I Z A Institute
of Labor Economics
Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 13909

Organised Labour, Labour Market Imperfections, and Employer Wage Premia

Sabien Dobbelaere
Boris Hirsch
Steffen Mueller
Georg Neuschaeffer

NOVEMBER 2020

I Z A Institute of Labor Economics

Initiated by Deutsche Post Foundation

DISCUSSION PAPER SERIES

IZA DP No. 13909

Organised Labour, Labour Market Imperfections, and Employer Wage Premia

Sabien Dobbelaere
Vrije Universiteit Amsterdam, Tinbergen Institute and IZA

Boris Hirsch
Leuphana University Lüneburg, IWH and IZA

Steffen Mueller
IWH, University of Magdeburg and CesIfo

Georg Neuschaeffer
IWH

NOVEMBER 2020

ISSN: 2365-9793

IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Organised Labour, Labour Market Imperfections, and Employer Wage Premia*

This paper examines how collective bargaining through unions and workplace codetermination through works councils shape labour market imperfections and how labour market imperfections matter for employer wage premia. Based on representative German plant data for the years 1999-2016, we document that labour market imperfections are the norm rather than the exception. Wage mark-downs, that is wages below the marginal revenue product of labour rooted in employers' monopsony power, are the most prevalent outcome. We further find that both types of organised labour are accompanied by a smaller prevalence and intensity of wage mark-downs whereas the opposite holds for wage mark-ups, that is wages above the marginal revenue product of labour rooted in workers' monopoly power. Finally, we document a close link between our production-based labour market imperfection measures and employer wage premia. The prevalence and intensity of wage mark-downs are associated with a smaller level and larger dispersion of premia whereas wage mark-ups are only accompanied by a higher premium level.

JEL Classification: J42, J50, J31, D22

Keywords: wage mark-downs, wage mark-ups, collective wage agreements, works councils, employer wage premia

Corresponding author:
Boris Hirsch
Leuphana University Lüneburg
Universitätsallee 1
21335 Lüneburg
Germany
E-mail: hirsch@leuphana.de

* We would like to thank Laszlo Goerke for very useful suggestions. We further appreciate comments by participants of the EALE/SOLE/AASLE 2020, EEA 2020, and the Verein für Socialpolitik 2020 conferences and of presentations in Amsterdam, Basel, Halle, and Lüneburg. We also gratefully acknowledge financial support from the Deutsche Forschungsgemeinschaft under the grant title "Firm Wage Differentials in Imperfect Labour Markets: The Role of Market Power and Industrial Relations in Rent Splitting between Workers and Firms".

1 Introduction

It has not been long since most labour economists abandoned the textbook model of perfect competition and embraced the idea that workers and employers possess some market power in the wage formation process. In the broadest sense, imperfect competition in the labour market can be seen as a situation where substantial employment rents accrue to workers and employers (Manning, 2011). This vision immediately raises the question of how these rents are split among workers and employers or, in other words, what wage emerges under a bilateral monopoly in which both parties possess some market power.

As Addison *et al.* (2014) put it, the essential question is whether the labour market outcome will be on the labour demand curve with employers paying wages equal to the marginal revenue product of labour as under perfect competition or off this curve due to labour market imperfections. In a recent survey, Booth (2014) approaches this question by considering two polar cases of wage formation under imperfect competition: employer wage setting, where employers possess monopsony power, and union wage setting, where workers exercise monopoly power when negotiating wages. Put differently, labour market imperfections may either result in a wage mark-down with employers' monopsony power allowing them to set wages below the marginal revenue product of labour, or in a wage mark-up with workers' monopoly power permitting them to push through wages above the marginal revenue product.

Against this backdrop, our contribution is to investigate for Germany the extent of labour market imperfections, how industrial relations shape employers' and workers' market power in the labour market and how labour market imperfections relate to employer wage premia. Building on a production-based approach that enables us to jointly identify labour and product market imperfections and a large representative sample of about 9,000 plants for the years 1999–2016, this paper is the first to document the prevalence and intensity of both wage mark-downs and wage mark-ups in the labour market as well as mark-up pricing in the product market for Germany. We will see that labour and product market imperfections are the norm rather than the exception in Germany. They should thus figure much more prominently in both science and politics, not the least since the (lack of) competition in the labour market promises important insights into recent labour market trends like the falling labour share in income and rising wage inequality.

Our core result will be that collective bargaining and works councils matter for both the prevalence and the intensity of labour market imperfections. Specifically, we will find that the presence of any of these labour market institutions is associated with a lower probability of a wage mark-down and a higher probability of a wage mark-up. On top of these findings at the extensive margin, we will also see that both forms of organised labour are accompanied with lower monopsony power of employers and higher bargaining power of workers at the intensive margin, that is given an outcome involving either a wage mark-down or a wage mark-up. These results suggest that organised labour benefits workers in shifting market power from employers to workers.

Moreover, we will see that the presence of collective bargaining and works councils is negatively related to the probability of switching from marginal-product wages to a wage mark-down as well as to the switching probability from a wage mark-up to marginal-product wages. These findings lend further credence to the hypothesis that industrial relations shape labour market imperfections and they also suggest that the erosion of organised labour during our period of observation has contributed to shifting market power from workers to employers.

Finally, we will document that employer wage premia, that is wage differences that are left after differences in workers' human capital and unobservable skills have been rewarded, are closely related to labour market imperfections. Holding constant the rents to be split between workers and employers, the mean employer wage premium is lower when a wage mark-down exists and larger when there is a wage mark-up compared to marginal-product wages, and it is also related in the same way to employers' and workers' market power at the intensive margin. Moreover, wage premia are more dispersed when there is a wage mark-down, so that employers' monopsony power not only depresses workers' wage outcomes, but also aggravates inequality. In short, our evidence strongly suggests that organised labour matters for labour market imperfections that, in turn, matter for employer wage premia.

Whereas wage mark-ups and their theoretical foundation in union wage-setting models form the starting point of the broad empirical rent-sharing literature (surveyed by Card *et al.*, 2018, and Dobbelaere and Mairesse, 2018), possible wage mark-downs are at the heart of a recent literature on the prevalence and causes of monopsony in the labour market (for overviews, see Manning, 2011, 2021). Until recently, though, both strands of the literature evolved separately. What is more, they have also largely neglected possible links between labour and product market imperfections that may contaminate findings. The only exception we are aware of is the study by Dobbelaere and Mairesse (2013) that introduces an estimation approach encompassing both types of labour market imperfections while also allowing for product market imperfections.

This approach's origins lie in Hall's (1988) framework that allows estimating price-cost mark-ups under the assumptions of constant returns to scale in production and marginal-product wages and its extensions to non-constant returns by Klette (1999) and imperfect labour markets involving wage mark-ups by Crépon *et al.* (2005). Generalising Crépon *et al.*'s framework to allow for labour market imperfections that yield either a wage mark-down or a wage mark-up, Dobbelaere and Mairesse's (2013) approach uses production function estimates to measure how imperfect labour and product markets are. Intuitively spoken, Dobbelaere and Mairesse show that labour and product market imperfections drive a wedge between the output elasticities of labour and intermediate inputs and their revenue shares that is informative on these imperfections. This wedge, which they term the joint market imperfections parameter, allows not only to determine whether wages are below or above the marginal revenue product of labour, but also to infer the intensity of imperfections in labour and product markets. It thus accounts for a possible interdependency between both types of market imperfections that contaminates estimates of wage mark-downs, wage mark-ups, and price-cost mark-ups (for a discussion in the case of price-cost mark-ups, see De Loecker *et al.*, 2016).

In their empirical analysis, Dobbelaere and Mairesse (2013) document substantial labour and product market imperfections for France as do other studies using their approach for Japan and the Netherlands (Dobbelaere *et al.*, 2015), for Chile (Dobbelaere *et al.*, 2016), and for Portugal (Félix and Portugal, 2016). Dobbelaere and Kiyota (2018) further show for Japan that exporters are more likely to operate in imperfect product markets and to share rents with their workers by paying a wage mark-up, but are less likely to set a wage mark-down, whereas the opposite patterns emerge for multinationals.

What is lacking, though, is empirical evidence on how industrial relations, such as collective bargaining through unions and workplace co-determination through works councils, shape market imperfections. In theory, such labour market institutions matter for how employment rents are split between workers and employers. As a case in point, Falch and Strøm (2007) show that wage bargaining between a union and an employer with wage-setting power not only limits the employer's monopsony power, but may also lead to an efficiency gain compared to the solution without the union, that is compared to the wage mark-down under pure monopsonistic wage setting. And, notably, in a recent *Issue Brief*, the Council of Economic Advisors (2016) argues that declining unionisation in the US has raised employers' monopsony power, which has led to lower wage growth and increased wage inequality.

By examining how industrial relations shape labour market imperfections, this paper thus not only contributes to the literature that investigates the determinants of workers' and employers' market power in rent splitting, but also adds to the literatures on the falling labour share in income (e.g. Karabarbounis and Neiman, 2014) and rising wage inequality (for a survey, see Acemoglu and Autor, 2011, and for the German case, see Dustmann *et al.*, 2009). For example, Card *et al.* (2013) document that increasing dispersion in employer wage premia during the 1990s and 2000s contributed to the rise in wage inequality in West Germany, and Hirsch and Mueller (2020), in turn, observe that the fall in collective bargaining coverage during that period contributed to the rise in the dispersion of employer wage premia. If organised labour matters for the prevalence and the intensity of labour market imperfections in that it shifts market power from employers to workers, then the erosion of industrial relations documented for Germany (e.g. Oberfichtner and Schnabel, 2019) as for other countries may be one common source of the trends of a decreasing labour share in income and increasing wage inequality. Therefore, our analysis not only promises insights into the relevance of industrial relations for labour market imperfections, but it is also likely to inform important recent debates among scientists and policy-makers alike.

The remainder of this paper is organised as follows. Section 2 gives an overview of the institutional setting in Germany and provides hypotheses for the relationship between industrial relations on labour market imperfections. Section 3 introduces the theoretical foundations of our estimation approach, and Section 4 gives the details on its econometric implementation. Section 5 describes our data. Sections 6 and 7 present and discuss our results for the link between industrial relations and labour market imperfections and between labour market imperfections and employer wage premia, respectively, and Section 8 concludes.

2 Institutional backdrop and hypotheses

In Germany, the principle of bargaining autonomy gives unions and employers the right to regulate wages and working conditions absent state interference. Collective agreements are legally binding, are predominantly concluded as multi-employer agreements between a single union and an employers' association at the sectoral level, and almost always apply to all of the covered employers' workers irrespectively of workers' union status. Although sectoral negotiations mostly take place in regional bargaining units, officials of the two bargaining parties closely coordinate the regional negotiations within one sector, so that variations between them are small. There even exists some cross-sectoral coordination by both parties, giving rise to some uniformity in collective bargaining policy across sectors (for more details, see Hirsch and Schnabel, 2014).

Collective bargaining in Germany predominantly concerns wages, but also determines job classifications, working time, and working conditions. Norms stipulated in the collective agreement are generally minimum terms, so that employers bound by the agreement cannot undercut, but only improve upon these terms and conditions. Exceptions to this general rule are in some cases laid down in so-called opening clauses that allow re-negotiating collective bargaining issues, mostly wages and working time, at the plant level, typically under conditions of economic hardship.

Whereas many employers do in fact pay higher wages than stipulated in the collective agreements (for details on this wage cushion, see Jung and Schnabel, 2011) and opening clauses have grown in importance in the last decades, for most workers the wages set in the collective agreements are crucial for the level and development of their actual wages. At the end of our observational window in 2016, 58% (47%) of workers in West (East) Germany held jobs in the 32% (21%) of plants covered by a collective agreement (Ellguth and Kohaut, 2017). Compared to the start of our observation period, we see a marked fall in collective bargaining coverage. In 2000, 70% (55%) of workers in West (East) Germany were employed by the 48% (28%) of covered plants (Kohaut and Schnabel, 2003).

On average, plants covered by a collective agreement pay higher wages than uncovered plants (Guertzgen, 2009; Fitzenberger *et al.*, 2013). In a recent study, Hirsch and Mueller (2020) further show that higher average wages in covered plants reflect higher employer wage premia, that is higher wages paid to equally productive workers, holding constant the level of rents to be split between workers and employers. They interpret their finding as evidence that collective bargaining increases workers' bargaining power. This interpretation is in line with evidence from the empirical rent-sharing literature and with a host of theoretical contributions arguing that collective bargaining enables workers to push through wage mark-ups (e.g. McDonald and Solow, 1981). Hence, we expect a higher prevalence and intensity of wage mark-ups in covered than in uncovered plants. We further suspect the opposite to hold for wage mark-downs, although we lack direct empirical evidence on this received wisdom analysed by Falch and Strøm (2007), who show theoretically that collective bargaining limits employers' wage-setting power. In this paper, we will put these hypotheses to a rigorous test.

