.123 (0.71)	0.215 (0.58)
Share of qualified workers (%)	1.048*** (6.91)	1.621*** (2.56)	0.306** (2.07)	0.345 (1.10)
Share of commercial workers (%)	0.391* (1.69)	0.207 (0.26)	0.254 (1.14)	0.396 (0.71)
Industry dummies	Yes***	Yes***	Yes***	Yes**
Western Germany dummy	Yes**	Yes	Yes***	Yes*
Urban area dummy	Yes	Yes	Yes	Yes
No. observations	6,777 [†]	3,436 [†]	3,529 [‡]	2,188 [‡]
Adj. R ²	0.161	0.165	0.139	0.195

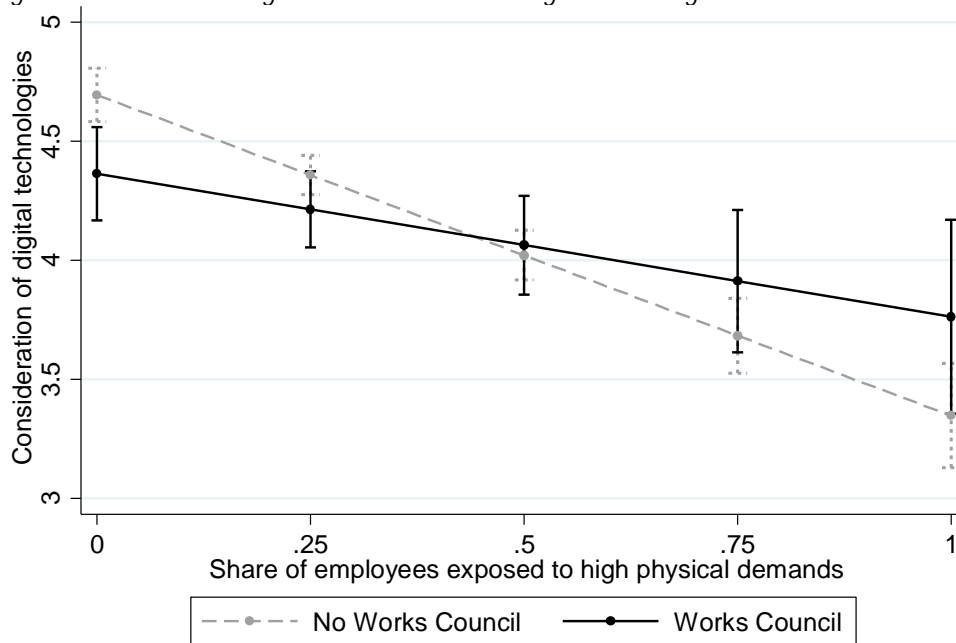
Sample: †private sector establishments, without establishments in agriculture and non-profit organizations

‡ private sector establishments, without establishments in agriculture and non-profit organizations, which see potentials to apply digital technologies; establishments with missings and answer category "do not know" are excluded

Note: t-statistics in parentheses; ***, **, * indicate statistical significance at the 1%-/5%-/10% level

