Working Paper No. 162

Competition, Institutions and Company-sponsored Training

Tina Hinz and Jens Mohrenweiser

Universität Zürich
IBW – Institut für Betriebswirtschaftslehre

b
UNIVERSITÄT
BERN

Working Paper No. 162

Competition, Institutions and Company-sponsored Training

Tina Hinz and Jens Mohrenweiser

June 2019

The Swiss Leading House on Economics of Education, Firm Behavior and Training Policies is a Research Program of the Swiss State Secretariat for Education, Research, and Innovation (SERI).

www.economics-of-education.ch

Competition, Institutions and Company-sponsored Training*

Tina Hinz (Friedrich-Alexander University Erlangen-Nürnberg)
Jens Mohrenweiser (Bournemouth University)

Version: June 2019

The new training literature argues that imperfect labour markets (i.e. less competition) lead to an increasing productivity-wage wedge. We show that this relation does not hold for all institutional and market environments. We use representative establishment panel data for Germany and apply a control function approach for estimating the production function to correct for endogeneity in input factors. We show that the skill-productivity gradient responds stronger to increases in product market competition and labour market density than the skill-wage gradient. This leads to an increasing productivity-wage wedge in more competitive environments. Similarly, works councils have a stronger effect on the skill-productivity than on the skill-wage gradient while both gradients are similar in the presence of union wage bargaining. Our results call for a more nuanced interpretation of the exposition of the new training literature to understand company-sponsored training across institutional and market environments.

JEL: J24, M53, R23
Keywords: training, productivity, wages, wage compression

---

* Corresponding author: Jens Mohrenweiser, mohrenweiserj@bournemouth.ac.uk
Acknowledgments: We thank Michael Oberfichtner, Claus Schnabel, Gesine Stephan, Stijn Vanormelingen, Thomas Zwick and the participants at the IAB Ph.D. Workshop in Nuremberg, the Colloquium on Personnel Economics in Augsburg, Bildungsökonomischer Ausschuss in Hannover, the BGPE workshop in Bayreuth, the annual conference of the Verein für Socialpolitik in Vienna as well as EALE conference in St. Gallen for valuable discussions on an earlier versions of the paper. Data access was provided via on-site use at the Research Data Centre (FDZ) of the German Federal Employment Agency (BA) at the Institute for Employment Research (IAB) and subsequently remote data access.

1. Introduction

Life-long learning and skill updating become more important as technology advancements reduce the shelf-life of knowledge. Employers provide the majority of training after the labour market entry of employees (Booth and Bryan, 2005; Booth and Katic, 2011; Waddoups, 2014) because they have an information advantage against employees about technological trends in the industry, trends in the organisation of work and the nature of workplaces, plans for investment in new machines, new processes and new products.

The increasing relevance of employer-led training calls for a sophisticated understanding of the institutional and market environments that enable employers to invest in skills of employees. The most influential theoretical framework is the human capital theory (Becker, 1962) which has evolved into the new training literature (Acemoglu and Pischke, 1999). The new training literature argues that market imperfections such as search frictions, monopsony, or labour market institutions compress the wages offered by outside firms. As a result, firms can offer post-training wages below productivity but above the compressed external market wage. The compressed external wage allows firms to generate a rent that increases in skills and serves as an incentive to invest even in purely transferable skills (Acemoglu and Pischke, 1999; Booth and Zoega, 2004; Leuven, 2005). This productivity-wage wedge in skills, i.e. productivity increases stronger in skills than wages, has been shown in several empirical studies (Conti, 2005; Dearden et al., 2006; Konings and Vanormelingen, 2015).

The theoretical argument, however, solely focusses on the compressed external wage structure to generate the wedge in skills. In contrast, the theory does not put much attention to the production function assuming that general skills are similarly valuable in all firms. While the assumption is sufficient to explain incentives for company-sponsored training in general skills, it has its limits in understanding the variety of employer-led training across institutional and market environments. The assumption that the production function is not affected by market frictions, for example that more competition does not affect productivity, sounds not very convincing for economists who traditionally argue that competition improves productivity. Indeed, a number of theoretical and empirical contributions have shown that more competition increases the productivity of firms, such as product market competition (Nickell, 1996; Aghion et al., 2004; Griffith et al., 2010) and local agglomeration (for an overview, see Combes and Gobillon, 2015). Moreover, institutions such as trade unions and mandatory worker representations can boost productivity (Freeman and Lazear, 1995; Hübler and Jirjahn, 2003; Müller, 2012).

The key argument in all these strands of literature is that increasing competition (or stronger employee bargaining power) reduces the rent of firms and firms respond with improving the management quality (Bloom et al., 2019), innovation efforts (Aghion et al., 2005) and technological adaptation (Matsa, 2011; Bloom et al., 2016). All these activities increase productivity. These organisational and technological changes are also likely to favour higher skill employees who become more productive relatively to low skilled employees providing an incentive for firms for upskilling either by training or hiring. Hence, increasing competition leads to a steeper production function in skills.

If shrinking rents affect both slopes, productivity and wages in skills, the net effect (i.e. change in the productivity-wage wedge) becomes ambiguous. The net effect might increase, decrease or be unaffected by different market imperfections. As a consequence, firms' incentive to invest in general skills of employees might depend on the institutional and market environment. Hence, a more nuanced view of the firms' productivity adjustments to market frictions might modify the original exposition of the new training literature: the response of the productivity-wage wedge to market frictions remains essentially an empirical question.

To identify the productivity-wage wedge under several market imperfections, we extend the study of Konings and Vanormelingen (2015), who identify the productivity-wage wedge for Belgium, and include indicators for institutions and market imperfections. Following Konings and Vanormelingen (2015), we apply recent advancements in jointly estimating production and wage functions and address endogeneity following the approach proposed by Ackerberg et al. (2015) using intermediate inputs to identify the production function and control for unobserved labour quality in the wage function.

Our initial regression confirms a productivity-wage wedge in skills in Germany. Afterwards, we investigate several indicators for market imperfections. Increasing product and labour market competition boost the productivity-wage wedge whereby the productivity effect dominates the wage effect. This result seems to contradict the new training literature arguing that more competition leads to reduced search costs for employees and firms and a higher likelihood of poaching, both of which close the productivity-wage wedge by increasing the slope of wages in skills. However, we find that the productivity-wage wedge increases because competition leads to a stronger increase of the skill-productivity than the skill-wage gradient. The productivity response support arguments in the literature on product market competition and on regional labour markets (Combes et al., 2012; Griffith et al., 2010). Hence, the impact of competition on the skill-productivity gradient dominates the impact on the skill-wage gradient. More competition leads to an increasing productivity-wage wedge.

Furthermore, union wage bargaining has no effect on the productivity-wage wedge but reduces the skill-productivity and the skill-wage gradient similarly. The flatter wage function supports the common finding that the wage dispersion in unionised firms is lower than in non-unionised firms (Dustmann and Schönberg, 2009), hence the wage increase in skills is flatter. However, firms with a collective agreement invest more in training than firms without an agreement which might explain the lower productivity gradient in skills. Finally, works council increases both the skill-productivity and skill-wage gradient but a dominating productivity gradient results in a larger productivity-wage wedge in firms with a works council than in firms without a works council. This finding amends empirical patterns that works councils increase productivity (Müller, 2012; Brändle, 2017) and wages (Addison et al., 2010) by demonstrating that works councils increase the skill gradient in both functions. Works councils seem to be able to implement more targeted skill investments that boost productivity but also ensure that employees receive a share of the generated rent.

Our study shows that the productivity-wage wedge increases when product and labour market competition increase and in the presence of a works council. These findings demonstrate that the interplay between productivity and wage function is not as simple as the new training literature suggests. When the skill-productivity gradient responds stronger to competition than the skill-wage gradient, the original exposition of the new training literature does not hold.

2. Literature review

We combine theoretical arguments and empirical findings from several separated strands of literature. We start introducing the predictions of the new training literature Afterwards we introduce the arguments in the literature of product market competition, labour market density and union wage bargaining that explain why each environment leads to increasing returns to skills in productivity and wages.

The new training literature

The new training literature explains why firms invest in general skills of employees. Under perfectly competitive market conditions, firms pay employees their marginal product and, hence, all returns to skill investments accrue to the employee, so that employers do not invest in general skill training (Becker, 1962). In contrast, imperfect market conditions compress the external wage structure and employees cannot claim their marginal product even if skills are general and similarly productive in all firms. One example is information asymmetry on training contents. If the training firm knows the training content but not the outside firm, the trainee cannot credible signal the improved skills to outside firms and thus does not get an improved outside wage offer after training. If the training firm increases the post-training wage marginally above the (compressed) external wage but below productivity, it reduces the employee's incentive to move as the employee cannot get a higher wage elsewhere. This wage also allows the training firm to generate a higher rent of trained than of untrained employees and creates an incentive to invest in training. The compressed external wage structure renders general skills into quasi-specific skills (Acemoglu and Pischke, 1999). The key assumption in the theory is that productivity grows stronger in skills than the wage, generating a rent for training firms because of market imperfections (Acemoglu and Pischke, 1999; Booth and Zoega, 2004; Leuven, 2005). However, the theory solely focusses on responses of wages to the market environment assuming that general skills are equally valuable for all firms.