On top of collective bargaining typically conducted at the sectoral level, the second backbone of Germany's dual system of industrial relations is given by workplace co-determination through works councils, the German counterpart of the workplace union in other countries. Works councils are mandatory but not automatic in all plants with at least five permanent workers, for setting up a works council requires three workers or a union representative to initiate an election procedure in the plant (for details, see Addison, 2009). At the end of our observation period in 2016, 43% (34%) of workers in West (East) Germany were employed by the 9% (9%) of plants with a works council (Ellguth and Kohaut, 2017). As collective bargaining coverage, plant-level co-determination dropped compared to the start of our observational window. In 2000, 50% (41%) of workers in West (East) Germany held jobs in the 12% (12%) of plants with a works council (Ellguth and Kohaut, 2018). Together, shrinking collective bargaining coverage and works council prevalence point at an erosion of the traditional model of industrial relations in Germany.

Whereas works councils are formally independent of unions, in practice most works councilors are union members (Behrens, 2009). The size of the works council is an increasing function of the plant's employment level, and the entire cost of the works council apparatus is borne by the employer with works councilors being exempted from work once certain plant size thresholds are reached. Works councils have extensive information, consultation, and co-determination rights (for details, see Addison, 2009). In particular and in contrast to continental European counterparts of workplace representation, German works councils have co-determination rights on what are termed 'social matters', which comprise remuneration arrangements, the commencement and termination of working hours, the regulation of overtime and reduced working hours, as well as health and safety measures. Works councils can also negotiate social plans, which establish compensation for the dislocation caused by (partial) plant closings and by major changes in plant organisation. Unlike unions, though, works councils may not call a strike and they are excluded from reaching agreement with the employer on wages and working conditions that are settled or normally settled by collective agreements between unions and employers' associations at the sectoral level. One exception to this general rule is that collective agreements contain opening clauses (mentioned before) that explicitly authorise works councils to do so.

However, even if opening clauses are absent, works councils' extensive information, consultation, and co-determination rights on many other issues mean that works council existence is likely to improve workers' bargaining power and thus to spur rent-seeking activities (Freeman and Lazear, 1995). In line with this conjecture, extant studies have documented that works council presence is accompanied by higher average wages (Addison *et al.*, 2001, 2010). Furthermore, Hirsch and Mueller (2020) show that the higher average wages in plants with a works council mirror higher employer wage premia holding constant the level of rents and interpret their finding as evidence that workplace co-determination increases workers' bargaining power. Although we lack direct empirical evidence on how works council presence shapes labour market imperfections, we follow the received wisdom that it shifts market power from employers to workers and thus expect a lower prevalence and intensity of wage mark-downs when works councils are present and the opposite for wage mark-ups. As with collective bargaining, we will put these hypotheses to a rigorous test.

3 Theoretical framework

To determine a plant's market power in its labour and product markets, we follow the approach introduced by Dobbelaere and Mairesse (2013) that allows to infer both types of market imperfections from production function estimates.[1] Consider plant i at time t that produces a good Q_{it} from its labour input N_{it}, its intermediate inputs M_{it}, and its capital input K_{it}, subject to the twice differentiable, strictly increasing (in all its arguments) and concave production function:

$$Q_{it} = Q(N_{it}, M_{it}, K_{it}) \tag{1}$$

In terms of the plant's input choices, we assume (i) that labour and intermediate inputs are free of adjustments costs and are thus choice variables in the short run, (ii) that capital is predetermined and thus no choice variable in the short run, and (iii) that the plant takes the price of its intermediate inputs as given.[2] We further assume that all

[1] In our data, we observe plants rather than firms and will thus refer to plants throughout the paper.

[2] Given recent evidence on imperfections in intermediate inputs markets by Kikkawa *et al.* (2019) and Morlacco (2019), this latter assumption of price taking for intermediate inputs might be perceived as

plants in the market maximise short-run profits. Plant i's short-run profits at time t are given by

$$\Pi_{it} = R_{it} - W_{it}N_{it} - J_{it}M_{it}, \tag{2}$$

where $R_{it} = P_{it}Q_{it}$ denotes the plant's revenues, P_{it} the price of the good, and W_{it} and J_{it} the input prices of labour and intermediate inputs, respectively. Then, the plant's optimisation problem involves maximising short-run profits (2) with respect to output Q_{it}, labour N_{it}, and intermediate inputs M_{it}.

Turning to the plant's product market first, the first-order condition with respect to Q_{it} yields the plant's price-cost mark-up:

$$\mu_{it} = \frac{P_{it}}{(C_Q)_{it}} = \left(1 + \frac{s_{it}\kappa_{it}}{\eta_t}\right)^{-1} \tag{3}$$

In equation 3, $(C_Q)_{it} = \partial C_{it}/\partial Q_{it}$ denotes the marginal cost of production, C_{it} the plant's cost function, $s_{it} = Q_{it}/Q_t$ the market share of plant i in industry demand Q_t, $\eta_t = (\partial Q_t/\partial P_t)(P_t/Q_t)$ the own-price elasticity of industry demand, and $\kappa_{it} = \partial Q_t/\partial Q_{it}$ a conjectural variations parameter that captures competitors' quantity response to plant i's output choice.[3]

Turning to plant i's choice of intermediate inputs next, the first-order condition with respect to M_{it} yields $(Q_M)_{it} = \mu_{it}J_{it}/P_{it}$, where $(Q_M)_{it} = \partial Q_{it}/\partial M_{it}$ denotes the marginal

being restrictive. This evidence notwithstanding, we stick to the assumption for two reasons. The first is a data reason. Like Morlacco (2019), we could easily model imperfections in intermediate inputs markets as an additional unit cost that drives a wedge between the marginal cost of production and the marginal products of plants' inputs. Data constraints, however, prevent us from putting this approach to work. The second reason is that we want to focus our empirical analysis on the relationship between industrial relations and labour and product market imperfections faced by plants, abstaining from non-competitive buyer behaviour in the market for intermediate inputs.

3 Specifically, under Cournot competition with plants producing a homogenous good and competing in quantities, $\kappa_{it} = \partial Q_t/\partial Q_{it} = 1$ with a single industry-wide output price in equilibrium $P_{it} = P_t$. Hence, in this case the price-cost mark-up is $\mu_{it} = P_t/(C_Q)_{it} = (1 + s_{it}/\eta_t)^{-1}$. Under Betrand competition with plants producing a horizontally differentiated good and competing in prices instead of quantities, $\partial P_t/\partial P_{it} = 1$ and thus $\kappa_{it} = \partial Q_t/\partial Q_{it} = \eta_t/(s_{it}\eta_{it})$ with $\eta_{it} = (\partial Q_{it}/\partial P_{it})(P_{it}/Q_{it})$ denoting plant i's own-price elasticity of residual demand. Hence, in this case the price-cost mark-up is $\mu_{it} = P_{it}/(C_Q)_{it} = (1 + s_{it}/\eta_{it})^{-1}$.

product of intermediate inputs. Multiplying this expression by M_{it}/Q_{it} yields

$$(\varepsilon_M^Q)_{it} = \mu_{it}\alpha_{Mit} \tag{4}$$

with the output elasticity of intermediate inputs $(\varepsilon_M^Q)_{it} = (\partial Q_{it}/\partial M_{it})(M_{it}/Q_{it})$ and their revenue share $\alpha_{Mit} = J_{it}M_{it}/R_{it}$. Hence, in the optimum the output elasticity of intermediate inputs equals the share of their expenditures in output evaluated at the marginal cost of production. In what follows, we will use equation (4) to identify the price-cost mark-up as

$$\mu_{it} = \frac{(\varepsilon_M^Q)_{it}}{\alpha_{Mit}} \tag{5}$$

from the plant's production technology that provides us with the output elasticity $(\varepsilon_M^Q)_{it}$ and its intermediate input choice that provides us with the revenue share α_{Mit}.

Unlike the price of intermediate inputs that the plant takes as given, wage formation depends on possible labour market imperfections as does the plant's optimal labour demand. If the plant takes the wage as given too, the first-order condition with respect to N_{it} is analogous to intermediate inputs $(Q_N)_{it} = \mu_{it}W_{it}/P_{it}$, where $(Q_N)_{it} = \partial Q_{it}/\partial N_{it}$ denotes the marginal product of labour. In other words, we arrive at a solution on the labour demand curve, which nests both perfect competition and right-to-manage bargaining (Nickell and Andrews, 1983), in which the plant and a union bargain over wages and the plant is then free to choose the employment level at this bargained wage. Multiplying $(Q_N)_{it} = \mu_{it}W_{it}/P_{it}$ by N_{it}/Q_{it} yields

$$(\varepsilon_N^Q)_{it} = \mu_{it}\alpha_{Nit} \tag{6}$$

with the output elasticity of labour $(\varepsilon_N^Q)_{it} = (\partial Q_{it}/\partial N_{it})(N_{it}/Q_{it})$ and its revenue share $\alpha_{Nit} = W_{it}N_{it}/R_{it}$. As with intermediate inputs, this condition means that in the optimum the output elasticity of labour equals the share of the plant's payroll in its output evaluated at the marginal cost of production.

Absent labour market imperfections, comparing equations (4) and (6) shows that there exists no wedge

$$\psi_{it} = \frac{(\varepsilon_M^Q)_{it}}{\alpha_{Mit}} - \frac{(\varepsilon_N^Q)_{it}}{\alpha_{Nit}} = 0 \tag{7}$$

between the output elasticities of intermediate inputs and labour and their respective revenue shares. Hence, $\psi_{it} = 0$ indicates the absence of labour market imperfections, that is a labour market setting in which workers obtain the marginal product of labour and thus an outcome on the labour demand curve. We will denote ψ_{it} as the plant's joint market imperfections parameter in the following, the reason of which will become clear shortly.

Things look different when labour market imperfections are present as these give rise to an outcome off the labour demand curve.[4] Imperfections may either stem from plants' monopsony power that enables them to set a wage mark-down or from workers' monopoly power that allows them to impose a wage mark-up on plants.

We first consider a solution below the labour demand curve. In this case, plants' wage-setting power may originate from concentration or collusion, but may also be pervasive in labour markets with many competing employers due to search frictions, mobility costs, or job differentiation (Manning, 2011, 2021). All these possible channels impede workers' responsiveness to wages, so that the labour supply curve faced by a single employer is upward-sloping rather than horizontal as it would be under perfect competition. Let the labour supply faced by the plant paying wage W_{it} be $N_{it}(W_{it})$ and its inverse $W_{it}(N_{it})$. Plugging the latter into the plant's profits (2) and maximising these with respect to N_{it} yields the first-order condition

$$(R_N)_{it} = (W_N)_{it} N_{it} + W_{it}(N_{it}), \tag{8}$$

[4] Strictly speaking, labour market imperfections give rise to a solution off the marginal revenue product curve that coincides with the plant's labour demand curve under marginal-product wages (but, for instance, not under labour market monopsony where the wage-employment outcome will not lie on the marginal revenue product curve). Yet, for the sake of intuition and readability, we will refer to the marginal revenue product curve as the labour demand curve throughout.

where $(R_N)_{it} = \partial R_{it}/\partial N_{it}$ denotes the marginal revenue product of labour and $(W_N)_{it} = \partial W_{it}/\partial N_{it}$ the slope of the labour supply curve to the plant.

Rewriting equation (8) gives

$$W_{it} = \beta_{it}(R_N)_{it}, \tag{9}$$

where $\beta_{it} = W_{it}/(R_N)_{it} = (\varepsilon_W^N)_{it}/[(\varepsilon_W^N)_{it} + 1] \leqslant 1$ denotes the wage mark-down and $(\varepsilon_W^N)_{it} = (\partial N_{it}/\partial W_{it})(W_{it}/N_{it})$ the wage elasticity of plant-level labour supply. The latter informs us on how wage-driven workers are and thus on the plant's monopsony power. Under perfect competition, the plant-level labour supply curve is horizontal with $(\varepsilon_W^N)_{it} = \infty$ and workers obtain the marginal revenue product of labour, i.e. $\beta_{it} = 1$. Under monopsony, workers respond imperfectly to wages, which provides the plant with wage-setting power that is inversely related to the elasticity of labour supply $(\varepsilon_W^N)_{it}$. Rewriting equation (9) using $(R_N)_{it} = P_{it}(Q_N)_{it}/\mu_{it}$, we arrive at:

$$(\varepsilon_N^Q)_{it} = \mu_{it}\alpha_{Nit}\left[1 + \frac{1}{(\varepsilon_W^N)_{it}}\right] \tag{10}$$

Combining equations (10) and (5) yields the joint market imperfections parameter

$$\psi_{it} = \frac{(\varepsilon_M^Q)_{it}}{\alpha_{Mit}} - \frac{(\varepsilon_N^Q)_{it}}{\alpha_{Nit}} = -\frac{\mu_{it}}{(\varepsilon_W^N)_{it}} < 0, \tag{11}$$

which now has a negative sign. In words, the plant's wage-setting power allows it to set a mark-down on wages that, in turn, drives a negative wedge between the output elasticities of intermediate inputs and labour and their respective revenue shares. A negative ψ_{it} thus signifies a labour market setting favouring plants that impose a wage mark-down on workers. Based on ψ_{it}, we can further recover the plant-level labour supply elasticity $(\varepsilon_W^N)_{it}$ and the wage mark-down β_{it} as structural parameters that inform us on the intensity of labour market imperfections. Finally, the more negative ψ_{it} gets, the more pronounced are the combined labour and product market imperfections, which is the reason why we refer to ψ_{it} as the joint market imperfections parameter.