Source: IAB-Establishment Panel 2016, own calculations

Figure A1: Predictive margins for consideration of digital technologies

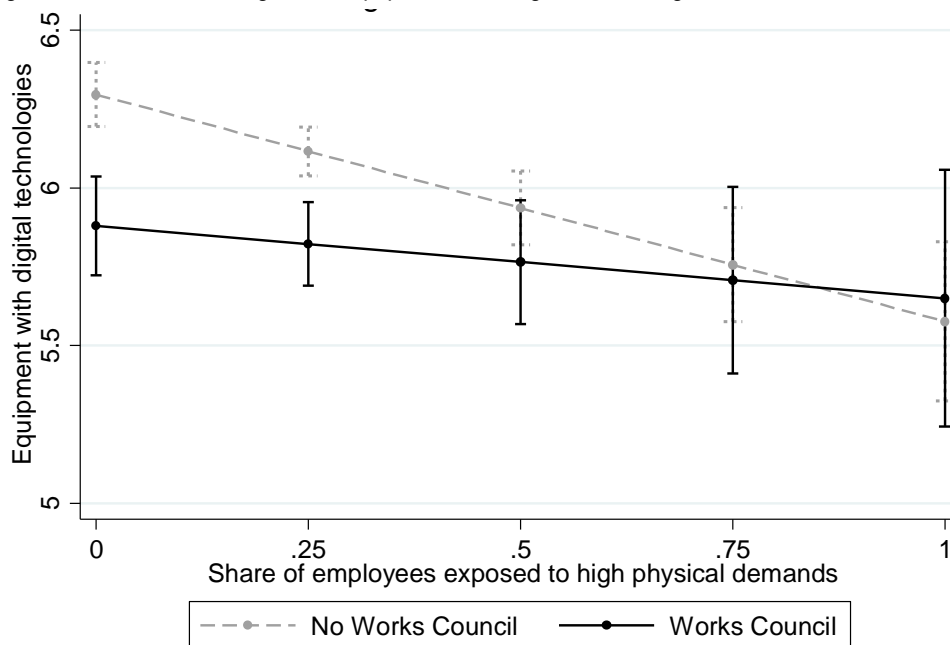


Sample: private sector establishments, without establishments in agriculture and non-profit organization; establishments with missings and answer category "do not know" are excluded

Note: Vertical lines indicate 95% confidence interval.

Source: IAB-Establishment Panel 2016, own calculations

Figure A2: Predictive margins for equipment with digital technologies



Sample: private sector establishments, without establishments in agriculture and non-profit organizations, which see potentials to apply digital technologies; establishments with missings and answer category "do not know" are excluded

Note: Vertical lines indicate 95% confidence interval.

Source: IAB-Establishment Panel 2016, own calculations

Table A8: Implementation of digital technologies in the presence of high competitive pressure

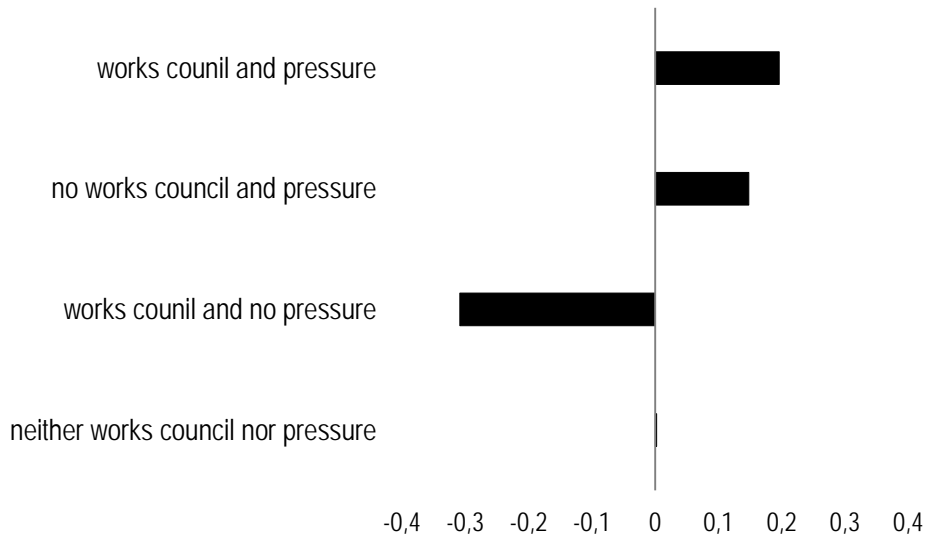
	Consideration of digital technologies		Equipment with digital technologies	
	Baseline	After entropy balancing	Baseline	After entropy balancing
No. of employees	≥ 5	≥ 5	≥ 5	≥ 5
Works council (1=yes)	-0.309** (-2.54)	0.125 (0.52)	-0.305*** (-2.95)	-0.158 (-0.91)
Interaction Works council * competition pressure	0.357** (2.47)	-0.365 (-1.08)	-0.022 (-0.17)	-0.298 (-1.17)
Competition pressure (1=high)	0.148* (1.76)	0.870*** (2.71)	0.126 (1.61)	0.417* (1.86)
Establishment size (ln(number of employees))	0.393*** (11.75)	0.289*** (3.69)	0.085*** (3.00)	-0.029 (-0.51)
Establishment age (1=founded before 1990)	-0.053 (-0.69)	0.220 (1.07)	-0.123* (-1.73)	-0.227* (-1.74)
Industry-wide wage agreement (1=yes)	0.164** (2.00)	0.045 (0.23)	0.197*** (2.65)	0.284** (2.10)
Establishment wage agreement (1=yes)	0.134 (0.96)	0.292 (1.12)	0.059 (0.48)	-0.141 (-0.75)
Profit situation (1=good/very good)	0.222*** (3.23)	0.153 (0.85)	0.264*** (4.23)	0.269** (2.00)
State of technology (1=modern/state of the art)	1.008*** (13.95)	1.150*** (5.93)	1.218*** (17.14)	1.333*** (9.49)
Branch plant (1= yes)	0.349*** (3.60)	0.566*** (2.99)	-0.004 (-0.05)	-0.057 (-0.45)
Legal form of establishment (1=individually-owned firm/partnership)	-0.579*** (-6.15)	0.180 (0.64)	-0.174* (-1.95)	0.149 (0.35)
Member in chamber of crafts/trades (1=yes)	-0.051 (-0.57)	0.236 (0.97)	0.101 (1.19)	0.188 (1.19)
Share of workers with physical strain (%)	-1.215*** (-9.19)	-1.381*** (-3.09)	-0.603*** (-4.17)	-0.197 (-0.76)
Share of routine workers (%)	0.180 (1.09)	0.692 (1.19)	0.119 (0.68)	0.231 (0.60)
Share of qualified workers (%)	1.034*** (6.81)	1.596** (2.55)	0.298** (2.02)	0.337 (1.08)
Share of commercial workers (%)	0.391* (1.69)	0.226 (0.28)	0.255 (1.14)	0.402 (0.72)
Industry dummies	Yes***	Yes***	Yes***	Yes**
Western Germany dummy	Yes**	Yes	Yes***	Yes*
Urban area dummy	Yes	Yes	Yes	Yes
No. observations	6,777 [†]	3,436 [†]	3,529 [‡]	2,188 [‡]
Adj. R ²	0.161	0.162	0.138	0.197