Several market imperfections can cause a compressed external wage structure, for example asymmetric information on training content (Katz and Ziderman, 1990), asymmetric information on employee ability (Chang and Wang, 1995; Acemoglu and Pischke, 1998), complementarities between firm-specific and general human capital (Kessler and Lülfesmann, 2006), firm-specific bundles of general skills (Lazear, 2009), product market dominance (Gersbach and Schmutzler, 2012), search and mobility frictions (Acemoglu and Pischke, 1999), union wage bargaining (Dustmann and Schönberg, 2009) and minimum wages (Acemoglu and Pischke, 1999).

The new training literature has triggered a number of empirical studies testing its predictions. Konnings and Vanormelingen (2015), Dearden et al. (2006) and Conti (2005) have shown for different countries and periods that the slope of the production function in skills is steeper than the slope of the wage function in skills. Pfeifer (2016) provides evidence that a more compressed wage structure leads to more company-sponsored training investments.

Product market competition and training

In a non-competitive environment firms earn rents. Increasing competition reduces the rents and forces firms to invest in productivity enhancing technology and organisational practices.[1] However, not the size of the absolute rents lead firms to invest in productivity enhancing technology but the sensitivity of rents to unit cost reductions (Aghion et al., 2001; Bassanini and Brunello, 2011). The sensitivity explains firms' response to competition. Firms may either become more innovative (Aghion et al., 2005; Griffith et

[1] Competition has several impacts on firms and also wipes out low performing firms and those not adaptable for change. However, we analyse surviving firms and focus on the strategies of successful survivors.

al., 2010), introduce modern management practices (Schmitz, 2005; Matsa, 2011; Kaufman, 2015), change the organisational structure (Guadalupe and Wulf, 2010) or introduce the latest technology (Matsa, 2011; Bloom et al., 2016). Moreover, these productivity enhancing investments are likely to be skill-biased because organisational adjustments, innovation and technological change typically favour high-skilled employees whose skills are more likely to complement new technology. High-skilled workers become more attractive for firms because they are able to produce with lower unit labour costs (Guadalupe, 2007).

The empirical literature finds that increasing product market competition increases productivity (Nickell, 1996; Aghion et al., 2004; Griffith et al., 2010; Holmes and Schmitz, 2010), increases wages, and led to a higher wage growth for higher skilled employees (Guadalupe, 2007; Philippon and Reshef, 2012).

The theoretical literature of training and product market competition derives opposing predictions depending on the focus on the productivity or wage function. Gersbach and Schmutzler (2012) and Bilanakos et al. (2017) focus on the compressed wage function and borrow the main argument from the new training literature. Hence, a more competitive environment should lead to increasing wages, a smaller productivity-wage wedge and lower training investments. In contrast, Autor (2001) focusses on the production function and argues that more competition squeezes (monopoly) rents but makes training more likely if ability and training are complements. A blended model is presented by Bassanini and Brunello (2011) who conclude that it remains an empirical question which effect dominates: the `rent effect' that more competition drives wages up reducing the incentive for firms to invest in training or the `business stealing effect' that more competition increases the pressure to reduce unit costs by investing in skills.

The empirical literature on the relationship between product market competition and firms training provision is also inconclusive, estimating positive (Autor, 2001; Bassanini and Brunello, 2011), insignificant (Görlitz and Stiebale, 2011; Picchio and van Ours, 2011) and negative effects (Bilanakos et al., 2017). A recent paper by Heywood et al. (2017) explains the inconclusive results by either a u-shape effect of increasing competition on training or sectoral differences. Training in the service sector is more likely to respond to competition because skill-updating is the more promising strategy to reduce unit costs while technology-related strategies are more effective in manufacturing.

Regional monopsony and training

Labour market competition is widely discussed as the urban premium or agglomeration effect in the literature arguing that urban areas have higher productivity than rural areas because of pooling externalities, agglomeration spillover effects and sorting processes. Pooling externalities improve the matching between employees and workplaces by reducing search frictions; facilitate sharing suppliers and lower transportation costs. Agglomeration spillover effects enable the diffusion and generation of knowledge and facilitate absorbing tacit knowledge through informal learning and more frequent face-to-face interactions. Sorting processes lead to more ambitious and able employees working in urban areas. Finally, faster learning, knowledge spillover and complementarities between skills and technology favour high-skilled employees. Hence, the skill-productivity gradient of firms in urban areas is higher than in rural areas (Moretti, 2004; Combes and Duranton, 2006; Almazan et al., 2007; Heuermann et al., 2010; Moretti, 2011; Combes et al., 2012).

The empirical literature finds higher productivity (e.g., Combes et al., 2012, Combes and Gobillon, 2015) and higher wages in urban areas compared to rural regions (e.g., Hirsch et al., 2016, de la Roca and Puga, 2017) and a higher wage premium for high-skilled workers in urban areas (Carlsen et al., 2016).

The theoretical literature of employer-sponsored training and regional labour market competition primarily focusses on the wage function and follows the arguments in the new training literature that more competition leads to higher wages because of lower search and mobility costs and a higher poaching probability (Acemoglu and Pischke, 1999). One exception is the model by Brunello and de Paola (2008) which blends the new training literature narrative with the positive effects of agglomeration on the production function following the urban premium literature. They conclude that the net-effect between production and wage function remains an empirical question. The empirical literature finds mostly negative or insignificant effects of labour market competition on the provision of employer-provided training, for example Brunello and Gambarotto (2007), Brunello and de Paola (2008), Picchio and van Ours (2011) and Rzepka and Tamm (2016).

Unions, works councils and training

Union wage bargaining and mandatory employee representations are not external market sources but interactions between management and workforce. Union wage bargaining increases the wage level and squeezes the rent share of shareholders, which is the key analogy to regional and product market competition. If workers obtain a larger slice of the rent, managers might respond by engaging in activities to reduce unit costs such as becoming more innovative, adopt the latest technologies or introduce modern organisational practices. These activities should increase the productivity to compensate for higher wages. Importantly, these activities are also likely to be skill-biased and make high-skilled workers more valuable as they can produce with lower unit costs.

In addition to these management-led initiatives to increase productivity, unions and worker representation enable an additional channel to improve productivity by providing employees with a collective voice (Freeman and Medoff, 1984; Hirsch, 2004; Jirjahn and Smith, 2018). In Germany, plant-level employee representation bodies are works councils with strong statutory rights.[2] Works councils can improve productivity by several additional mechanisms. They reduce information asymmetries through facilitating internal two-way communication and improving the credibility of information provided by the management to come up with new solutions to organisational problems. They moderate worker demands by reducing information inefficiencies. Collective voice also reduces transaction costs by summarising and communicating employees' preferences and thereby optimises the public goods that working conditions provide within the firm. The collective voice function supported by legal rights additionally increases the employees' long-term commitment to the firm by providing job security. It can further lead to more trustful and cooperative employment relations that increase motivation and commitment and finally productivity. The downside of these productivity enhancing effects is the increasing bargaining power of workers so that the resulting net-effect on profitability remains ambiguous (Freeman and Medoff, 1984; Freeman and Lazear, 1995; Jirjahn and Smith, 2018).

Moreover, the effect of such voice channels on the slope of skills in productivity and wages is not clear. On the one side, the productivity enhancing policies are likely to have a skill-biased component with a stronger increase in the marginal return for higher skill levels. On the other side, worker representation bodies have a taste for equality and lower wage dispersion within the firm. Particularly unions are associated with a lower within-firm wage dispersion (Dustmann and Schönberg, 2009) leading to lower returns to skills for employees.

Empirical findings support the positive effect of unions on wages (Gürtzgen, 2016; Brändle, 2017) and on productivity in the presence of a works council in Germany (Hübler and Jirjahn, 2003; Müller, 2015; Brändle, 2017). Furthermore, works councils are associated with higher wages (Addison et al., 2010; Brändle, 2017) and higher

[2] In Germany, statutory works council rights are strongest in social and personnel matters such as the introduction of new payment methods, the allocation of working hours and the introduction of technical devices designed to monitor employee performance (Jirjahn and Mohrenweiser, 2016). Hence, works councils can either block or facilitate a route to reduce unit labour costs.

productivity (Hübler and Jirjahn, 2003; Wagner et al., 2006; Jirjahn et al., 2011; Müller, 2012; Jirjahn and Müller, 2014; Müller and Stegmaier, 2017; Brändle, 2017).

The link between unions, works councils and firms' training provision has an additional angle compared to product and labour market competition. Several collective contracts entail explicit clauses about training (Berger and Moraal, 2012) and works councils typically negotiate about training as well (Stegmaier, 2012). Hence, both institutions are found to be positively associated with more employer-provided training (Zwick, 2005; Stegmaier, 2012; Heywood et al., 2017). Moreover, the individual returns to training increase by qualification level (Booth et al., 2003; Zwick and Kuckulenz, 2005).