That said, labour market imperfections may also originate from workers' monopoly power enabling them to impose a wage mark-up on plants, thereby yielding an outcome above the labour demand curve. As an underlying structural model, we will consider efficient bargaining (McDonald and Solow, 1981) between a risk-neutral plant and its risk-neutral workforce, though other theoretical structural models are possible as well. For instance, Stole and Zwiebel (1996) show that a wage mark-up may also arise from wage bargaining between individual workers and their employer when incomplete labour contracts provide incumbent workers with some hold-up power. What is crucial, though, is that the plant is no longer able to unilaterally set employment once the wage has been determined and thus cannot achieve a solution on the labour demand curve.

Under efficient bargaining, the negotiated wage-employment pair maximises both parties' joint surplus and follows from maximising the generalised Nash product

$$\Omega = [N_{it}(W_{it} - \overline{W}_{it})]^{\phi_{it}}[R_{it} - W_{it}N_{it} - J_{it}M_{it}]^{1-\phi_{it}} \tag{12}$$

with respect to the wage and employment, where $\overline{W}_{it}$ denotes workers' alternative wage and $0 < \phi_{it} < 1$ the part of the surplus accruing to workers. In other words, ϕ_{it} measures workers' bargaining power. In the generalised Nash product (12), workers' surplus is the amount by which their payroll exceeds their outside option while the plant's surplus is its short-run profits.[5]

In the (interior) optimum, the first-order condition with respect to W_{it} yields

$$W_{it} = \overline{W}_{it} + \gamma_{it}\left[\frac{R_{it} - W_{it}N_{it} - J_{it}M_{it}}{N_{it}}\right] \tag{13}$$

with workers' relative bargaining power $\gamma_{it} = \phi_{it}/(1 - \phi_{it}) > 0$. The first-order condition with respect to N_{it} gives:

$$W_{it} = (R_N)_{it} + \phi_{it}\left[\frac{R_{it} - (R_N)_{it}N_{it} - J_{it}M_{it}}{N_{it}}\right] \tag{14}$$

5 This formulation of efficient bargaining assumes that all employed union members immediately return to the external labour market when negotiations fail. Yet, results do not change when considering a sequence of bargaining sessions between the plant and a union of declining size whose members gradually lose jobs when disagreement continues (Dobbelaere and Luttens, 2016).

Combining the first-order conditions (13) and (14) yields the so-called contract curve

$$(R_N)_{it} = \overline{W}_{it} \tag{15}$$

that characterises efficient wage-employment pairs. In equilibrium, the price-cost mark-up satisfies $\mu_{it} = P_{it}/(C_Q)_{it} = P_{it}/(R_Q)_{it}$ with the marginal revenue $(R_Q)_{it} = \partial R_{it}/\partial Q_{it}$. Plugging equation (15) into equation (13), we thus arrive at:

$$(\varepsilon_N^Q)_{it} = \mu_{it}\alpha_{Nit} - \mu_{it}\gamma_{it}(1 - \alpha_{Nit} - \alpha_{Mit}) \tag{16}$$

Combining equations (16) and (5) gives the joint market imperfections parameter

$$\psi_{it} = \frac{(\varepsilon_M^Q)_{it}}{\alpha_{Mit}} - \frac{(\varepsilon_N^Q)_{it}}{\alpha_{Nit}} = \mu_{it}\gamma_{it}\left[\frac{1 - \alpha_{Nit} - \alpha_{Mit}}{\alpha_{Nit}}\right] > 0, \tag{17}$$

which now has a positive sign. In words, workers' monopoly power allows them to capture part of the surplus by imposing a wage mark-up on the plant that, in turn, drives a positive wedge between the output elasticities of intermediate inputs and labour and their respective revenue shares. A positive ψ_{it} thus indicates a labour market setting favouring workers who achieve a wage mark-up. Based on ψ_{it}, we can further recover workers' absolute (relative) bargaining power ϕ_{it} (γ_{it}) as a structural parameter that informs us on the intensity of labour market imperfections and on the magnitude of the resulting wage mark-up. Lastly, the more positive ψ_{it} gets, the more pronounced are the combined labour and product market imperfections.

In summary, the outlined theoretical framework allows us to determine the plant's labour market and product market setting from its production technology providing us with the output elasticities of intermediate inputs $(\varepsilon_M^Q)_{it}$ and labour $(\varepsilon_N^Q)_{it}$ and its input choices providing us with the revenue shares of intermediate inputs α_{Mit} and labour α_{Nit}. Equation (5) permits us to determine the price-cost mark-up and thus the product market setting as either involving marginal-cost pricing (PMC) or mark-up pricing (PMU):

$$\mu_{it} = \frac{(\varepsilon_M^Q)_{it}}{\alpha_{Mit}} \begin{cases} = 1 & \text{if } PMS_{it} = PMC \\ > 1 & \text{if } PMS_{it} = PMU \end{cases} \tag{18}$$

On top of this extensive margin, the size of the price-cost mark-up allows us to directly infer the magnitude of product market imperfections at the intensive margin.

The sign of the wedge between the output elasticities of intermediate inputs and labour and their respective revenue shares allows us to determine the labour market setting as either one without imperfections involving marginal-product wages (WMP), or as one with imperfections that result either in a wage mark-down (WMD) or in a wage mark-up (WMU):

$$\psi_{it} = \frac{(\varepsilon_M^Q)_{it}}{\alpha_{Mit}} - \frac{(\varepsilon_N^Q)_{it}}{\alpha_{Nit}} \begin{cases} = 0 & \text{if } LMS_{it} = WMP \\ = -\dfrac{\mu_{it}}{(\varepsilon_W^N)_{it}} < 0 & \text{if } LMS_{it} = WMD \\ = \mu_{it}\gamma_{it}\left[\dfrac{1 - \alpha_{Nit} - \alpha_{Mit}}{\alpha_{Nit}}\right] > 0 & \text{if } LMS_{it} = WMU \end{cases} \tag{19}$$

On top of this extensive margin, equation (19) permits us to recover the magnitude of labour market imperfections at the intensive margin, that is the structural parameters of the labour market for a given labour market setting $LMS_{it} \in \{WMP, WMD, WMU\}$. For $LMS_{it} = WMD$ or $\psi_{it} < 0$ we can recover the plant-level labour supply elasticity $(\varepsilon_W^N)_{it}$ and the wage mark-down β_{it} and for $LMS_{it} = WMU$ or $\psi_{it} > 0$ workers' (relative) bargaining power ϕ_{it} (γ_{it}), which informs us on the size of the wage mark-up.

4 Econometric implementation

To determine labour and product market imperfections based on the price-cost mark-up (18) and the joint market imperfections parameter (19), we have to estimate the output elasticities of intermediate inputs $(\varepsilon_M^Q)_{it}$ and labour $(\varepsilon_N^Q)_{it}$ as well as their revenue shares

α_{Mit} and α_{Nit}. Our econometric implementation is based on a production function

$$q_{it} = f(n_{it}, m_{it}, k_{it}; \boldsymbol{\beta}) + \omega_{it} \tag{20}$$

with lower-case letters denoting logs of variables, e.g. $q_{it} = \ln Q_{it}$, a vector of common (within two-digit sectors) technology parameters $\boldsymbol{\beta}$, and a Hicks-neutral productivity shock ω_{it} observed by the plant, but unobserved by us. Identifying $\boldsymbol{\beta}$ crucially depends on controlling for the productivity shocks ω_{it} because these will be correlated with the plant's input choices and ignoring them could thus induce omitted variable bias. To control for them, we follow the estimation approach by Ackerberg *et al.* (2015) that builds on the insight that plants' optimal input choices hold information about unobserved productivity.[6] We provide the details in Appendix A.

In our empirical specification, we approximate the unknown regression function $f(\cdot)$ by means of a second-order Taylor polynomial and estimate the coefficients of a translog production function at the two-digit sector level (including a full set of region dummies and a linear time trend, which we will omit in the following for notational ease). Specifically, we estimate

$$\begin{aligned} y_{it} = {} & \beta_0 + \beta_n n_{it} + \beta_m m_{it} + \beta_k k_{it} + \beta_{nn} n_{it}^2 + \beta_{mm} m_{it}^2 + \beta_{kk} k_{it}^2 \\ & + \beta_{nm} n_{it} m_{it} + \beta_{nk} n_{it} k_{it} + \beta_{mk} m_{it} k_{it} + \omega_{it} + \epsilon_{it}, \end{aligned} \tag{21}$$

where the regression constant β_0 measures the mean efficiency level across plants and ϵ_{it} is an idiosyncratic error term that comprises unpredictable output shocks and potential measurement error in output and inputs and is assumed to be mean independent of current and past input choices.

We arrive at estimates of the output elasticities $(\varepsilon_M^Q)_{it}$ and $(\varepsilon_N^Q)_{it}$ by combining the

6 Note that some recent papers have shown that factor adjustment costs and non-neutral productivity shocks could also drive a wedge between the output elasticities of labour and intermediate inputs and their respective revenue shares (e.g. Doraszelski and Jaumandreu, 2018; Bond *et al.*, 2020; Raval, 2020). However, these papers ignore labour market imperfections and assume competitive labour markets instead. To the best of our knowledge, there exists no comprehensive approach that would allow us to incorporate their insights into our investigation of labour market imperfections.

estimated $\widehat{\boldsymbol{\beta}}$ with data on plants' input choices:

$$(\widehat{\varepsilon}_N^Q)_{it} = \widehat{\beta}_n + 2\widehat{\beta}_{nn} n_{it} + \widehat{\beta}_{nm} m_{it} + \widehat{\beta}_{nk} k_{it} \tag{22}$$

$$(\widehat{\varepsilon}_M^Q)_{it} = \widehat{\beta}_m + 2\widehat{\beta}_{mm} m_{it} + \widehat{\beta}_{mn} n_{it} + \widehat{\beta}_{mk} k_{it} \tag{23}$$

Hence, both output elasticities vary across plants and over time.[7] Since the observed output $Y_{it} = Q_{it} \exp \epsilon_{it}$ includes idiosyncratic factors that are orthogonal to input use and productivity, we cannot take revenue shares from our data without correcting for these factors. We do so by recovering an estimate of ϵ_{it} from the production function estimation and calculate adjusted revenue shares as:

$$\widehat{\alpha}_{Nit} = \frac{W_{it} N_{it}}{P_{it} Y_{it} / \exp \widehat{\epsilon}_{it}} \tag{24}$$

$$\widehat{\alpha}_{Mit} = \frac{J_{it} M_{it}}{P_{it} Y_{it} / \exp \widehat{\epsilon}_{it}} \tag{25}$$

Combining the estimated output elasticities (22) and (23) and the adjusted revenue shares (24) and (25), we arrive at estimates of the price-cost mark-up and the joint market imperfections parameter:

$$\widehat{\mu}_{it} = \frac{(\widehat{\varepsilon}_M^Q)_{it}}{\widehat{\alpha}_{Mit}} \tag{26}$$

$$\widehat{\psi}_{it} = \frac{(\widehat{\varepsilon}_M^Q)_{it}}{\widehat{\alpha}_{Mit}} - \frac{(\widehat{\varepsilon}_N^Q)_{it}}{\widehat{\alpha}_{Nit}} \tag{27}$$

Based on $\widehat{\mu}_{it}$, we then use equation (18) to classify plant i's product market setting at time t as either marginal-cost pricing ($\mu_{it} = 1$) or mark-up pricing ($\mu_{it} > 1$), that is $PMS_{it} \in \{PMC, PMU\}$. Based on $\widehat{\psi}_{it}$, we further use equation (19) to characterise its labour market setting as either involving marginal-product wages ($\psi_{it} = 0$) or a wage mark-down ($\psi_{it} < 0$) or a wage mark-up ($\psi_{it} > 0$), that is $LMS_{it} \in \{WMP, WMD, WMU\}$.