Sample: [†]private sector establishments, without establishments in agriculture and non-profit organizations
[‡] private sector establishments, without establishments in agriculture and non-profit organizations, which see potentials to apply digital technologies; establishments with missings and answer category "do not know" are excluded

Note: t-statistics in parentheses; ***, **, * indicate statistical significance at the 1%/-5%/-10% level

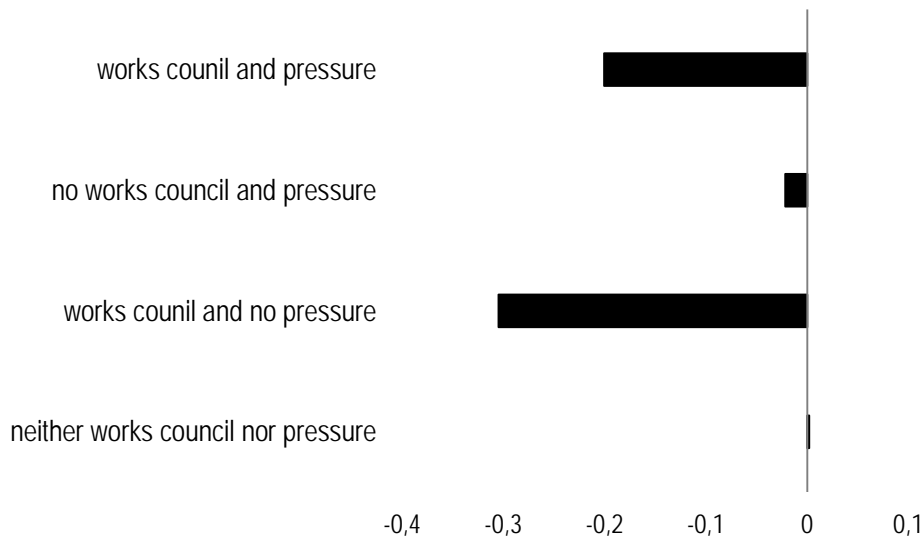
Source: IAB-Establishment Panel 2016, own calculations

Figure A3: Consideration of digital technologies and the role of high competitive pressure



Sample: private sector establishments, without establishments in agriculture and non-profit organization; establishments with missings and answer category "do not know" are excluded.
 Source: IAB-Establishment Panel 2016, own calculations

Figure A4: Equipment with digital technologies and the role of competitive pressure



Sample: private sector establishments, without establishments in agriculture and non-profit organizations, which see potentials to apply digital technologies; establishments with missings and answer category "do not know" are excluded
 Source: IAB-Establishment Panel 2016, own calculations