3. Estimation Strategy

The literature review shows that both – the skill-productivity gradient and skill-wage gradient – are likely to be affected by the level of competition and institutional settings. We jointly estimate the production and wage function, following a standard framework introduced by Hellerstein et al. (1999) and recently extended by Konings and Vanormelingen (2015). Equation (1) shows the production function (after taking the logarithm of a Cobb-Douglas style production function):

$$\log(q_{it}) = \alpha_0 + \alpha_1 \log(l_{it}) + \alpha_2 \log(k_{it}) + \alpha_3\, train_{it} + X_{it}'\alpha + \gamma_t + \omega_{it} + \varepsilon_{it} \qquad (1)$$

where q_{it} is the productivity measure, i.e. value added, for a firm *i* in year *t*, and the input factors are labour l_{it}, capital k_{it} and the skill shift measure is the share of trained workers $train_{it}$. X'_{it} are firm-specific control variables, γ_t year effects, ω_{it} unobserved productivity shocks and ε_{it} denotes the error term.

Estimating equation (1) by OLS results in biased estimates if unobserved productivity shocks ω_{it} are correlated with the input factors of interest (Marschak and Andrews, 1944). We account for the endogeneity by applying the latest methodological advancement using Ackerberg et al. (2015, henceforth "ACF") GMM-based approach. They argue that firms' current demand for intermediate inputs permits catching unobserved productivity because the productivity-relevant shock ω_{it} is unobserved for the econometrician, but not for the firm when making input choices. Hence, the demand for intermediate inputs is a function of labour, capital, unobserved productivity and recently trained employees:

$$intermediates_{it} = f_t(l_{it}, train_{it}, k_{it}, \omega_{it}) \qquad (2)$$

To estimate equation (1) we include the inverted function for intermediate input demand (2) in the equation:

$$\log(q_{it}) = \alpha_0 + \alpha_1 \log(l_{it}) + \alpha_2 \log(k_{it}) + \alpha_3\, train_{it} + X_{it}'\alpha + \gamma_t + f_t^{-1}(interm_{it}, l_{it}, train_{it}, k_{it}) + \varepsilon_{it} \quad (3)$$

The coefficient α_3 is the parameter of interest describing the productivity response to an increase in employees' skills via training. The causal interpretation of this approach relies on three assumptions: the timing of input choices, scalar unobservable and strict monotonicity.

First, the timing of input choices implies that capital inputs are made before the intermediate input demand. Capital is predetermined if investments are decided in the previous period and can be described by $k_{it} = f(k_{it-1}, i_{it-1})$ with investments i_{it-1} in t-1. Hence, capital is uncorrelated with the current (period t) unobserved productivity shocks ω_{it} when estimating equation (1). We follow Konings and Vanormelingen (2015) and assume the specific functional form for the capital formation:

$$k_{it} = (1-\delta)k_{it-1} + i_{it-1} \quad (4)$$

Capital depreciates by a constant rate δ. In contrast, the input factors labour and training are endogenous with respect to productivity. Both inputs enter the intermediate input demand function of a firm, equation (2), i.e. the intermediate inputs are chosen after or simultaneous to the input factor labour and training in period t, the same period as the production takes place (Ackerberg et al., 2015). Hence, labour and training are adjusted prior to the choice of intermediate inputs.

Second, scalar unobservable assumes that the intermediate input demand function, equation (2), has only one common unobservable factor. Third, strict monotonicity assumes that the input function needs to be strictly monotonous in ω_{it} to invert the function and include $f_t^{-1}(.)$ in equation (3). The strict monotonicity implies that no unobservable factors directly affect the intermediate inputs. Otherwise, inverting the intermediate input demand function would be infeasible.

In a next step, we estimate the firm's wage equation to derive the wage premium for trained employees using a standard Mincer-style equation. The wage premium is likely to be biased if the training measure is correlated with unobserved quality of labour. We follow Frazer (2001) who argues that labour quality is the main component of the productivity-relevant shock ω_{it} and include the total factor productivity (TFP) derived from the production function as a proxy for labour quality ($\widehat{TFP_{it}}$):

$$\log(w_{it}) = \beta_0 + \beta_1 \log({}^{k_{it}}/_{l_{it}}) + \beta_2 \widehat{TFP_{it}} + \beta_3\, train_{it} + X'_{it}\beta + \gamma_t + \varepsilon_{it} \qquad (5)$$

Equation (5) can be estimated by OLS. Controlling for the TFP combines the productivity and the wage estimation. The parameter β_3 shows the response of the wage function to an increase in skills measured by employer-sponsored training. We test the difference between α_3 and β_3 representing the productivity-wage wedge in skills (Conti, 2005; Dearden et al., 2006; Konings and Vanormelingen, 2015).

4. Data and variable definitions

We use the IAB Establishment Panel for the period 2007-2016, for which all necessary variables are consistently available. The IAB Establishment Panel is an annual survey covering about 16,000 German establishments with at least one employee subjected to social security insurance. The survey asks about firm characteristics, investments, employment, and business polices (for further information see Ellguth et al., 2014). We restrict our sample to private, commercial establishments with at least five employees, the statutory threshold that employees can establish a works council. We further exclude the agricultural sector, establishments moving between regions and observations with missing values. Since the IAB Establishment Panel collects information about sales, input costs, and investments retrospectively for the previous year, we use one year lags of these variables. Consequently, our estimation sample comprises the period 2008 - 2016.

We use two outcome variables: productivity and wages (Table 1 summarises variable definitions and descriptive statistics). We follow Konings and Vanormelingen (2015) and measure real productivity by the log value added (sales minus input) and wages by the total wage bill per worker. Sales, inputs and wages are deflated by the consumer price index provided by the German statistical office.

We measure firm-sponsored training using the share of trained employees on all employees if the establishment usually pays the direct and indirect costs of training, following Pfeifer (2016).[3] The IAB Establishment survey reports either the number of

[3] This measure includes establishments that pay the majority of training costs and provide training during working time. Since these questions on training costs and time coverage are included in every second year in the IAB Establishment (for details see Pfeifer, 2016), we use the modus of

trained workers or the number of participants in training. The chosen reporting option differs systematically by observable firm characteristics. Restricting our analysis to one reporting option may bias the estimated results. To obtain an unbiased sample, we follow the imputation proposed by Hinz and Stegmaier (2018). The presented results are robust to excluding observations with imputed training values. About 80.7 per cent of the establishments bear direct and indirect training costs. On average, firms train 27.8 per cent of employees in the first six months of a year.

We measure product market competition using a subjective assessment of the firm. Firms report whether they face either no, weak, or strong competitive pressure. We generate a binary variable with the value one if the modus of responses of the firm is strong competitive pressure. About 45 per cent of firms report strong competitive pressure. Self-reported measures have several advantages compared to traditional measures using for example the Herfindahl-index of market shares. Subjective measures are available for all industries and not only for manufacturing, cover relevant national and international competitors and capture within industry variation in product market differentiation (see Heywood et al., 2017 for an in-depth discussion).

We measure labour market competition with the number of firms per industry in each regional labour market divided by the size of the labour market region in square kilometres. We use the modus of the density measure for each firm during our analysis period to assign either a high or a low level of labour market competition. The regional classification is based on commuter flows following the Kosfeld and Werner (2012) classification.[4] We calculate the number of firms per industry in each region using the Establishment History Panel (BHP), which is a 50 per cent sample of all firms with at least one employee (Schmucker et al., 2016). The average number of firms per ten square kilometres is 7.28 in the observation period.

Union wage bargaining is captured by a dummy variable if the firm is covered by a collective agreement on the firm- or sectoral-level. German firms apply the collective agreement typically for all employees and not only for union members (Schnabel et al., 2006). Finally, presence of a works council is captured by a dummy variable indicating its existence at the establishment. We also take the modus of both variables.[5] In our

---

these variables to define whether the establishment sponsors training. The results are robust to changes in the definition.

[4] This classification is common in regional labor market studies with German data (see Görlitz and Rzepka, 2017; Rzepka and Tamm, 2016; Hirsch et al., 2016; Stockinger and Zwick, 2017).

[5] We also test the robustness of the results and found that regime changes in collective bargaining and works council status do not affect the results.

sample, 44 per cent of establishments are covered by a collective agreement and 31 per cent have a works council.

We use standard control variables for the production function (see e.g., Zwick, 2006; Trax et al., 2015; Grunau, 2016). We assess the capital stock of firms using the perpetual inventory method proposed by Hempell (2005). We account for exporting status, young plant, single plant, location (i.e. West Germany), workforce composition, and industry affiliation. In line with Konings and Vanormelingen (2015), we use the same set of control variables for the wage regression to get comparable results for the returns to training on productivity and wages.