We account for the estimation uncertainty in $\widehat{\mu}_{it}$ and $\widehat{\psi}_{it}$ by basing our classification

[7] Note that with a Cobb-Douglas production technology, output elasticities would simplify to $(\widehat{\varepsilon}_N^Q)_{it} = \widehat{\beta}_n$ and $(\widehat{\varepsilon}_M^Q)_{it} = \widehat{\beta}_m$ and would thus neither vary across plants (within two-digit industries) nor over time.

on the two-sided 95% confidence intervals (CI) for μ_{it} and $gap_{Nit} = \mu_{it} - \psi_{it} = (\varepsilon_N^Q)_{it}/\alpha_{Nit}$

$$[A_{\widehat{\mu}_{it}}, B_{\widehat{\mu}_{it}}] = [\widehat{\mu}_{it} - 1.96 \times \widehat{\sigma}_{\widehat{\mu}_{it}}, \widehat{\mu}_{it} + 1.96 \times \widehat{\sigma}_{\widehat{\mu}_{it}}] \tag{28}$$

$$[A_{\widehat{gap}_{Nit}}, B_{\widehat{gap}_{Nit}}] = [\widehat{gap}_{Nit} - 1.96 \times \widehat{\sigma}_{\widehat{gap}_{Nit}}, \widehat{gap}_{Nit} + 1.96 \times \widehat{\sigma}_{\widehat{gap}_{Nit}}] \tag{29}$$

with $\widehat{\sigma}_{\widehat{\mu}_{it}}$ and $\widehat{\sigma}_{\widehat{gap}_{Nit}}$ denoting the respective standard errors computed using the Delta method (e.g. Wooldridge, 2010, p. 47). Specifically, to pin down plant i's product market setting in t, we consider the lower bound $A_{\widehat{\mu}_{it}}$ of the CI for μ_{it} and classify the plant's product market setting as marginal-cost pricing ($PMS_{it} = PMC$) if $A_{\widehat{\mu}_{it}} \leqslant 1$ and as mark-up pricing ($PMS_{it} = PMU$) if $A_{\widehat{\mu}_{it}} > 1$. To classify the plant's labour market setting, we check for an overlap of the CIs for μ_{it} and gap_{Nit} that informs us on whether the difference of these two, i.e. ψ_{it}, is statistically significant. If the CIs overlap, we conclude that $\psi_{it} = 0$ and classify the labour market setting as involving marginal-product wages ($LMS_{it} = WMP$). If they do not overlap and $A_{\widehat{gap}_{Nit}} > B_{\widehat{\mu}_{it}}$, we conclude that $\psi_{it} < 0$ with a wage mark-down ($LMS_{it} = WMD$), whereas if they do not overlap and $A_{\widehat{\mu}_{it}} > B_{\widehat{gap}_{Nit}}$, we conclude that $\psi_{it} > 0$ with a wage mark-up ($LMS_{it} = WMU$).

The classification of plants' labour and product market settings allows us to make statements about market imperfections at the extensive margin. Yet, statements about the intensity of imperfections are of no less interest. In the case of product market imperfections, $\widehat{\mu}_{it}$ at once allows assessing their intensity. Turning to labour market imperfections, we can assess the size of wage mark-downs and wage mark-ups using the structural parameters of the respective labour market setting. For $LMS_{it} = WMD$, we can recover the plant-level labour supply elasticity $(\varepsilon_W^N)_{it}$ and the wage mark-down β_{it} using equation (19) together with the estimates (22)–(27) as:

$$(\widehat{\varepsilon}_W^N)_{it} = -\frac{\widehat{\mu}_{it}}{\widehat{\psi}_{it}} \tag{30}$$

$$\widehat{\beta}_{it} = \frac{(\widehat{\varepsilon}_W^N)_{it}}{(\widehat{\varepsilon}_W^N)_{it} + 1} \tag{31}$$

For $LMS_{it} = WMU$, we can recover workers' absolute (relative) bargaining power ϕ_{it}

(γ_{it}) using equation (19) together with the estimates (22)–(27) as:

$$\widehat{\gamma}_{it} = \frac{\widehat{\psi}_{it}}{\widehat{\mu}_{it}} \left[\frac{\widehat{\alpha}_{Nit}}{1 - \widehat{\alpha}_{Nit} - \widehat{\alpha}_{Mit}} \right] \tag{32}$$

$$\widehat{\phi}_{it} = \frac{\widehat{\gamma}_{it}}{1 + \widehat{\gamma}_{it}} \tag{33}$$

These, in turn, inform us on the size of the wage mark-up.

5 Data

Our data come from the IAB Establishment Panel described by Ellguth *et al.* (2014). Starting in 1993 (1996), the IAB Establishment Panel has surveyed West (East) German plants (not firms) that employ at least one worker covered by the social security system on 30th June of the survey year, and is representative of the population of these plants. Crucial for our purpose, it contains information on plants' revenues and intermediate inputs, employment, wage bill, export status, and industrial relations (i.e. collective bargaining coverage and works council existence). To arrive at plants' total labour costs, we use information from the Federal Statistical Office on the non-wage labour costs at the two-digit sector level and add it to the wage bill. We further deflate all nominal values using two-digit price deflators and apply the procedure by Eberle *et al.* (2011) to construct a time-consistent sector classification. Although the IAB Establishment Panel has no direct information on plants' capital stock, it can readily be computed from the included investment data using a modified perpetual inventory approach put forward by Mueller (2008). Since our estimation approach uses lagged information on plants and since the survey information for plants' revenues and intermediate inputs is for the previous year, plants only enter the sample if we observe them in at least three consecutive years. Using information from the survey waves for 1998–2017, we are thus able to build a panel for the years 1999–2016.[8]

In our analysis, we focus on the manufacturing and service sectors and discard the

[8] We cannot use earlier waves because of a change in the questionnaire regarding plants' industrial relations and because we do not want to constrain our analysis to West Germany.

financial and insurance sectors, for which output measures are not comparable to the other sectors in our sample. We further exclude plants producing tobacco products (i.e. 89 plant-year observations belonging to this highly regulated industry) and disregard plants with less than five workers, which are not at risk of having a works council. Before estimating production functions for each two-digit sector, we drop observations with revenue shares of labour and intermediate inputs outside the unit interval and, to remove outliers, only keep observations within the sector-specific 1% trimmed range of value added per worker and capital intensity. Our final regression sample comprises 40,856 observations of 9,061 plants belonging to 38 two-digit sectors (for descriptive statistics, see Table 1; the included sectors are visible from Table 2).[9]

— Table 1 about here —

6 Do industrial relations matter for labour market imperfections?

6.1 Descriptive analysis

Using our panel of German plants for 1999–2016, we now apply the estimation approach described in detail in Section 4. In a first step, we estimate translog production functions for each two-digit sector based on the control function approach by Ackerberg *et al.* (2015) that allows us to control for unobserved productivity shocks. In a second step, we use the estimated coefficients together with information on plants' input use to infer their labour and product market settings and to quantify the intensity of market imperfections in both markets.

— Table 2 about here —

[9] Note that we drop the small number of observations with a negative estimate of the price-cost mark-up (236 plant-year observations) and an estimated parameter of workers' absolute bargaining power outside the unit interval (1,145 plant-year observations). Note also that including these observations would not change any of our conclusions.

Table 2 presents means (overall and by two-digit sectors) of the estimated output elasticities of labour, intermediate inputs, and capital as well as the resulting returns to scale, i.e. the sum of the three output elasticities. For our whole sample, average output elasticities are 0.44 for labour, 0.55 for intermediate inputs, and 0.10 for capital, with returns to scale amounting to 1.10 and thus slightly above constant returns. We also see marked differences in production technologies across sectors.

We now use plants' estimated output elasticities and revenue shares to infer their joint market imperfections parameter and price-cost mark-up that allow us to pin down plants' time-varying labour and product market settings. Throughout, our descriptive evidence will come from population weighted samples, thereby allowing us to draw conclusions on the population of manufacturing and service plants in Germany.[10]

— Table 3 about here —

As is clear from Table 3, which summarises our classification, the majority of (plant-year) observations involve an imperfect labour market. Just 36% of observations are classified as free from labour market imperfections involving marginal-product wages, whereas for 49% of observations we find a wage mark-down at the detriment of workers and for another 15% a wage mark-up at the detriment of plants. Market imperfections are no less frequent in the product market where 61% of observations show mark-up pricing while only 39% involve marginal-cost pricing.

Simultaneously considering labour and product market imperfections, we find that only 17% of observations are free from market imperfections in that they combine marginal-product wages with marginal-cost pricing. The largest group are the 27% of observations that involve a wage mark-down and mark-up pricing followed by the 22% of observations with a wage mark-down together with marginal-cost pricing. Third come the 19% of observations combining marginal-product wages with mark-up pricing. Another 14% of observations involve a wage mark-up together with mark-up pricing, whereas we rarely observe the combination of a wage mark-up and marginal-cost pricing, which is

10 We also repeated our descriptive analysis weighting plants with their number of workers, which did not change any of our insights.

unsurprising given that rents to be split between employers and workers are arguably small under marginal-cost pricing.

— Tables 4 and 5 about here —

Turning to plants' industrial relations, we observe clear differences in the prevalence of market imperfections across plants covered and uncovered by collective bargaining and across plants with and without a works council (see Tables 4 and 5). In terms of labour market imperfections, a wage mark-down is less frequent and a wage mark-up is more frequent where collective bargaining or works councils are present. These correlations suggest that both forms of organised labour benefit workers in that they limit employers' ability to set a wage mark-down and more often give rise to a wage mark-up. Yet, they are also consistent with a causal link in the opposite direction with workers unionising or setting up a works council to foster rent extraction when confronted with a rather weak employer who pays a wage mark-up from the outset. Since our interest lies in how industrial relations shape labour market imperfections, we will later regress market imperfections on industrial relations and further control variables to substantiate a possible causal link running from industrial relations to imperfections.

Product market imperfections are more frequent when collective bargaining or works councils are present. Again, causality may be in both directions. On the one hand, these positive correlations are consistent with the view that organised labour hampers product market competition, for example through successfully lobbying for anti-competition policies. On the other hand, these correlations are also in line with workers unionising or electing works councils where product market competition is limited and rents to be distributed are therefore high, that is with a causal link from product market imperfections to the existence of any of these forms of organised labour. Later regressions may shed more light on the plausibility of a causal link running from industrial relations to imperfections.

To assess the intensity of labour market imperfections, we use our estimates of the joint market imperfections parameter and the price-cost mark-up to recover the structural parameters of the respective labour market setting off the labour demand curve. In other words, we look at our outcomes through the lens of monopsony or efficient bargaining as two structural models that are compatible with either a wage mark-down or a wage mark-up and that make sense in the German institutional setting. Specifically, we arrive at estimates of the plant-level labour supply elasticity $(\varepsilon_W^N)_{it}$ and the implied wage mark-down β_{it} when the outcome is below the labour demand curve and at estimates of workers' (relative) bargaining power ϕ_{it} (γ_{it}) when the outcome is above the curve. In the latter case, larger bargaining power points at an outcome farther away from the labour demand curve and thus at a wider wage mark-up. While using these specific models allows us to give a structural interpretation to our labour market imperfection parameters, the reported means in Table 6 could more generally be interpreted as sizes of wage mark-downs and wage mark-ups.

— Table 6 about here —

For the 49% of observations involving a wage mark-down, we find that the average plant-level labour supply elasticity amounts to 1.13, which points at marked monopsony power for plants. This number is not too different from the median of 1,320 elasticity estimates of 1.68 reported in Sokolova and Sorensen (2021) and is almost identical to the average elasticity estimate for US firms of 1.08 in Webber (2015), which is one of the rare studies that provide elasticity estimates at the individual firm level as we do. Note, however, that our average elasticity estimate is also in line with previous studies obtaining larger estimates because the average elasticity for all plants estimated by earlier studies is a weighted average of the elasticity in plants with a significant wage mark-down and the elasticity in those with no mark-down at all. The latter are plants paying wages on or above the labour demand curve, and thus plants facing very large elasticities. Plants' marked monopsony power translates into an average wage mark-down of 0.45, so on average workers obtain just 45% of the marginal product of labour when the outcome is below the labour demand curve.

For the 15% of observations involving a wage mark-up, we observe on average an absolute bargaining power of workers of 0.48, meaning that workers' bargaining power is roughly at par with employers' bargaining power. Note, however, that the average relative bargaining power of workers is much larger than one, which reflects that it is unbounded above and thus sensitive to outliers (i.e. observations with workers' absolute bargaining power near one).

Turning to the intensity of product market imperfections, we obtain an average price-cost mark-up of 1.23. Hence, on average prices are 23% above marginal costs, rendering the average mark-up across plants economically significant, but rather modest in size compared to existing estimates in the literature. Yet, one has to bear in mind that previous studies typically ignore labour market imperfections in that they assume marginal-product wages and thus, given that wage mark-downs are much more prevalent than wage mark-ups in our data, are prone to overstating the wedge between prices and marginal costs (as discussed in detail by De Loecker *et al.*, 2016). And, reassuringly, our numbers are similar in size to recent estimates that allow for labour market imperfections (e.g. Dobbelaere *et al.*, 2015; Soares, 2020).

At the extensive margin, we find that the presence of collective bargaining or works councils is associated with a labour market setting that is more favourable to workers, that is a lower prevalence of wage mark-downs and a higher prevalence of wage mark-ups, and also with more mark-up pricing on the product market. Now that we look at the intensity of market imperfections, the picture emerging is less clear (see Table 6). Both types of organised labour are associated with a somewhat larger plant-level labour supply elasticity and thus a narrower wage mark-down. On the other hand, when a wage mark-up is present, workers' bargaining power is even somewhat lower if collective bargaining or works councils exist. These inconsistent correlation patterns, however, may simply be the result of confounding factors, such as plant size. Therefore, we now turn to partial correlations coming from regressions.

6.2 Regression analysis

So far, our statements about plants' labour and product market settings, the intensity of market imperfections, and their link to industrial relations have been entirely descriptive in nature. Although such a comprehensive description of market imperfections for Germany is novel and thus interesting on its own, we ultimately seek to make statements about how industrial relations shape market imperfections, both at the extensive and intensive margins. Obviously, the descriptive correlations between industrial relations and market imperfections cannot establish a causal link running from industrial relations to imperfections. To come a bit closer to causal statements, we now run several regressions for the prevalence and the intensity of market imperfections.

In terms of the extensive margin, we investigate which factors including industrial relations captured by dummies for collective bargaining coverage and the existence of works councils influence plants' labour and product market settings. Specifically, we run multinomial probit regressions for the labour market setting being one either involving a wage mark-down or a wage mark-up (as opposed to the baseline involving marginal-product wages) and probit regressions for mark-up pricing on the product market (as opposed to the baseline involving marginal-cost pricing).

— Tables 7 and 8 about here —

Starting with labour market imperfections, Tables 7 and 8 report average marginal effects for the probability of a wage mark-down and a wage mark-up, respectively, from successively richer multinomial probit regressions. All models include as controls a full set of region, year, and two-digit sector dummies as well as a dummy for a single-plant company. We then successively include plant size, i.e. log employment, and dummies for plant age (model 2); information on workforce composition, i.e. the share of skilled workers, apprentices, part-time workers, and female workers (model 3); and a dummy for exporting activity (model 4).

Once we add plant size and plant age to the multinomial probit regression (models 2–4 of Table 7), we find that both the presence of collective bargaining and works councils is associated with a marked reduction in the conditional probability of a wage mark-down, which is in all models statistically significant at least at the 5% level. In our richest specification (model 4), collective bargaining is accompanied by an average drop in the probability of 3.1pp and works council existence even by a drop of 5.3pp, both of which are statistically significant at the 1% level. Furthermore, both forms of organised labour are positively related to the probability of a wage mark-up, though in the richest specification (model 4 of Table 8) the marginal effect of collective bargaining is only statistically significant at the 5% level. Collective bargaining is accompanied by an average rise in the probability of a wage mark-up of 1.6pp and works council existence even by a rise of 5.1pp. These findings support the view that organised labour matters for the labour market setting in that it seems to reduce the likelihood that employers can impose a wage mark-down on workers and to raise the likelihood that workers can push through a wage mark-up. And in line with our descriptive evidence, works council existence appears to matter more than collective bargaining coverage.

We further observe some interesting patterns for the control variables. Plant size shows a positive association with the probability of a wage mark-down and a negative one with the probability of a wage mark-up, whereas we find the opposite pattern for exporting plants (in line with previous evidence by Dobbelaere and Kiyota, 2018, for Japan). Hence, larger and non-exporting plants seem to be more powerful in the labour market. Finally, the composition of the workforce seems to matter. The probability of a wage mark-down is lower the more skilled workers are employed, whereas it is larger the more apprentices, part-timers, and females are among the workers, suggesting a more pronounced power imbalance for the latter groups. This latter suggestion is further substantiated by mirror-inverted patterns for the probability of a wage mark-up.

— Table 9 about here —

In analogy to the multinomial probit regressions for the labour market setting, Table 9 reports average marginal effects for the probability of mark-up pricing on the plant's product market. In all models, collective bargaining coverage turns out to be statistically insignificant. Once we add plant size and age to the probit regression (models 2–4), we find that works council presence is associated with a statistically significantly larger probability of an imperfect product market by 2.4–3.0pp. However, we are cautious not to over-interpret these partial correlations because workers arguably have a greater incentive to set up a works council where product market imperfections give rise to high rents and because later findings at the intensive margin will show that price-cost mark-ups are unrelated to works council existence. Hence, industrial relations seem to be of less importance for plants' product market setting. For the control variables, we find that the probability of an imperfect product market shows a statistically significant association with plant size (negative), workforce composition (positive for the share of skilled workers and negative for the shares of apprentices, part-timers, and female workers), and exporting activity (positive).

Turning to the intensive margin, we examine how industrial relations and the other plant characteristics included in our preferred specification of the (multinomial) probit regression influence the magnitude of labour and product market imperfections. Yet, meaningful measures of these imperfections are only available if plants' labour and product markets were classified as imperfect, that is if we have either $\psi_{it} < 0$ and thus a wage mark-down or $\psi_{it} > 0$ and thus a wage mark-up in the labour market or $\mu_{it} > 1$ and thus mark-up pricing in the product market. Rather than running OLS regressions, we correct for censoring by fitting type II Tobit models, in which the first-stage probit participation equation for $\psi_{it} < 0$, $\psi_{it} > 0$, or $\mu_{it} > 1$, respectively, and the second-stage outcome equation for the respective imperfection parameter include the same regressors, but these are allowed to have different coefficients in the two equations (e.g. Cameron and Trivedi, 2005). Table 10 presents the results for the second-stage outcome equations and underscores that what we found at the extensive margin with few exceptions also shows up at the intensive margin. Since all dependent variables are in logs, estimated coefficients are interpretable as (approximate) percentage changes and thus directly inform us on the economic significance of the respective variables.

— Table 10 about here —

Given a wage mark-down, we find that the presence of collective bargaining and works councils reduces plants' wage-setting power, which is in line with some suggestive earlier evidence presented by Bachmann and Frings (2017). The labour supply elasticity is on average 5.7% larger and the gap between the marginal revenue product and workers' wages is on average 4.5% narrower in covered than in uncovered plants, both statistically significant at least at the 5% level. Furthermore, works council existence is associated with a 7.2% higher elasticity and a 5.2% narrower gap. We also find the same patterns for the control variables that we obtained at the extensive margin. Plants' monopsony power shows a positive association with plant size and a negative with exporting activity (as is found by Dobbelaere and Kiyota, 2018, for Japan). Moreover, plants' monopsony power is significantly related to workforce composition. It is smaller the more skilled workers are employed and larger the more apprentices, part-timers, and females are in the workforce. Particularly the latter finding for females is in line with existing evidence that employers possess more monopsony power over female as opposed to male workers (see the recent survey by Hirsch, 2016, and Hirsch *et al.*, 2010, for Germany).

Given a wage formation process involving a wage mark-up, we find that the presence of collective bargaining is associated with a rise in workers' relative bargaining power by 8.9% and the presence of a works council even with a rise by 12.7%, though only the latter association is statistically significant at the 10% level, which may reflect the rather small number of observations involving a wage mark-up. As with the extensive margin, works councils seem to be more important for workers' monopoly power in wage formation than collective bargaining. These findings do make sense as collective bargaining is typically conducted at the sectoral level and thus is unlikely to loosen employers' control over employment, whereas worker co-determination at the workplace may more plausibly force employers off the labour demand curve. They further square up with the result of Hirsch and Mueller (2020) that works council existence has a stronger association with the mean employer wage premium than collective bargaining coverage. For the control variables, we obtain the same patterns as at the extensive margin, which are again mirror-inverted *vis-à-vis* the patterns for plants' monopsony power.

Finally, we find that the intensity of product market imperfections measured by the size of above-one price-cost mark-ups is unrelated to industrial relations, both in terms of effect size and statistical significance. In terms of the control variables, we see some differences to the extensive margin, particularly for plant age, but typically effect sizes are modest.

6.3 Analysis of switches in plants' labour market setting

Exploiting the time-varying nature of our estimates of the joint market imperfections parameter and the price-cost mark-up and the resulting classification of plants' labour market setting, we next investigate how switches in plants' labour market setting are related to the presence of collective bargaining and works councils. In doing so, we hope to further back up the claim that industrial relations shape labour market imperfections (rather than the other way round). Besides, such an analysis promises suggestive evidence on whether the deterioration of organised labour during our period of observation shifted market power from workers to employers and is thus plausibly contributing to the long-term trends of a falling labour share in income and rising wage inequality.

— Table 11 about here —

Table 11 provides a transition matrix for the three labour market settings. What emerges is that wage mark-downs are by far the most persistent among the three settings. For 87% of plants with a wage mark-down, we also find a wage mark-down in the subsequent observation. On the other hand, 13% of plants with a wage mark-down change their labour market setting, with almost all of them changing to marginal-product wages. In terms of persistence, marginal-product wages come next. 73% of plants with marginal-product wages stay in this setting in the subsequent observation, whereas 16% of plants change to a wage mark-down and 11% of plants switch to a wage mark-up. Finally, 68% of plants with a wage mark-up keep having one in the subsequent observation, whereas 26% switch to marginal-product wages and 6% to a wage mark-down.[11]

[11] We also checked whether plants entering or exiting our sample differ in terms of their labour market settings from those plants staying in our sample, which contribute to the reported transition matrix. Notably, exit probabilities are very similar across the three labour market settings, and also the prevalence of the respective labour market settings for plants entering our sample does not differ

— Tables 12 and 13 about here —

Separate transition matrices for plants covered by a collective agreement and uncovered plants (see Table 12) reveal that covered plants are more likely to move from marginal-product wages to a wage mark-up than uncovered plants and are considerably more likely to keep having a wage mark-up. Separate transition matrices for plants with and without a works council (see Table 13) show more persistent wage mark-ups in co-determined plants compared to plants without a works council, whereas the opposite holds for the persistence of wage mark-downs. Furthermore, plants with a works council are considerably less likely to switch from marginal-product wages to a wage mark-down than plants without.

— Table 14 about here —

Most of these patterns also show up when running probit regressions for the four most observed types of switches in plants' labour market setting, for which the numbers of observations are sufficiently large for estimation purposes (see Table 14). Collective bargaining coverage is on average associated with a 2.0pp larger probability of changing from marginal-product wages to a wage mark-up, which is statistically significant at the 1% level. At the same time, it reduces the probability of switching from marginal-product wages to a wage mark-down by 1.6pp, which is statistically significant at the 10% level, as well as the probability of switching from a wage mark-up to marginal-product wages by 1.7pp, which is statistically insignificant at conventional levels probably due to the small number of transitions from a wage mark-up to marginal-product wages. These latter two switching probabilities show an even more pronounced negative correlation with works council existence that is on average associated with a drop in the switching probability from marginal-product wages to a wage mark-down by 4.7pp and a drop in the switching probability from a wage mark-up to marginal-product wages by 6.8pp, both of which are statistically significant at the 1% level. Given the marked persistence of plants' labour market setting, all these numbers represent sizeable changes.

much from the prevalence of settings for incumbent plants. Hence, the picture would not change when accounting for compositional changes following plant entry and plant exit.

In summary, we find that both types of organised labour favour workers in that they reduce the probability of unfavourable switches in plants' labour market setting, that is moving away from a wage mark-up or into a wage mark-down. We thus have further evidence suggesting that industrial relations shape labour market imperfections. And, reassuringly, these findings are unlikely to suffer from reversed causality running from labour market imperfections to industrial relations and therefore strengthen our results from regressions of labour market imperfections on industrial relations where issues of reversed causality are more of a concern.

Briefly turning to product market imperfections, the presence of any form of organised labour is associated with a higher persistence of the current product market setting (see the further tables reported in Appendix B). We see this both at the descriptive level by means of transition matrices and in a pair of probit regressions for the two types of switches from marginal-cost to mark-up pricing and the other way round. These findings are in line with the notion that organised labour limits management's flexibility in decision-taking, also when it comes to pricing decisions in the product market.

7 Do labour market imperfections matter for employer wage premia?

Our findings so far strongly suggest that industrial relations matter for labour market imperfections. But do labour market imperfections, in turn, matter for the wage premium paid by employers to their workers? In other words, what is the impact of labour market imperfections on the level and the dispersion of wages after accounting for sorting of workers with different abilities into plants that differ in labour market imperfections and in the size of rents to be split between employers and workers? Answering this question is not only crucial for our research question and against the background that rising dispersion in employer wage premia is an important driver of increasing wage inequality in Germany (Card *et al.*, 2013), but also provides a most welcome opportunity of cross-validating our measures of labour market imperfections, that is examining their predictive power for actual employer wage premia.