5. Empirical findings

We start estimating the productivity-wage wedge for Germany by replicating the main estimation of Konings and Vanormelingen (2015) for Belgium. Table 2 presents the results of OLS regressions (columns 1 and 2) and the respective ACF regressions controlling for endogeneity (columns 3 and 4). The ACF is our preferred regression. The share of trained employees is statistically significant positive in both the production and the wage function. In the production function, a ten percentage point increase in the proportion of trained workers increases value added by about 1.5 per cent using OLS and 2.05 per cent using ACF.[6] This shows that the OLS results are downward biased. This finding supports the arguments in Bartel (1994) and Zwick (2006) that companies are more likely to invest in training during a temporary downturn because of lower opportunity costs. Turning to the wage equation, establishments that increase the proportion of trained employees by ten percentage points face an increased wage bill by about 0.88 per cent (OLS) and 0.91 per cent (ACF).

Finally, we investigate if the productivity-wage wedge opens in skills by testing the equivalence of the training share coefficients between both estimations. For the ACF estimation, the productivity-wage wedge is statistically significant and opens by 1.14 per cent for a ten percentage point increase in trained employees. The productivity-wage wedge has a similar size as in Konings and Vanormelingen (2015). The result confirms the basic mechanism described in the new training literature: wages increase less in skills than productivity allowing firms to reap returns of training investments.

[6] In a log-level model, the marginal effect of the coefficient is $exp^{(\beta-1)}$.

To explain the productivity-wage wedge, the new training literature discusses several sources of market imperfections. We proceed testing the productivity-wage wedge in more and less competitive environments focussing on the ACF results.

Product market competition

The impact of product market competition is shown in Table 3, panel A. Columns 1 and 2 show the productivity and wage function in an environment with weak product market competition and columns 3 and 4 with strong product market competition. In an environment characterised by weak product market competition, a ten percentage point increase in the proportion of trained employees results in a 1.55 per cent increase in value added and a 0.95 per cent increase in the total wage bill, resulting in a significant 0.6 per cent increase in the productivity-wage wedge. In an environment characterised by strong product market competition, a ten percentage point increase in the proportion of trained employees results in a 2.51 per cent increase in value added and a 0.92 per cent increase in the total wage bill, resulting in a 1.59 per cent increase in the productivity-wage wedge.

These findings elucidate previous theoretical and empirical findings by showing that increasing product market competition leads to an increasing skill-productivity gradient. Hence, firms use training investments to recapture rents lost by more fierce competition on the product market where upskilling is a viable strategy to survive (Guadalupe, 2007; Kaufman, 2015). In this light, the total factor productivity, a common measure for management quality (Bloom et al., 2019), is more relevant in a strong than in a weak competition environment.

The findings complement studies discussing firms' responses to increasing product market competition (Matsa, 2011; Kaufman, 2015; Bloom et al., 2016). Complementing training with other polices to reduce unit costs results in an additional feedback effect on the skill-productivity gradient: training has a stronger effect on productivity in a market environment with strong than with weak product market competition. The dominating productivity effect leads to an increasing productivity-wage wedge in a more competitive market environment. This modifies the exposition of the new training literature. Training is not similarly effective in firms facing stronger and weaker product market competition. Firm responses to competition with policies such as innovation, investments in technology and organisational adaptation increase the skill-productivity gradient making training more beneficial in more competitive market environments.

The findings support the theoretical models about company-sponsored training investments of Autor (2001) predicting a positive response of increasing product market competition on the skill-productivity gradient and Bassanini and Brunello (2011) who describe the two opposing forces of product market competition on wages and productivity. On the contrary, the findings challenge arguments that more product market competition leads to a stronger increase in wages than productivity because poaching becomes a more profitable strategy (Gersbach and Schmutzler, 2012; Bilanakos et al., 2017).

Competition on the labour market

The results for labour market competition are summarized in Table 3, panel B. Columns 1 and 2 show the weak labour market competition regime and columns 3 and 4 the strong labour market competition regime. In an environment in which fewer firms compete in a local labour market and the same industry, a ten percentage point increase in the proportion of trained employees lead to a 1.57 per cent increase in value added and a 0.98 per cent increase in the total wage bill resulting in a 0.59 per cent increase in the productivity-wage wedge. In a dense labour market, a ten percentage point increase in the proportion of trained employees lead to a 2.5 per cent increase in value added and a 0.88 per cent increase in the total wage bill resulting in a 1.62 per cent increase in the productivity-wage wedge.

The productivity-wage wedge is larger in a more competitive environment because the productivity returns to skills dominate the wage returns. This is again surprising from the new training literature perspective but not from the regional labour markets perspective. The regional labour market literature highlights that the productivity returns to skills increase in denser labour markets because agglomeration leads to a faster dissemination of ideas, knowledge and technology (Combes et al., 2012), which favours higher-skilled employees and makes investments in skills more profitable (Guadalupe, 2007; Combes and Gobillon, 2015). The finding demonstrates that the assumption that general skills are equally valuable across all firms does not always hold because agglomeration effects complement high-skilled employees, resulting in a steeper skill-productivity gradient. The findings support the argument in Brunello and de Paola (2008) who conclude that knowledge-spillovers outweigh the investment discouraging effects of increasing wages and turnover in denser labour markets.

Union wage bargaining and employee representation

The effect of the labour market institutions union wage bargaining and works councils is shown in Table 4 contrasting the situation without and with a collective bargaining agreement (Panel A) and works council (Panel B). Regarding unions, a ten percentage point increase in the proportion of trained employees' increases the value added by about 2.1 per cent in uncovered and by about 1.73 per cent in covered firms while the wage bill increases by 1.03 and 0.73 per cent respectively. The resulting productivity-wage wedge is similar with 1.07 and 1.0 percent. Regarding works councils, the same increase in trained employees' results in a 1.5 per cent increase in value added in firms without a works council and a 3.28 per cent increase in firms with a works council. The effect on the wage bill is 0.93 per cent in firms without and 1.13 per cent in firms with a works council resulting in a productivity-wage wedge of 0.57 per cent in firms without and 2.15 per cent in firms with a works council.

Both collective bargaining regimes have a comparable productivity-wage wedge. However, the skill-wage gradient is smaller in unionised than in non-unionised firms confirming findings that the wage dispersion is lower in unionised firms (Dustmann and Schönberg, 2009). Moreover, unionised firms have a smaller skill-productivity gradient but a higher proportion of trained employees on all employees than non-unionised firms (see Table A1 in the Appendix). This might be caused by the substantial training clauses in collective agreements (Berger and Moraal, 2012). These clauses might push training investments and reduce the marginal productivity returns to skills. However, the more compressed wage structure offsets the lower productivity returns.

In contrast, works councils increase the efficacy of employer-provided training resulting in a stronger effect on productivity in firms with than in firms without a works council. This result fits the theoretical arguments that works councils improve information sharing and the efficacy of communication within firms (Freeman and Lazear, 1995; Jirjahn and Smith, 2018). However, the results go beyond previous empirical findings as they demonstrate that works councils increase the skill-productivity gradient: works councils do not only increase the level of training but also the returns to training. They might, for example, support more targeted training investments or better learning and implementation efforts of employees. Moreover, the higher returns to wages in presence of a works council also support findings that firms with a works council provide higher pay (Hübler and Jirjahn, 2003; Addison et. al, 2010; Brändle, 2017). The results suggest a potential mechanism for higher wages via increasing returns to training.

Moreover, the stronger return to productivity outweighs the return to wages and the net-effect of the productivity-wage wedge is substantially larger for firms with than without a works council. Hence, employer-sponsored training becomes a more valuable strategy to boost productivity in firms with a works council. This result provides an explanation for findings that firms with a works councils have higher company-sponsored training investments (Zwick, 2005; Stegmaier, 2012; Heywood et al., 2017) and demonstrates that the increase in training is backed by increasing returns to training and not (only) by demands of worker representatives for more training.

Interestingly, while works councils improve the efficacy of training, collective agreements cannot increase the efficacy of training on the firm-level. Moreover, unionised firms train more employees and have lower marginal returns to training than non-unionised firms (Appendix Table A1), firms covered by a works councils train more employees but also have higher marginal returns to training than firms without a works council. This might be due to the fact that collective agreements are typically negotiated on the sectoral and regional level (Schnabel et al., 2006; Brändle, 2017) leaving the establishment-level co-determination bodies, the works councils, to find efficient and effective solutions to implement training. These findings might explain that empirical research finds a positive effect of collective agreements on productivity in establishments that also had a works council (Hübler and Jirjahn, 2003; Müller, 2015; Brändle, 2017).

Robustness checks

We run several robustness tests. First, we tested the sensitivity of the definition of firm-sponsored training and found qualitatively similar results if we relax the cost coverage to direct training costs only (Table A3 Panel A, column 1). More importantly, we find no productivity-wage wedge if we condition our sample to firms reporting that employees finance the training (Table A3 Panel A, column 2). In this case, the wage returns are slightly higher but the productivity returns are considerably lower than for company-sponsored training. Second, we restrict our sample to firms with more than 20 employees to reduce the integer problems in small firms regarding our main explanatory variable, the proportion of employees that receive training on all employees. The results are robust (Table A3 Panel B). Third, we abstain from using deflated variables for the value added and capital but get robust results (Table A3, Panel C).

Furthermore, we test the sensitivity of our competition and institution measures. Table A4 Panel A shows that dropping establishments that report changing the product market competition over time does not impact our main finding. Panel B shows that using the population density rather than firm-industry density to measure labour market competition does not affect the main finding.