Up to now, there is scant evidence on this issue, though some recent contributions find that labour market imperfections are associated with wages (not employer wage premia). Hirsch *et al.* (2021) show that employers' smaller monopsony power in denser local labour markets accounts for about half of the urban wage premium in Germany. For the US, Azar *et al.* (2021) observe lower posted wages in more concentrated local labour markets and Benmelech *et al.* (2021) find a negative association between labour market concentration and wages that is rising over time and more pronounced where unionisation rates are low. Furthermore, Brooks *et al.* (2019) show that wage mark-downs substantially depress the labour share in China and India whereas Berger *et al.* (2019) find that labour market concentration, while substantial, has not contributed to the falling US labour share. Finally, Rinz (2021) documents for the US that higher labour market concentration is accompanied by higher wage inequality while Webber (2015) finds that a larger labour supply elasticity to the employer reduces the dispersion of wages because its wage-lifting effect is most pronounced at the lower end of the wage distribution.

All this evidence, however, is about individual wages and not about employer wage premia, that is wage differences that are left after differences in workers' human capital and unobservable skills have been rewarded, and thus worker sorting may contaminate findings. To obtain a measure of employer wage premia that does not suffer from worker sorting, we follow Card *et al.* (2018) and Hirsch and Mueller (2020) and rely on the plant wage effect from a two-way fixed-effects decomposition of log wages *à la* Abowd, Kramarz, and Margolis (1999, AKM hereafter) estimated for our data by Bellmann *et al.* (2020). In the AKM framework, which provides a suitable approximation of the German wage structure (Card *et al.*, 2013), the plant wage effect measures the wage premium enjoyed by all workers in a plant's workforce adjusted for observed and unobserved worker quality. Since we are interested in how labour market imperfections shape wage outcomes for a given plant surplus, we further follow Hirsch and Mueller (2020) in controlling for the quasi rent per worker as the proper measure of this surplus. We provide details on our measures of plant wage premia and plant surplus in Appendix C.

For the subsample of 36,633 plant-year observations for which AKM plant wage effects are available, we investigate the link between employer wage premia and labour market imperfections by regressing the standardised plant wage effect on measures of labour market imperfections, the quasi rent per worker to control for the plant surplus, and all the control variables included in the regressions before.[12] As measures of labour market imperfections at the extensive margin, we include dummy variables for the existence of a wage mark-down and a wage mark-up. And given a specific labour market setting involving either a wage mark-down or a wage mark-up, we include the plant-level labour supply elasticity, the size of the wage mark-down, or workers' relative bargaining power as the respective measure of the intensity of labour market imperfections. For all our labour market imperfection measures, that is for the extensive-margin indicators and the three intensive-margin variables, we estimate four regression models: an OLS regression for the mean employer wage premium, which provides the impact of labour market imperfections on the level of wage premia, and re-centred influence function (RIF) regressions (Firpo *et al.*, 2009) for the variance, the first decile, and the ninth decile of the unconditional wage premium distribution, which inform us on their influence on the dispersion of wage premia.

— Table 15 about here —

Table 15 presents our results at the extensive margin of labour market imperfections. Holding constant plant surplus and the other control variables, a labour market setting involving a wage mark-down is accompanied by a 0.15 standard deviations lower mean wage premium (where a standard deviation in employer wage premia amounts to about 28 log points in our data). Whereas the level of wage premia is thus lower when there is a wage mark-down, the opposite holds for the dispersion of wage premia. A wage mark-down is associated with a 14% larger variance (of standardised wage premia), which reflects that a wage mark-down is associated with a 0.2 standard deviations lower first decile and a 0.04 standard deviations lower ninth decile of wage premia and thus widens the wage

[12] Note that our earlier results for the link between industrial relations and labour market imperfections also show up in this reduced sample, though estimation precision is a bit lower than in the full sample.

premium distribution. All these partial correlations are statistically significant at the 1% level. Our findings suggest not only that wage mark-downs harm workers in reducing the level of employer wage premia for a given surplus, but also that workers with low-premium employers suffer most and that wage mark-downs thus aggravate inequality.

In contrast to wage mark-downs, wage mark-ups are only related to the level but not to the dispersion of wage premia. The existence of a wage mark-up is accompanied by a statistically significant rise in the mean wage premium by 0.08 standard deviations and little change in premia variance because its influence is the same, i.e. roughly 0.06 standard deviations, at the first and the ninth decile of the wage premium distribution. Hence, wage mark-ups seem to benefit workers uniformly leaving inequality unaltered. In passing, we note that the R^2 of 0.54 in the OLS regression means that the included regressors can account for the majority of the variation in wage premia, and we further note that the included control variables show little surprises so that we leave them uncommented.

Turning to the intensive margin of labour market imperfections, Tables 16, 17, and 18 present analogous regressions that include (in logs) the plant-level labour supply elasticity, the size of the wage mark-down, and workers' relative bargaining power as respective measures of the intensity of labour market imperfections provided there exists either a wage mark-down or a wage mark-up. Remarkably and reassuringly, all our findings at the extensive margin also show up at the intensive margin.

— Table 16 about here —

Starting with the plant-level labour supply elasticity that measures the intensity of employers' monopsony power, Table 16 shows that employers' monopsony power is significantly related to both the level and the dispersion of wage premia. When a wage mark-down is present, which is the case for 15,503 observations in the subsample of plants with AKM plant wage effects, a one standard deviation larger log elasticity, which amounts to 0.88 in our sample, is associated with a 0.09 ($= 0.88 \times 0.107$) standard deviations larger mean plant wage premium, which is statistically significant at the 1% level. Further, such an increase is accompanied by a statistically significant drop in the variance of premia by

19.4%, which reflects the associated rise of the first decile of the premium distribution by 0.17 standard deviations and the almost unaltered ninth decile.

— Table 17 about here —

Considering the size of the wage mark-down instead, Table 17 shows that a one standard deviation narrower log wage mark-down, which amounts to 0.52 in our sample, is accompanied by a rise in the mean premium by 0.09 standard deviations and a drop in the variance of wage premia by 19.4%, both statistically significant at the 1% level. Observe that these estimates for the wage mark-down are of the very same size as the estimates for the elasticity. This finding is reassuring and hardly surprising given that the elasticity and the wage mark-down are two sides of the same coin under monopsony. The drop in the variance of wage premia reflects the associated rise in the first decile of the premium distribution from the narrowing of the wage mark-down by 0.18 standard deviations and the nearly constant ninth decile.

In short, our findings show that more monopsony power harms workers and particularly those working for low-premium plants thereby aggravating inequality in employer wage premia. This squares with our findings at the extensive margin and documents that both the existence of wage mark-downs and the intensity of employers' monopsony power seem to matter for employer wage premia.

— Table 18 about here —

Turning to the intensity of wage mark-ups, which are present for 6,830 observations, Table 18 shows that a one standard deviation larger log relative bargaining power of workers, which amounts to 1.15 in our sample, is accompanied by a 0.05 standard deviations larger mean plant wage premium and a 0.06 (0.03) standard deviations larger first (ninth) decile of the premium distribution and thus little change in the variance of plant wage premia. All these partial correlations are statistically significant at least at the 5% level, though effect sizes are more modest than in the case of a wage mark-down. Hence, given a wage mark-up, more bargaining power of workers benefits workers uniformly across the wage premium distribution, though to a modest extent.

In summary, our findings suggest that labour market imperfections matter for employer wage premia, and in the way predicted by theory thereby cross-validating our measures of imperfections in the labour market. The existence of a wage mark-down harms workers, with workers working for low-premium employers suffering most. It thus not only depresses employer wage premia, but also aggravates inequality. In contrast, the presence of a wage mark-up benefits workers uniformly leaving inequality unaltered, though effect sizes are smaller for a wage mark-up than for wage mark-down. These findings at the extensive margin also show up at the intensive margin when considering the plant-level labour supply elasticity, the size of the wage mark-down, and workers' relative bargaining power. In consequence, both the existence and the intensity of labour market imperfections seem to influence the level and the dispersion of employer wage premia while they themselves seem to be shaped by industrial relations.

8 Conclusions

This paper has investigated the interplay between industrial relations, labour market imperfections, and employer wage premia in Germany and posed two questions. Do industrial relations matter for labour market imperfections? And do labour market imperfections, in turn, matter for employer wage premia? Using representative plant-level data from the IAB Establishment Panel encompassing the years 1999–2016, we answered both questions in the affirmative.

We approached these two questions using the production function approach of Dobbelaere and Mairesse (2013) that allows to determine labour and product market imperfections from production function estimates. In the labour market, the approach allows for competitive outcomes on the labour demand curve involving marginal-product wages, or outcomes off the curve with employers' monopsony power enabling them to impose a wage mark-down on workers or workers' monopoly power permitting them to push through a wage mark-up. Moreover, the approach enables us to make statements about the intensity of labour market imperfections for outcomes off the labour demand curve. Specifically, it allows to recover the labour supply elasticity to the single employer and thus employers' monopsony power when wage formation involves a wage mark-down and workers' relative bargaining power when there exists a wage mark-up. In the product market, the approach encompasses competitive solutions involving marginal-cost prices as well as mark-up pricing, for which it allows to recover the price-cost mark-up.

At a descriptive level, we found that wage mark-downs are the most prevalent outcome in the labour market (49% of plant-year observations), followed by outcomes on the labour demand curve involving marginal-product wages (36%), whereas wage mark-ups are much less frequent (15%). Notably, wage mark-ups are almost always accompanied by mark-up pricing suggesting that they are only sustainable when product market imperfections shield employers from competition. We further observed that wage mark-downs are less frequent when collective bargaining or plant-level co-determination through works councils are present and that the opposite holds for wage mark-ups. These findings at the extensive margin, that is with respect to the prevalence of outcomes off the labour demand curve, are complemented by results at the intensive margin, i.e. within labour market settings, where we observe that employers' monopsony power (workers' bargaining power) is less (more) pronounced when collective bargaining or works councils exist, other things being equal.

All these descriptive correlations between labour market imperfections and industrial relations also showed up in multinomial probit regressions for the labour market setting and type II Tobit regressions for the intensity of labour market imperfections that control for a broad range of plant characteristics. Collective bargaining and, even more so, works council existence have a marked association with labour market imperfections at the extensive and intensive margins. Turning to switches in plants' labour market setting over time, we further observed that wage mark-downs are most persistent, followed by marginal-product wages, whereas wage mark-ups are least persistent. We also saw in probit regressions that the presence of collective bargaining and works councils is associated with a lower probability of switching from a wage mark-up to marginal-product wages and a lower switching probability from marginal-product wages to a wage mark-down, lending further credence to a causal link running from industrial relations to labour market imperfections.

Finally, we found that employer wage premia are smaller and more dispersed when a wage mark-down is present as workers with low-premium employers suffer most. In contrast, we saw that the existence of a wage mark-up is accompanied by larger pay premia but leaves their dispersion unaltered as wage mark-ups benefit workers uniformly across the premium distribution. On top of these results at the extensive margin, the same patterns showed up for the intensity of labour market imperfections within a given labour market setting.

In short, our results document that labour market imperfections are the norm rather than the exception in Germany and typically give rise to a power imbalance favouring employers who are able to impose a wage mark-down on workers. Wage mark-downs, in turn, harm workers as they are associated with lower employer wage premia. And they also aggravate inequality in that they are accompanied by more dispersed wage premia because workers with low-premium jobs suffer most. What is more, our findings strongly suggest that labour market imperfections are shaped by industrial relations, with collective bargaining and worker co-determination shifting market power from employers to workers. Hence, they point at organised labour's erosion as one possible contributor to the falling labour share and rising wage inequality. While our regression results, in particular those for switches in labour market settings, go some way in substantiating causal links running from industrial relations to labour market imperfections and from labour market imperfections to employer wage premia, establishing causality in a rigorous way using exogenous variation in industrial relations remains a promising avenue for future research.

Tables

Table 1: Descriptive statistics

	Mean	SD	p25	p50	p75
Real plant output growth rate (Δq_{it})	0.001	0.228	–0.087	0.000	0.092
Labour growth rate (Δn_{it})	0.013	0.154	–0.029	0.000	0.072
Intermediate inputs growth rate (Δm_{it})	0.002	0.424	–0.172	0.000	0.171
Capital growth rate (Δk_{it})	0.006	0.128	–0.054	–0.028	0.027
Revenue share of intermediate inputs (α_{Mit})	0.471	0.197	0.322	0.474	0.620
Revenue share of labour (α_{Nit})	0.281	0.180	0.142	0.249	0.380
$1 - \alpha_{Nit} - \alpha_{Mit}$	0.206	0.214	0.064	0.188	0.347
ln(wagebill$_{it}$)	5.716	1.224	4.864	5.557	6.410
ln(employment$_{it}$)	2.618	0.905	1.946	2.398	3.045
ln(capital$_{it}$)	13.093	1.533	12.113	12.999	13.968
ln(material$_{it}$)	13.264	1.604	12.158	13.122	14.272
ln(output$_{it}$)	14.093	1.330	13.122	13.868	14.896
Capital intensity ($\ln(\frac{K}{N})_{it}$)	10.457	1.133	9.756	10.515	11.201
Value added per worker ($\ln(\frac{Q-M}{N})_{it}$)	10.609	0.819	10.156	10.617	11.077
Solow residual (SR_{it})	–0.026	0.202	–0.094	–0.005	0.067
Works council (dummy)	0.093	0.290	0.000	0.000	0.000
Collective bargaining (dummy)	0.364	0.481	0.000	0.000	1.000
Single-plant company (dummy)	0.852	0.355	1.000	1.000	1.000
Plant age $\leqslant$ 4 years (dummy)	0.051	0.221	0.000	0.000	0.000
Plant age 5–9 years (dummy)	0.121	0.327	0.000	0.000	0.000
Plant age 10–14 years (dummy)	0.102	0.302	0.000	0.000	0.000
Plant age 15–19 years (dummy)	0.075	0.264	0.000	0.000	0.000
Plant age $\geqslant$ 20 years (dummy)	0.650	0.477	0.000	1.000	1.000
Share of skilled workers	0.647	0.249	0.500	0.714	0.833
Share of apprentices	0.048	0.077	0.000	0.000	0.083
Share of part-time workers	0.265	0.249	0.067	0.188	0.400
Share of female workers	0.423	0.288	0.167	0.357	0.667
Exporting activity (dummy)	0.239	0.426	0.000	0.000	0.000
West Germany (dummy)	0.791	0.407	1.000	1.000	1.000
Observations			40,856		
Plants			9,061		

Notes: IAB Establishment Panel, 1999–2016, weighted using sample weights. The Solow residual is defined as $SR_{it} = \Delta q_{it} - \alpha_{Nit}\Delta n_{it} - \alpha_{Mit}\Delta m_{it} - (1 - \alpha_{Nit} - \alpha_{Mit})\Delta k_{it}$.

Table 2: Estimated output elasticities and returns to scale by two-digit sector (means)

Sector (NACE Rev.2)		Output elasticity of... labour	inter-mediate inputs	capital	Returns to scale	Obs.	Plants
Food products	(10)	0.461	0.498	0.118	1.077	1,863	444
Beverages	(11)	0.386	0.601	0.192	1.180	266	45
Textiles	(13)	0.060	0.585	0.268	0.913	521	112
Wearing apparel, leather	(14–15)	0.297	0.827	0.084	1.207	203	48
Wood and wood products	(16)	0.287	0.713	0.076	1.076	888	181
Paper and paper products	(17)	0.385	0.571	0.013	0.969	372	75
Printing and recorded media	(18)	0.490	0.265	0.274	1.028	664	131
Chemicals and petroleum products	(19–20)	0.241	0.689	0.086	1.016	1,190	236
Basic pharmaceutical products	(21)	0.399	0.666	0.059	1.124	151	35
Rubber and plastic products	(22)	0.267	0.708	0.049	1.024	1,363	271
Non-metallic mineral products	(23)	0.391	0.579	0.106	1.076	1,402	279
Basic metals	(24)	0.525	0.469	0.060	1.054	1,419	270
Fabricated metal products	(25)	0.529	0.482	0.085	1.096	3,479	669
Computer and electronic products	(26)	0.561	0.645	0.169	1.375	1,048	250
Electrical equipment	(27)	0.317	0.573	0.106	0.996	1,057	219
Machinery and equipment	(28)	0.350	0.553	0.043	0.946	3,108	636
Motor vehicles and trailers	(29)	0.412	0.625	0.037	1.073	1,196	259
Other transport equipment	(30)	0.266	0.681	0.069	1.016	281	78
Furniture	(31)	0.519	0.504	0.025	1.048	658	130
Other manufacturing	(32)	0.580	0.471	0.062	1.113	1,049	211
Repair, installation of machinery	(33)	0.414	0.564	0.091	1.069	617	149
Wholesale trade (w/ vehicles)	(45)	0.231	0.636	0.129	0.996	1,996	433
Wholesale trade (w/o vehicles)	(46)	0.343	0.757	0.031	1.131	3,097	672
Retail trade (w/o vehicles)	(47)	0.382	0.672	0.026	1.079	4,064	923
Transport and warehousing	(49–53)	0.377	0.620	0.194	1.191	2,329	586
Publishing activities	(58–63)	0.402	0.413	0.201	1.016	1,037	291
Legal and accounting activities	(69)	0.833	0.260	0.099	1.191	1,283	284
Consultancy activities	(70)	0.492	0.569	0.203	1.264	311	89
Engineering activities	(71)	0.570	0.293	0.345	1.208	1,191	285
Scientific research	(72)	0.505	0.442	0.104	1.051	401	101
Advertising, market research	(73)	0.424	0.533	–0.049	0.908	219	58
Other professional activities	(74–75)	0.622	0.381	0.155	1.158	188	43
Rental and leasing activities	(77)	0.271	0.653	0.021	0.945	102	28
Employment activities	(78)	0.750	0.184	0.239	1.173	450	164
Travel agencies	(79)	0.370	0.599	0.112	1.081	140	39
Security activities	(80)	1.021	0.372	–0.156	1.237	105	32
Services to buildings and landscape	(81)	0.570	0.443	0.147	1.160	850	230
Office administration and support	(82)	0.087	0.678	0.023	0.787	298	75
All		0.441	0.553	0.104	1.097	40,856	9,061

Notes: IAB Establishment Panel, 1999–2016, weighted using sample weights.

Table 3: Plants' labour and product market settings

Labour market setting	Product market setting		∑
	Marginal-cost	Mark-up pricing	
Wage mark-down	21.6	27.0	48.6
Marginal-product wages	17.1	19.4	36.4
Wage mark-up	0.7	14.3	15.0
∑	39.4	60.6	

Notes: IAB Establishment Panel, 1999–2016, percentages of 40,856 plant-year observations, weighted using sample weights. Based on the estimates of the price-cost mark-up (equation 26) and the joint market imperfections parameter (equation 27), we classify observations to labour market settings using equation (19) and to product market settings using equation (18).

Table 4: Labour and product market settings of plants covered (uncovered) by collective agreements

Labour market setting	Product market setting		∑
	Marginal-cost	Mark-up pricing	
Wage mark-down	14.2 (25.8)	33.2 (23.5)	47.4 (49.3)
Marginal-product wages	15.6 (17.9)	20.7 (18.6)	36.3 (36.5)
Wage mark-up	0.5 (0.8)	15.8 (13.4)	16.3 (14.2)
∑	30.3 (44.6)	69.7 (55.4)	

Notes: IAB Establishment Panel, 1999–2016, percentages of 40,856 plant-year observations, weighted using sample weights. Based on the estimates of the price-cost mark-up (equation 26) and the joint market imperfections parameter (equation 27), we classify observations to labour market settings using equation (19) and to product market settings using equation (18).

Table 5: Labour and product market settings of plants with (without) a works council

Labour market setting	Product market setting		∑
	Marginal-cost	Mark-up pricing	
Wage mark-down	14.7 (22.3)	22.3 (27.5)	37.0 (49.8)
Marginal-product wages	16.5 (17.1)	24.9 (18.8)	41.3 (35.9)
Wage mark-up	1.1 (0.7)	20.6 (13.6)	21.7 (14.3)
∑	32.2 (40.1)	67.8 (59.9)	

Notes: IAB Establishment Panel, 1999–2016, percentages of 40,856 plant-year observations, weighted using sample weights. Based on the estimates of the price-cost mark-up (equation 26) and the joint market imperfections parameter (equation 27), we classify observations to labour market settings using equation (19) and to product market settings using equation (18).

Table 6: The intensity of labour and product market imperfections (means)

Market imperfection intensity	All	Collective bargaining		Works council	
		Yes	No	Yes	No
Joint market imperfections parameter (ψ_{it})	–0.71	–0.76	–0.68	–0.49	–0.74
… when wage mark-down ($\psi_{it} < 0$)	–1.89	–1.93	–1.87	–1.93	–1.90
… when wage mark-up ($\psi_{it} > 0$)	1.67	1.33	1.91	1.19	1.75
Given wage mark-down ($\psi_{it} < 0$) …					
Plant-level labour supply elasticity ($(\varepsilon_W^N)_{it}$)	1.13	1.17	1.11	1.29	1.12
Wage mark-down (β_{it})	0.45	0.46	0.45	0.47	0.45
Given wage mark-up ($\psi_{it} > 0$) …					
Workers' absolute bargaining power (ϕ_{it})	0.48	0.44	0.50	0.45	0.48
Workers' relative bargaining power (γ_{it})	3.33	2.58	3.83	2.13	3.52
Price-cost mark-up (μ_{it})	1.23	1.24	1.23	1.32	1.22
… when mark-up pricing ($\mu_{it} > 1$)	1.39	1.35	1.41	1.46	1.38

Notes: IAB Establishment Panel, 1999–2016, weighted using sample weights. Based on the estimates of the price-cost mark-up (equation 26) and the joint market imperfections parameter (equation 27), we classify observations to labour market settings using equation (19) and to product market settings using equation (18). For a given labour market setting, structural parameters are recovered using equations (30)–(33).

Table 7: Average marginal effects for the probability of a wage mark-down from multinomial probit regressions

	(1)	(2)	(3)	(4)
Collective bargaining	–0.015*	–0.023**	–0.027***	–0.031***
	(0.009)	(0.009)	(0.009)	(0.009)
Works council	–0.016	–0.072***	–0.055***	–0.053***
	(0.011)	(0.012)	(0.012)	(0.012)
Log employment		0.036***	0.039***	0.043***
		(0.004)	(0.004)	(0.005)
Plant age 5–9 years		0.010	0.008	0.008
		(0.014)	(0.014)	(0.014)
Plant age 10–14 years		0.007	0.008	0.007
		(0.015)	(0.015)	(0.015)
Plant age 15–19 years		0.012	0.015	0.015
		(0.017)	(0.016)	(0.016)
Plant age $\geqslant$ 20 years		0.024*	0.025*	0.024*
		(0.014)	(0.014)	(0.014)
Share of skilled workers			–0.092***	–0.092***
			(0.018)	(0.018)
Share of apprentices			0.693***	0.677***
			(0.061)	(0.061)
Share of part-time workers			0.296***	0.283***
			(0.027)	(0.027)
Share of female workers			0.052**	0.057**
			(0.024)	(0.024)
Exporting activity				–0.045***
				(0.009)
Log likelihood	–32,941.3	–32,765.6	–32,102.1	–32,038.7
Number of observations	40,856			

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is a categorical variable for the classification of the labour market setting as involving either marginal-product wages or a wage mark-down or a wage mark-up. Reported numbers are average marginal effects on the probability of a wage mark-down with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

Table 8: Average marginal effects for the probability of a wage mark-up from multinomial probit regressions

	(1)	(2)	(3)	(4)
Collective bargaining	0.004	0.009	0.013*	0.016**
	(0.007)	(0.007)	(0.007)	(0.007)
Works council	0.031***	0.064***	0.052***	0.051***
	(0.008)	(0.010)	(0.010)	(0.009)
Log employment		–0.020***	–0.019***	–0.023***
		(0.003)	(0.003)	(0.003)
Plant age 5–9 years		–0.015	–0.013	–0.013
		(0.011)	(0.011)	(0.011)
Plant age 10–14 years		–0.006	–0.004	–0.004
		(0.012)	(0.012)	(0.012)
Plant age 15–19 years		–0.005	–0.005	–0.004
		(0.013)	(0.013)	(0.013)
Plant age $\geqslant$ 20 years		–0.015	–0.014	–0.013
		(0.011)	(0.011)	(0.011)
Share of skilled workers			0.030**	0.031**
			(0.013)	(0.013)
Share of apprentices			–0.465***	–0.454***
			(0.052)	(0.052)
Share of part-time workers			–0.134***	–0.123***
			(0.021)	(0.021)
Share of female workers			–0.068***	–0.071***
			(0.019)	(0.018)
Exporting activity				0.038***
				(0.007)
Log likelihood	–32,941.3	–32,765.6	–32,102.1	–32,038.7
Number of observations	40,856			

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is a categorical variable for the classification of the labour market setting as involving either marginal-product wages or a wage mark-down or a wage mark-up. Reported numbers are average marginal effects on the probability of a wage mark-up with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