Panels C to E of Table A4 comprise robustness analyses for works councils and union wage bargaining. In Panel C we distinguish the four possible regimes of collective bargaining coverage and works council presence.[7] The results show that the existence

[7] Oberfichtner and Schnabel (2019) show that it is important to consider these combinations of industrial relations in Germany.

of a works council dominates the effect on the productivity-wage wedge. If no works council is present (columns (1) and (4) of Panel C), the productivity-wage wedge is either small or insignificant, which corroborates the results presented in Table 4. Panels D and E demonstrate that dropping establishments that change the works councils or collective bargaining status does not affect the main findings.

6. Conclusions

We investigate the productivity-wage wedge, i.e. the difference in the skill-productivity and skill-wages gradients, for several institutional and market environments. We show that, in contradiction to the new training literature, more competition on the product and labour market leads to a larger productivity-wage wedge. This response is driven by an increasing skill-productivity gradient in more competitive environments. While the new training literature assumes that productivity returns to skills are constant for all firms in, the literature on product market competition and local labour market density provides plenty of arguments and evidence why high-skilled employees become more productive than low skilled employees when competition increases. Moreover, we show a stronger productivity-wage wedge in the presence of a works council is driven by a stronger effect on productivity than on wage returns. Works councils seem to improve the efficacy of training for example by a more targeted training approach. Finally, firms with and without collective agreement have a similar productivity-wage wedge.

The findings accentuate the new training literature by showing that the institutional and market environments have also an effect on the productivity returns to skills. The increasing skill-productivity gradient modifies some expositions of the new training literature: more competition (or less imperfection) can also increase firms' incentive to invest in company-sponsored training if the productivity return to skills dominates the wage return to skills. The skill-productivity gradient increases because competition forces firms to adapt more efficient organisation, production and service, innovate or introduce the latest technology. All of these policies are likely to favour higher skilled employees and lead to a steeper skill-productivity gradient. The increasing skill-productivity gradient dominates the increasing skill-wage gradient in the analysed more competitive environments.

In addition, our findings can reconcile contradicting theoretical predictions about the effect of market frictions on training. For example, theoretical models about training and product market competition derive opposing predictions. They focus either on the production function to argue for more training in more competitive markets (Autor, 2001; Bassanini and Brunello, 2011) or on the wage function to argue for less training

(Gersbach and Schmutzler, 2012; Bilanakos et al., 2017). We show that both mechanisms are empirically valid but the net effect between productivity and wage function determines the outcome of company-sponsored training investments.

Nevertheless, the results do not imply that more competition always leads to an increasing productivity-wage wedge. Previous research has shown that firms operating without product market competition, for example, are associated with more training than firms facing some competition on the product market (Bilanakos et al., 2017). Further, moderating factors such as the technological nature of the industry affect the product market - training relation (Heywood et al., 2017). Hence, although this paper demonstrates that competition influences the skill-productivity gradient, identifying universal mechanisms is beyond the scope of the paper and can be addressed in future research.

REFERENCES

Acemoglu, D., & Pischke, J.S. (1998). Why do firms train? Theory and Evidence. *The Quarterly Journal of Economics*, *113*(1), 79-119.

Acemoglu, D., & Pischke, J.S. (1999). The Structure of Wages and Investment in General Training. *Journal of Political Economy*, *107*(3), 539-572.

Ackerberg, D.A., Caves, K., & Frazer, G. (2015). Identification properties of recent production function estimators. *Econometrica*, *83*(6), 2411-2451.

Addison, J.T., Bryson, A., Teixeira, P., Pahnke, A., & Bellmann, L. (2013). The Extent of Collective Bargaining and Workplace Representation: Transitions between States and their Determinants. A Comparative Analysis of Germany and Great Britain. *Scottish Journal of Political Economy*, *60*(2), 182-209.

Addison, J.T., Teixeira, P., & Zwick, T. (2010). German works councils and the anatomy of wages. *Industrial and Labor Relations Review*, *63*(2), 247-270.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and Innovation: An Inverted-U relationship. *The Quarterly Journal of Economics*, *120*(2), 701-728.

Aghion, P., Blundell, R., Griffith, R., Howitt, P., & Prantl, S. (2004). Entry and productivity growth: Evidence from microlevel panel data. *Journal of the European Economic Association*, *2*(2-3), 265-276.

Aghion, P., Harris, C., Howitt, P., & Vickers, J. (2001). Competition, imitation and growth with step-by-step innovation. The Review of Economic Studies, *68*(3), 467-492.

Almazan, A., de Motta, A., & Titman, S. (2007). Firm location and the creation and utilization of human capital. *The Review of Economic Studies*, *74*(4), 1305-1327.

Autor, D.H. (2001). Why do temporary help firms provide free general skills training?. *The Quarterly Journal of Economics*, *116*(4), 1409-1448.

Bartel, A.P. (1994). Productivity gains from the implementation of employee training programs. *Industrial Relations*, *33*(4), 411-425.

Bassanini, A., & Brunello, G. (2011). Barriers to entry, deregulation and workplace training: A theoretical model with evidence from Europe. *European Economic Review*, *55*(8), 1152-1176.

Becker, G.S. (1962). Investment in human capital: A theoretical analysis. *The Journal of Political Economy*, *70*(5), 9-49.

Berger, K., & Moraal, D. (2012). Tarifliche Weiterbildungspolitik in den Niederlanden und in Deutschland. *WSI Mitteilungen*, *65*(5), 382-390.

Bilanakos, C., Green, C.P., Heywood, J.S., & Theodoropoulos, N. (2017). Do dominant firms provide more training?. *Journal of Economics & Management Strategy*, *26*(1), 67-95.

Bloom, N., Brynjolfsson, E., Foster, L., Jarmin, R., Patnaik, M., Saporta-Eksten, I., & van Reenen, J. (2019), What Drives Differences in Management? *American Economic Review,* 109(5), 1648-83.

Bloom, N., Draca, M., & van Reenen, J. (2016). Trade induced technical change? The impact of Chinese imports on innovation, IT and productivity. *The Review of Economic Studies*, *83*(1), 87-117.

Booth, A.L., & Bryan, M.L. (2005). Testing some predictions of human capital theory: New training evidence from Britain. *The Review of Economics and Statistics*, *87*(2), 391-394.

Booth, A.L., Francesconi, M., & Zoega, G. (2003). Unions, work-related training, and wages: Evidence for British men. *Industrial and Labor Relations Review*, *57*(1), 68-91.

Booth, A.L., & Katic, P. (2011). Men at Work in a Land Down-Under: Testing Some Predictions of Human Capital Theory. *British Journal of Industrial Relations*, *49*(1), 1-24.

Booth, A.L., & Zoega, G. (2004). Is wage compression a necessary condition for firm-financed general training?. *Oxford Economic Papers*, *56*(1), 88-97.

Brändle, T. (2017). Flexible collective bargaining agreements: Still a moderating effect on works council behaviour?. *Managerial and Decision Economics*, *38*(8), 1137-1153.

Brunello, G., & de Paola, M. (2008). Training and economic density: Some evidence form Italian provinces. *Labour Economics*, *15*(1), 118-140.

Brunello, G., & Gambarotto, F. (2007). Do spatial agglomeration and local labor market competition affect employer-provided training? Evidence from the UK. *Regional Science and Urban Economics*, *37*(1), 1-21.

Carlsen, F., Rattsø, J., & Stokke, H. E. (2016). Education, experience, and urban wage premium. *Regional Science and Urban Economics*, *60*, 39-49.

Chang, C., & Wang, Y. (1995). A framework for understanding differences in labor turnover and human capital investment. *Journal of Economic Behavior & Organization*, *28*(1), 91-105.

Combes, P.P., & Duranton, G. (2006). Labour pooling, labour poaching, and spatial clustering. *Regional Science and Urban Economics*, *36*(1), 1-28.

Combes, P.P., Duranton, G., Gobillon, L., Puga, D., & Roux, S. (2012). The productivity advantages of large cities: Distinguishing agglomeration from firm selection. *Econometrica*, *80*(6), 2543-2594.

Combes, P.P., & Gobillon, L. (2015). The empirics of agglomeration economies. In Duranton, G., Henderson, J.V., & Strange, W.C. (Eds.), *Handbook of Regional and Urban Economics* (Vol. 5, pp. 247-348). North-Holland: Elsevier.

Conti, G. (2005). Training, productivity and wages in Italy. *Labour Economics*, *12*(4), 557-576.

Dearden, L., Reed, H., & van Reenen, J. (2006). The impact of training on productivity and wages: Evidence from British panel data. *Oxford Bulletin of Economics and Statistics*, *68*(4), 397-421.

De la Roca, J.D.L., & Puga, D. (2017). Learning by working in big cities. *The Review of Economic Studies*, *84*(1), 106-142.

Dustmann, C., & Schönberg, U. (2009). Training and union wages. *The Review of Economics and Statistics*, *91*(2), 363-376.

Ellguth, P., Kohaut, S., & Möller, I., (2014). The IAB Establishment Panel – Methodological Essentials and Data Quality. *Journal for Labour Market Research*, *47*(1), 27-41.

Frazer, G. (2001). Linking Firms and Workers: Heterogeneous Labor and Returns to Education. Yale University.

Freeman, R.B., & Lazear, E.P. (1995). An Economic Analysis of Works Councils. In Rogers J., & Streeck W. (Eds.), *Works Councils: Consultation, Representation and Cooperation in Industrial Relations* (pp. 27-52). Chicago: University of Chicago Press.

Freeman, R.B., & Medoff, J.L. (1984). *What do unions do?.* New York: Basic Books.

Gersbach, H., & Schmutzler, A. (2012). Product markets and industry-specific training. *The RAND Journal of Economics*, *43*(3), 475-491.

Görlitz, K., & Stiebale, J. (2011). The impact of product market competition on employers' training investments. Evidence from German establishment panel data. *De Economist*, *159*(1), 1-23.

Görlitz, K., & Rzepka, S. (2017). Does Regional Training Supply Determine Employees' Training Participation *The Annals of Regional Science, 59*(1), 281-296.

Griffith, R., Harrison, R., & Simpson, H. (2010). Product market reform and innovation in the EU. *Scandinavian Journal of Economics*, *112*(2), 389-415.

Grunau, P. (2016). The impact of overeducated and undereducated workers on establishment-level productivity: First evidence for Germany. *International Journal of Manpower*, *37*(2), 372-392.

Guadalupe, M. (2007). Product market competition, returns to skill, and wage inequality. *Journal of Labor Economics*, *25*(3), 439-474.

Guadalupe, M., & Wulf, J. (2010). The flattening firm and product market competition: The effect of trade liberalization on corporate hierarchies. *American Economic Journal: Applied Economics*, *2*(4), 105-27.

Gürtzgen, N. (2016). Estimating the Wage Premium of Collective Wage Contracts: Evidence from Longitudinal Linked Employer–Employee Data. *Industrial Relations*, *55*(2), 294-322.

Hellerstein, J.K., Neumark, D., & Troske, K.R. (1999). Wages, productivity, and worker characteristics: Evidence from plant-level production functions and wage equations. *Journal of Labor Economics*, *17*(3), 409-446.

Hempell, T. (2005). What's spurious, what's real? Measuring the productivity impacts of ICT at the firm-level. *Empirical Economics*, *30*(2), 427-464.

Heuermann, D., Halfdanarson, B., & Südekum, J. (2010). Human capital externalities and the urban wage premium: Two literatures and their interrelations. *Urban Studies*, *47*(4), 749-767.

Heywood, J.S., Jirjahn, U., & Pfister, A. (2017). *Product Market Competition and Employer Provided Training in Germany*, IZA Discussion Paper No. 11054.

Hinz, T., & Stegmaier, J., (2018). *Providing a consistent measure of further training for the IAB Establishment Panel*, FDZ-Methodenreport No. 2/2018.

Hirsch, B.T. (2004). What do unions do for economic performance?. *Journal of Labor Research*, *25*(3), 415-456.

Hirsch, B., Jahn, E.J., & Oberfichtner, M. (2016). *The urban wage premium in imperfect labour markets*, IZA Discussion Paper No. 9635.

Holmes, T.J., & Schmitz Jr, J.A. (2010). Competition and productivity: a review of evidence. *Annual Review of Economics*, *2*(1), 619-642.

Hübler, O., & Jirjahn, U. (2003). Works councils and collective bargaining in Germany: the impact on productivity and wages. *Scottish Journal of Political Economy*, *50*(4), 471-491.

Jirjahn, U., Mohrenweiser, J., & Backes-Gellner, U. (2011). Works councils and learning: On the Dynamic Dimension of Codetermination. *Kyklos*, *64*(3), 427-447.

Jirjahn, U., & Mohrenweiser, J. (2016). Owner-managers and the failure of newly adopted works councils. *British Journal of Industrial Relations*, *54*(4), 815-845.

Jirjahn, U., & Müller, S. (2014). Non-union worker representation, foreign owners, and the performance of establishments. *Oxford Economic Papers*, *66*(1), 140-163.

Jirjahn, U., & Smith, S.C. (2018). Nonunion Employee Representation: Theory and the German Experience with Mandated Works Councils. *Annals of Public and Cooperative Economics*, *89*(1), 201-233.

Katz, E., & Ziderman, A. (1990). Investment in general training: The role of information and labour mobility. *The Economic Journal*, *100*(403), 1147-1158.

Kaufman, B.E. (2015). Market competition, HRM, and firm performance: The conventional paradigm critiqued and reformulated. *Human Resource Management Review*, *25*(1), 107-125.

Kessler, A.S., & Lülfesmann, C. (2006). The theory of human capital revisited: on the interaction of general and specific investments. *The Economic Journal*, *116*(514), 903-923.

Konings, J., & Vanormelingen, S. (2015). The impact of training on productivity and wages: firm-level evidence. *The Review of Economics and Statistics*, *97*(2), 485-497.

Kosfeld, R., & Werner, A. (2012). Deutsche Arbeitsmarktregionen – Neuabgrenzung nach den Kreisgebietsreformen 2007 - 2011. *Raumforschung und Raumordnung*, *70*(1), 49-64.

Lazear, E.P. (2009). Firm-specific human capital: A skill-weights approach. *Journal of Political Economy*, *117*(5), 914-940.

Leuven, E. (2005). The Economics of Private Sector Training: a Survey of the Literature. *Journal of Economic Surveys*, *19*(1), 91-111.

Marschak, J., & Andrews, W.H. (1944). Random simultaneous equations and the theory of production. *Econometrica, 12(3/4)*, 143-205.

Matsa, D.A. (2011). Competition and product quality in the supermarket industry. *The Quarterly Journal of Economics*, *126*(3), 1539-1591.

Moretti, E. (2004). Human capital externalities in cities. In Henderson, V., & Thisse, J.-F. (Eds.), *Handbook of Regional and Urban Economics* (Vol. 4, pp. 2243-2291). North-Holland: Elsevier.

Moretti, E. (2011). Local labor markets. In Card, D., & Ashenfelter, O. (Eds.), *Handbook of Labor Economics* (Vol. 4, pp. 1237-1313). North-Holland: Elsevier.

Müller, S. (2012). Works councils and establishment productivity. *Industrial and Labor Relations Review*, *65*(4), 880-898.

Müller, S. (2015). Works councils and labour productivity: Looking beyond the mean. *British Journal of Industrial Relations*, *53*(2), 308-325.

Müller, S., & Stegmaier, J. (2017). The dynamic effects of works councils on labour productivity: First evidence from panel data. *British Journal of Industrial Relations*, *55*(2), 372-395.

Nickell, S.J. (1996). Competition and Corporate Performance. *Journal of Political Economy*, *104*(4), 724-746.

Oberfichtner, M., & Schnabel, C. (2019). The German model of industrial relations: (where) does it still exist? *Jahrbücher für Nationalökonomie und Statistik*, *239*(1), 5-37.

Pfeifer, C. (2016). Intra-firm Wage Compression and Coverage of Training Costs: Evidence from Linked Employer-Employee Data. *Industrial and Labor Relations Review*, *69*(2), 435-454.

Philippon, T., & Reshef, A. (2012). Wages and human capital in the US finance industry: 1909–2006. *The Quarterly Journal of Economics*, *127*(4), 1551-1609.

Picchio, M., & van Ours, J.C. (2011). Market imperfections and firm-sponsored training. *Labour Economics*, *18*(5), 712-722.

Rzepka, S., & Tamm, M. (2016). Local employer competition and training of workers. *Applied Economics*, *48*(35), 3307-3321.

Schmitz Jr, J.A. (2005). What determines productivity? Lessons from the dramatic recovery of the US and Canadian iron ore industries following their early 1980s crisis. *Journal of Political Economy*, *113*(3), 582-625.

Schmucker, A., Seth, S., Ludsteck, J., Eberle, J., & Ganzer, A. (2016). *Establishment History Panel 1975-2014*. FDZ-Datenreport, 03/2016 (en).

Schnabel, C., Zagelmeyer, S., & Kohaut, S. (2006). Collective bargaining structure and its determinants: An empirical analysis with British and German establishment data. *European Journal of Industrial Relations*, *12*(2), 165-188.

Stegmaier, J. (2012). Effects of works councils on firm-provided further training in Germany. *British Journal of Industrial Relations*, *50*(4), 667-689.

Stockinger, B., & Zwick, T. (2017). *Apprentice poaching in regional labor markets*. ZEW Discussion Papers 17.

Trax, M., Brunow, S., & Südekum, J. (2015). Cultural diversity and plant-level productivity. *Regional Science and Urban Economics*, *53*, 85-96.

Waddoups, C.J. (2014). Union Membership and Job-Related Training: Incidence, Transferability, and Efficacy. *British Journal of Industrial Relations*, *52*(4), 753-778.

Wagner, J., Schank, T., Schnabel, C., & Addison, J.T. (2006). Works councils, labor productivity and plant heterogeneity: first evidence from quantile regressions. *Jahrbücher für Nationalökonomie und Statistik*, *226*(5), 505-518.

Zwick, T. (2005). Continuing vocational training forms and establishment productivity in Germany. *German Economic Review*, *6*(2), 155-184.

Zwick, T. (2006). The impact of training intensity on establishment productivity. *Industrial Relations*, *45*(1), 26-46.

Zwick, T., & Kuckulenz, A. (2005). Heterogeneous returns to training in personal services. In Bazen, S., Lucifora, C., & Salverda, W. (Eds.), Job Quality and Employer Behaviour (pp. 216-234). London : Palgrave Macmillan.

Tables and Figures

Table 1: Variable definitions and summary statistics

Variable	Definition	Mean	S.D.
Dependent variables			
Value added, log	Log of sales minus costs of intermediate inputs, deflated with consumer price index (CPI)	14.488	1.712
Wages, log	Log of annual total wage bill per worker, deflated with CPI	10.050	0.498
Key explanatory variables			
Training, share	Number of trained employees as a proportion of all employees	0.278	0.280
Product market competition	Dummy variable equals 1 if firm reports high pressure of competition	0.451	0.498
Labour market competition	Number of firms in each region and industry divided by the size of the region in km^2	0.728	0.868
Collective agreements	Dummy variable equals 1 if firm is covered by a collective wage agreement, zero otherwise.	0.441	0.497
Works council	Dummy variable equals 1 if firm has a works council, zero otherwise	0.316	0.465
Control variables:			
Capital, log	Log of firms' capital stock derived using the perpetual inventory method deflated with CPI	12.585	2.983
Labour, log	Log of number of employees	3.723	1.380
Material, log	Log of intermediate inputs adjusted to input price index (industry level)	8.875	2.039
Capital-labour-ratio, log	Log of capital/labour, deflated with CPI	8.938	2.110
TFP	Total factor productivity predicted from the production function	1.205	1.801
Skilled employees	Share of employees with an university or an apprenticeship degree	0.726	0.227
Apprentices	Share of apprentice	0.052	0.079
Part-time	Share of employees working part-time	0.176	0.216
Female	Share of female employees	0.343	0.267
Single plant	Dummy variable equals 1 if firm is a single plant, zero otherwise	0.770	0.421
Exporter	Dummy variable equals 1 if firm exports, zero otherwise	0.362	0.481
Young firm	Dummy variable equals 1 if the firm was founded in the previous five years, zero otherwise	0.073	0.259
West	Dummy variable equals 1 if firm is located in West Germany, zero otherwise	0.597	0.491
Industry and year dummies	Dummy variables for 8 industries and 8 years		

Notes: N= 16,399 observations in 4,569 establishments

Data source: IAB Establishment Panel 2008-2016, own calculations.

Table 2: The impact of training on productivity and wages

	Production Function	Wage Regression	Production Function	Wage Regression
	OLS		ACF	
	(1)	(2)	(3)	(4)
Training, share	0.140***	0.084***	0.186***	0.087***
	(0.027)	(0.014)	(0.053)	(0.014)
Labour, log	0.929***		0.719***	
	(0.012)		(0.014)	
Capital, log	0.066***		0.082***	
	(0.005)		(0.013)	
Capital/Labour, log		0.031***		0.032***
		(0.003)		(0.003)
TFP				0.024
				(0.016)
Controls	yes	yes	yes	yes
Difference training	0.056***		0.099***	
Obs.	16,399	16,399	16,399	16,399
Establishments	4,569	4,569	4,569	4,569

Notes: Dependent variable: log real value added (production function) and log real total wage bill per worker (wage regressions). Method: OLS in columns (1) and (2) and Ackerberg et al. (2015) GMM approach to control for the endogeneity of inputs and training in column (3) and the corresponding OLS wage regression in column (4). Standard errors clustered at establishment-level in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1; Controls: dummies for export status, young plant, single plant, high product market competition, labour market competition, collective bargaining agreement, works council, West Germany; shares of qualified workers, university graduates, apprentices, female worker, part-time workers, and industry and year dummies. Total factor productivity (TFP) originates from the corresponding production function. Statistical significance of the difference in training is simulated using 10.000 bootstrap iterations and subsequent t-test. Data source: IAB Establishment Panel 2008-2016, own calculations.

Table 3: The impact of training on productivity and wages by market competition

Panel A	Weak product market competition		Strong product market competition	
	Production Function	Wage Regression	Production Function	Wage Regression
	(1)	(2)	(3)	(4)
Training, share	0.144**	0.090***	0.224***	0.088***
	(0.068)	(0.019)	(0.083)	(0.020)
Labour, log	0.731***		0.706***	
	(0.019)		(0.021)	
Capital, log	0.069***		0.100***	
	(0.015)		(0.023)	
Capital/Labour, log		0.031***		0.031***
		(0.004)		(0.005)
TFP		0.016		0.088***
		(0.012)		(0.011)
Controls	yes	yes	yes	yes
Difference training	0.054***		0.136***	
Obs.	9,538	9,538	6,861	6,861
Establishments	2,645	2,645	1,924	1,924

Panel B	Weak labour market competition		Strong labour market competition	
	Production Function	Wage Regression	Production Function	Wage Regression
	(1)	(2)	(3)	(4)
Training, share	0.146*	0.094***	0.223***	0.084***
	(0.077)	(0.019)	(0.072)	(0.021)
Labour, log	0.720***		0.727***	
	(0.022)		(0.019)	
Capital, log	0.090***		0.075***	
	(0.019)		(0.017)	
Capital/Labour, log		0.032***		0.029***
		(0.004)		(0.004)
TFP		0.070***		0.019
		(0.016)		(0.014)
Controls	yes	yes	yes	yes
Difference training	0.052***		0.139***	
Obs.	7,994	7,994	8,405	8,405
Establishments	2,174	2,174	2,395	2,395

Notes: For the sample splits in Panel A we use the modes of product market competitions. Weak product market competition (col. 1-2) is indicated by no, or some product market competition. Strong product market competition (col. 3-4) is indicated by high level of competition. In Panel B we split the samples using the median of labour market competition. Labour market competition is defined as the average of the number of firms in each region and industry divided by the size of the region in km^2. Standard errors clustered at establishment-level in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Control variables as noted in Table 2. Statistical significance of the difference in training is simulated using 10.000 bootstrap iterations and subsequent t-test. Data source: IAB Establishment Panel 2008-2016, own calculations.

Table 4: The impact of training on productivity and wages by union wage bargaining and works councils

Panel A	No collective bargaining agreement		With collective bargaining agreement	
	Production Function	Wage Regression	Production Function	Wage Regression
	(1)	(2)	(3)	(4)
Training, share	0.190***	0.098***	0.159*	0.070***
	(0.070)	(0.019)	(0.083)	(0.020)
Labour, log	0.745***		0.711***	
	(0.021)		(0.020)***	
Capital, log	0.076***		0.086***	
	(0.016)		(0.021)	
Capital/Labour, log		0.020***		0.039***
		(0.004)		(0.004)
TFP		0.119***		0.013
		(0.010)		(0.009)
Controls	yes	yes	yes	yes
Difference training	0.092***		0.089***	
Obs.	9,457	9,457	6,942	6,942
Establishments	2,571	2,571	1,998	1,998

Panel B	No works council		With works council	
	Production Function	Wage Regression	Production Function	Wage Regression
	(1)	(2)	(3)	(4)
Training, share	0.140**	0.089***	0.284***	0.107***
	(0.062)	(0.018)	(0.102)	(0.021)
Labour, log	0.726***		0.720***	
	(0.017)		(0.025)***	
Capital, log	0.079***		0.101***	
	(0.015)		(0.026)	
Capital/Labour, log		0.031***		0.028***
		(0.004)		(0.004)
TFP		0.110***		0.012
		(0.012)		(0.008)
Controls	yes	yes	yes	yes
Difference training	0.051***		0.177***	
Obs.	11,265	11,265	5,134	5,134
Establishments	3,040	3,040	1,529	1,529

Notes: Panel A: we split the samples by the existence of a collective agreement (modus over analysis years). Panel B: We split the samples by the existence of a works council (modus over analysis years). Standard errors clustered at establishment-level in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Control variables as noted in Table 2. Statistical significance of the difference in training is simulated using 10.000 bootstrap iterations and subsequent t-test. Data source: IAB Establishment Panel 2008-2016, own calculations.

Appendix

Table A1: Descriptive statistics for each sample

Panel A	Mean	S.D.	Mean	S.D.
	Full Sample		Cost coverage sample (Tab. 2)	
Training, share	0.281	0.284	0.278	0.280
Training, dummy	0.799	0.401	0.807	0.394
Value added, log	14.389	1.735	14.488	1.712
Wage bill, log	10.013	0.511	10.050	0.498
Number of employees	140.314	876.338	155.637	1038.166
Labour, log	3.664	1.385	3.723	1.380
Capital, log	12.490	2.995	12.585	2.983
Capital/Labour, log	8.901	2.108	8.938	2.110
TFP (of ACF estimation)	1.204	1.587	1.205	1.801
Obs.	23,616	23,616	16,399	16,399
Establishments	6,697	6,697	4,569	4,569
Panel B	Mean	S.D.	Mean	S.D.
	Weak product market competition		Strong product market competition	
Training, share	0.262	0.275	0.289	0.283
Training, dummy	0.810	0.392	0.805	0.396
Value added, log	14.741	1.742	14.307	1.667
Wage bill, log	10.081	0.486	10.027	0.505
Number of employees	207.998	1503.483	117.972	473.084
Labour, log	3.953	1.400	3.558	1.341
Capital, log	12.895	2.812	12.362	3.081
Capital/Labour, log	9.005	1.956	8.891	2.212
TFP (of ACF estimation)	1.199	0.902	1.208	2.277
Obs.	9,538	9,538	6,861	6,861
Establishments	2,645	2,645	1,924	1,924
Panel C	Mean	S.D.	Mean	S.D.
	Weak labour market competition		Strong labour market competition	
Training, share	0.268	0.281	0.287	0.279
Training, dummy	0.795	0.404	0.820	0.385
Value added, log	14.559	1.711	14.421	1.710
Wage bill, log	10.055	0.468	10.044	0.525
Number of employees	151.044	1105.694	160.006	969.632
Labour, log	3.773	1.352	3.675	1.405
Capital, log	12.869	2.887	12.314	3.047
Capital/Labour, log	9.156	2.002	8.731	2.187
TFP (of ACF estimation)	1.184	0.967	1.213	2.113
Obs.	7,994	7,994	8,405	8,405
Establishments	2,174	2,174	2,395	2,395

cont. on next page

Panel D	Mean	S.D.	Mean	S.D.
	No collective bargaining agreement		With collective bargaining agreement	
Training, share	0.276	0.285	0.280	0.274
Training, dummy	0.777	0.416	0.849	0.358
Value added, log	14.029	1.450	15.115	1.838
Wage bill, log	9.970	0.496	10.158	0.480
Number of employees	63.167	196.441	281.608	1570.403
Labour, log	3.335	1.143	4.251	1.495
Capital, log	12.090	2.694	13.259	3.218
Capital/Labour, log	8.823	2.004	9.096	2.236
TFP (of ACF estimation)	1.184	0.827	1.227	2.369
Obs.	9,457	9,457	6,942	6,942
Establishments	2,571	2,571	1,998	1,998
Panel E	Mean	S.D.	Mean	S.D.
	No works council		With works council	
Training, share	0.272	0.286	0.290	0.268
Training, dummy	0.753	0.431	0.927	0.260
Value added, log	13.781	1.307	16.040	1.451
Wage bill, log	9.924	0.486	10.326	0.404
Number of employees	47.596	166.627	392.700	1816.693
Labour, log	3.156	1.037	4.967	1.215
Capital, log	11.794	2.589	14.320	3.056
Capital/Labour, log	8.700	2.032	9.461	2.181
TFP (of ACF estimation)	1.183	0.841	1.235	2.474
Obs.	11,265	11,265	5,134	5,134
Establishments	3,040	3,040	1,529	1,529

Notes: Sample splits as described in Tables 3 and 4. Data source: IAB Establishment Panel 2008-2016, own calculations.

Table A2: The impact of training on productivity and wages (full results of Table 2)

	Production Function	Wage Regression	Production Function	Wage Regression
	OLS		ACF	
	(1)	(2)	(3)	(4)
Training, share	0.140***	0.084***	0.186***	0.087***
	(0.027)	(0.014)	(0.053)	(0.014)
Labour, log	0.929***		0.719***	
	(0.012)		(0.014)	
Capital, log	0.066***		0.082***	
	(0.005)		(0.013)	
Capital/Labour, log		0.031***		0.032***
		(0.003)		(0.003)
TFP				0.024
				(0.016)
				0.137
Skilled employees, share	0.455***	0.454***	0.289***	0.454***
	(0.045)	(0.023)	(0.042)	(0.023)
Apprentices, share	-0.725***	-0.763***	-0.685***	-0.761***
	(0.110)	(0.071)	(0.099)	(0.069)
Female, share	0.029	-0.195***	-0.068	-0.198***
	(0.058)	(0.031)	(0.049)	(0.030)
Part-time	-0.731***	-0.718***	-0.542***	-0.718***
	(0.066)	(0.040)	(0.058)	(0.039)
Labour market competition (density)	0.025*	0.039***	0.029***	0.039***
	(0.013)	(0.007)	(0.011)	(0.007)
Product market competition (ref.: no)				
low	-0.049	0.017	0.057	0.018
	(0.044)	(0.024)	(0.041)	(0.024)
medium	-0.097**	0.023	0.005	0.024
	(0.044)	(0.025)	(0.041)	(0.024)
high	-0.140***	0.006	-0.041	0.008
	(0.045)	(0.025)	(0.042)	(0.025)
Works council: yes (0/1)	0.266***	0.203***	0.132***	0.201***
	(0.028)	(0.012)	(0.025)	(0.012)
Collective agreements; yes (0/1)	0.023	0.049***	-0.002	0.048***
	(0.022)	(0.011)	(0.019)	(0.011)
Exporter (0/1)	0.117***	0.128***	0.104***	0.128***
	(0.022)	(0.011)	(0.019)	(0.011)
Young firm (0/1)	-0.046	-0.047***	-0.053**	-0.047***
	(0.029)	(0.015)	(0.027)	(0.015)
Single plant (0/1)	-0.088***	-0.075***	-0.066***	-0.076***
	(0.025)	(0.011)	(0.022)	(0.011)
West (0/1)	0.251***	0.254***	0.202***	0.255***
	(0.022)	(0.012)	(0.019)	(0.011)
Sector and year dummies	yes	yes	yes	yes
Difference training	0.056***		0.099***	
Observations	16,399	16,399	16,399	16,399
Establishments	4,569	4,569	4,569	4,569

Notes: Full estimation results of Table 2. Dependent variable: log real value added (production function) and log real total wage bill per worker (wage regressions). Method: OLS in columns (1) and (2) and Ackerberg et al. (2015) approach to control for the endogeneity of inputs and training in columns (3) and (4). Standard errors clustered at establishment-level in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Total factor productivity (TFP) originates from the corresponding production function. Statistical significance of the difference in training is simulated using 10.000 bootstrap iterations and subsequent t-test. Data source: IAB Establishment Panel 2007-2016, own calculations.

Table A3: Robustness regressions for the impact of training on productivity and wages (Table 2)

Panel A: cost coverage, direct costs only (monetary)		
	company-sponsored training	individual-sponsored training
	(1)	(2)
Difference training	0.092***	-0.020***
Obs.	20,793	2,823
Establishments	5,823	874
Panel B: only establishments with >20 employees		
	OLS	ACF
	(1)	(2)
Difference training	0.077***	0.179***
Obs.	11,010	11,010
Establishments	3,149	3,149
Panel C: No deflation of variables		
	OLS	ACF
	(1)	(2)
Difference training	0.056***	0.099***
Obs.	16,399	16,399
Establishments	4,569	4,569

Notes: Difference in training is the difference of the training coefficient derived from the estimated production function and wage regression. Regression method: If not mentioned differently: Ackerberg et al. (2015) approach to control for the endogeneity of inputs and training. Standard errors clustered at establishment-level in parentheses. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Control variables as noted in Table 2. Statistical significance of the difference in training is simulated using 10.000 bootstrap iterations and subsequent t-test. Data source: IAB Establishment Panel 2008-2016, own calculations.

Table A4: Robustness regressions for the impact of competition and institutions on productivity and wages (Tables 3 and 4)

Panel A: Product Market Competition - excluding establishment-observations that change their status		
	Weak product market competition (1)	Strong product market competition (2)
Difference training	0.053***	0.132***
Obs.	8,139	6,003
Establishments	2,645	1,924
Panel B: Labour Market Competition - using population density		
	Weak labour market competition (1)	Strong labour market competition (2)
Difference training	0.028***	0.161***
Obs.	2,167	2,402
Establishments	7,983	8,416
Panel C: Unions and works councils		
	Neither works council nor collective bargaining agreement (1)	With works council and with collective bargaining agreement (2)
Difference training	0.064***	0.147***
Obs.	8,014	3,691
Establishments	2,143	1,101
	With works council but without collective bargaining agreement (3)	Without works council but with collective bargaining agreement (4)
Difference training	0.231***	-0.010
Obs.	1,443	3,251
Establishments	428	897
Panel D: Unions - excluding establishment-observations that change their status		
	No collective bargaining agreement (1)	With collective bargaining agreement (2)
Difference training	0.079***	0.076***
Obs.	8,941	6,718
Establishments	2,571	1,998
Panel E: Works council - excluding establishment-observations that change their status		
	No works council (1)	With works council (2)
Difference training	0.054***	0.178***
Obs.	11,143	5,057
Establishments	3,040	1,529

Notes: Sample splits as described in Tables 3 and 4 For further notes see Table A3. Data source: IAB Establishment Panel 2008-2016, own calculations.