Table 9: Average marginal effects from probit regressions for mark-up pricing

	(1)	(2)	(3)	(4)
Collective bargaining	0.004	0.009	0.010	0.012
	(0.007)	(0.007)	(0.007)	(0.007)
Works council	–0.022**	0.030***	0.025**	0.024**
	(0.009)	(0.010)	(0.010)	(0.010)
Log employment		–0.034***	–0.034***	–0.037***
		(0.004)	(0.004)	(0.004)
Plant age 5–9 years		0.001	0.001	0.001
		(0.012)	(0.012)	(0.012)
Plant age 10–14 years		0.006	0.007	0.007
		(0.013)	(0.013)	(0.013)
Plant age 15–19 years		0.011	0.010	0.011
		(0.014)	(0.014)	(0.014)
Plant age $\geqslant$ 20 years		0.010	0.009	0.010
		(0.012)	(0.012)	(0.012)
Share of skilled workers			0.047***	0.048***
			(0.015)	(0.015)
Share of apprentices			–0.164***	–0.153***
			(0.046)	(0.046)
Share of part-time workers			–0.040**	–0.034*
			(0.020)	(0.020)
Share of female workers			–0.037**	–0.038**
			(0.019)	(0.019)
Exporting activity				0.024***
				(0.008)
Log likelihood	–19,020.3	–18,871.1	–18,819.9	–18,807.7
Number of observations	40,856			

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is an indicator for the product market setting involving mark-up pricing. Reported numbers are average marginal effects with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

Table 10: Estimates of the second-stage output equation of type II Tobit regressions for the intensity of market imperfections

	Log of... plant-level labour supply elasticity ($(\varepsilon_W^N)_{it}$)	wage mark-down (β_{it})	workers' relative bargaining power (γ_{it})	price-cost mark-up (μ_{it})
Collective bargaining	0.057**	0.045***	0.089	0.006
	(0.025)	(0.015)	(0.055)	(0.004)
Works council	0.072**	0.052**	0.127*	0.008
	(0.034)	(0.021)	(0.066)	(0.006)
Log employment	–0.148***	–0.095***	–0.074**	–0.015***
	(0.013)	(0.008)	(0.030)	(0.003)
Plant age 5–9 years	0.029	0.024	–0.213**	–0.010
	(0.038)	(0.024)	(0.095)	(0.008)
Plant age 10–14 years	0.082*	0.041	–0.149	–0.019**
	(0.042)	(0.026)	(0.100)	(0.009)
Plant age 15–19 years	0.081*	0.036	–0.161	–0.021**
	(0.044)	(0.027)	(0.109)	(0.009)
Plant age $\geqslant$ 20 years	0.102***	0.048**	–0.113	–0.017**
	(0.038)	(0.024)	(0.092)	(0.008)
Share of skilled workers	0.524***	0.277***	0.320***	–0.006
	(0.046)	(0.027)	(0.095)	(0.010)
Share of apprentices	–0.660***	–0.472***	–2.183***	–0.121***
	(0.150)	(0.094)	(0.423)	(0.032)
Share of part-time workers	–0.963***	–0.546***	–0.132	–0.000
	(0.062)	(0.038)	(0.171)	(0.015)
Share of female workers	–0.209***	–0.087**	–0.299*	–0.001
	(0.064)	(0.037)	(0.154)	(0.013)
Exporting activity	0.093***	0.052***	0.097*	–0.005
	(0.026)	(0.016)	(0.054)	(0.005)
Log likelihood	–31,369.9	–20,131.8	–17,290.1	–2,022.6
Number of observations	26,930	26,930	13,642	31,695

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is the logarithm of the respective market imperfection intensity measure. Reported numbers are coefficients from the outcome equation of type II Tobit regressions with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

Table 11: Transition matrix for plants' labour market setting

Labour market setting in t	Labour market setting in $t+1$		
	Wage mark-down	Marginal-product wages	Wage mark-up
Wage mark-down	86.8	11.9	1.2
Marginal-product wages	16.1	73.1	10.8
Wage mark-up	6.3	26.0	67.7

Notes: IAB Establishment Panel, 1999–2016, percentages of 31,795 plant-year observations, weighted using sample weights in t. Based on the estimates of the joint market imperfections parameter (equation 27), we classify observations to labour market settings using equation (19).

Table 12: Transition matrix for the labour market setting of plants covered (uncovered) by collective agreements

Labour market setting in t	Labour market setting in $t+1$		
	Wage mark-down	Marginal-product wages	Wage mark-up
Wage mark-down	87.0 (86.7)	11.8 (12.0)	1.2 (1.3)
Marginal-product wages	15.9 (16.2)	72.4 (73.5)	11.8 (10.3)
Wage mark-up	4.8 (7.3)	24.6 (27.0)	70.7 (65.7)

Notes: IAB Establishment Panel, 1999–2016, percentages of 31,795 plant-year observations, weighted using sample weights in t. Based on the estimates of the joint market imperfections parameter (equation 27), we classify observations to labour market settings using equation (19).

Table 13: Transition matrix for the labour market setting of plants with (without) a works council

Labour market setting in t	Labour market setting in $t+1$		
	Wage mark-down	Marginal-product wages	Wage mark-up
Wage mark-down	84.6 (87.0)	12.5 (11.9)	2.9 (1.1)
Marginal-product wages	11.2 (16.7)	78.4 (72.4)	10.5 (10.9)
Wage mark-up	5.8 (6.3)	20.1 (26.9)	74.1 (66.7)

Notes: IAB Establishment Panel, 1999–2016, percentages of 31,795 plant-year observations, weighted using sample weights in t. Based on the estimates of the joint market imperfections parameter (equation 27), we classify observations to labour market settings using equation (19).

Table 14: Average marginal effects from probit regressions for a switch in the plant's labour market setting

	(1) Marginal-product wages to wage mark-down	(2) Wage mark-down to marginal-product wages	(3) Marginal-product wages to wage mark-up	(4) Wage mark-up to marginal-product wages
Collective bargaining	–0.016*	0.007	0.020***	–0.017
	(0.009)	(0.008)	(0.007)	(0.016)
Works council	–0.047***	0.009	0.006	–0.068***
	(0.011)	(0.011)	(0.010)	(0.019)
Log employment	–0.003	–0.032***	–0.015***	–0.000
	(0.004)	(0.005)	(0.003)	(0.008)
Plant age 5–9 years	0.049***	0.001	–0.005	–0.026
	(0.017)	(0.018)	(0.015)	(0.032)
Plant age 10–14 years	0.038**	–0.003	0.002	–0.035
	(0.018)	(0.018)	(0.016)	(0.032)
Plant age 15–19 years	0.038**	0.001	–0.013	–0.027
	(0.018)	(0.018)	(0.016)	(0.034)
Plant age $\geqslant$ 20 years	0.031**	–0.007	–0.008	–0.033
	(0.016)	(0.016)	(0.014)	(0.029)
Share of skilled workers	–0.027	0.061***	0.032**	–0.002
	(0.018)	(0.017)	(0.015)	(0.029)
Share of apprentices	0.335***	–0.131***	–0.127**	0.347***
	(0.061)	(0.049)	(0.055)	(0.111)
Share of part-time workers	0.01	–0.137***	–0.032	0.114**
	(0.031)	(0.022)	(0.023)	(0.056)
Share of female workers	0.053**	–0.082***	–0.017	0.063
	(0.023)	(0.021)	(0.019)	(0.045)
Exporting activity	–0.001	0.020**	0.006	–0.047***
	(0.009)	(0.009)	(0.007)	(0.016)
Log likelihood	–4826.3	–4907.8	–3473.4	–2696.1
Number of observations	12,222	13,630	12,201	5,305

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is a dummy variable that indicates a switch in the labour market setting in the respective direction for two consecutive observations of the same plant. Reported numbers are average marginal effects with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

Table 15: Level and dispersion of plant wage premia and the plant's labour market setting (wage premium OLS and RIF regressions)

	(1) Mean	(2) Variance	(3) First decile	(4) Ninth decile
Wage mark-down	–0.148***	0.139***	–0.196***	–0.042***
	(0.016)	(0.032)	(0.022)	(0.014)
Wage mark-up	0.076***	–0.014	0.059***	0.063***
	(0.017)	(0.037)	(0.022)	(0.016)
Quasi rent per worker	0.002***	–0.001***	0.001***	0.001***
(in € 100,000)	(0.000)	(0.000)	(0.000)	(0.000)
Log employment	0.183***	–0.089***	0.166***	0.137***
	(0.007)	(0.011)	(0.007)	(0.005)
Plant age 5–9 years	–0.049*	0.096	–0.075	0.001
	(0.030)	(0.077)	(0.052)	(0.032)
Plant age 10–14 years	–0.076**	0.090	–0.104**	–0.022
	(0.033)	(0.076)	(0.053)	(0.030)
Plant age 15–19 years	–0.017	0.028	–0.214***	–0.013
	(0.035)	(0.078)	(0.056)	(0.031)
Plant age ⩾ 20 years	–0.008	–0.042	–0.080*	–0.044
	(0.030)	(0.069)	(0.045)	(0.029)
Share of skilled workers	0.297***	–0.242***	0.479***	0.059**
	(0.032)	(0.059)	(0.043)	(0.025)
Share of apprentices	–0.350***	–0.795***	0.333**	–0.458***
	(0.113)	(0.207)	(0.169)	(0.069)
Share of part-time workers	0.064	1.270***	–0.289***	0.459***
	(0.061)	(0.090)	(0.078)	(0.037)
Share of female workers	–0.315***	0.017	–0.539***	–0.197***
	(0.048)	(0.075)	(0.059)	(0.029)
Exporting activity	0.075***	–0.074**	0.094***	–0.016
	(0.016)	(0.030)	(0.018)	(0.013)
R^2	0.539	0.040	0.197	0.183
Number of observations	36,633			

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is the standardised plant wage effect. Reported numbers are coefficients from OLS and RIF regressions with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

Table 16: Level and dispersion of plant wage premia and the plant-level labour supply elasticity (wage premium OLS and RIF regressions)

	(1) Mean	(2) Variance	(3) First decile	(4) Ninth decile
Log of plant-level labour	0.107***	–0.220***	0.196***	–0.019
supply elasticity ($(\varepsilon_W^N)_{it}$)	(0.013)	(0.024)	(0.016)	(0.012)
Quasi rent per worker	0.002***	–0.001***	0.001***	0.002***
(in € 100,000)	(0.000)	(0.000)	(0.000)	(0.000)
Log employment	0.195***	–0.091***	0.163***	0.146***
	(0.011)	(0.017)	(0.011)	(0.010)
Plant age 5–9 years	–0.046	–0.068	0.005	–0.062
	(0.052)	(0.109)	(0.078)	(0.053)
Plant age 10–14 years	–0.067	0.008	–0.079	0.002
	(0.056)	(0.108)	(0.080)	(0.050)
Plant age 15–19 years	–0.026	–0.072	–0.181**	0.012
	(0.057)	(0.110)	(0.083)	(0.050)
Plant age $\geqslant$ 20 years	–0.031	–0.188*	–0.047	–0.057
	(0.052)	(0.096)	(0.068)	(0.047)
Share of skilled workers	0.220***	–0.231***	0.392***	0.022
	(0.051)	(0.084)	(0.060)	(0.043)
Share of apprentices	–0.381***	–0.622**	0.177	–0.531***
	(0.146)	(0.274)	(0.227)	(0.104)
Share of part-time workers	0.304***	1.163***	0.208**	0.519***
	(0.084)	(0.118)	(0.098)	(0.057)
Share of female workers	–0.149**	–0.162	–0.300***	–0.244***
	(0.067)	(0.103)	(0.081)	(0.047)
Exporting activity	0.026	0.027	0.019	–0.019
	(0.023)	(0.045)	(0.025)	(0.020)
R^2	0.560	0.062	0.213	0.219
Number of observations	15,503			

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is the standardised plant wage effect. Reported numbers are coefficients from OLS and RIF regressions with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

Table 17: Level and dispersion of plant wage premia and the size of the wage mark-down (wage premium OLS and RIF regressions)

	(1) Mean	(2) Variance	(3) First decile	(4) Ninth decile
Log of wage mark-down (β_{it})	0.169***	–0.373***	0.341***	–0.035
	(0.024)	(0.040)	(0.028)	(0.023)
Quasi rent per worker	0.002***	–0.001***	0.001***	0.002***
(in € 100,000)	(0.000)	(0.000)	(0.000)	(0.000)
Log employment	0.193***	–0.089***	0.162***	0.146***
	(0.011)	(0.017)	(0.011)	(0.010)
Plant age 5–9 years	–0.045	–0.068	0.005	–0.061
	(0.052)	(0.109)	(0.078)	(0.053)
Plant age 10–14 years	–0.066	0.009	–0.080	0.002
	(0.056)	(0.108)	(0.079)	(0.050)
Plant age 15–19 years	–0.025	–0.071	–0.183**	0.012
	(0.057)	(0.110)	(0.083)	(0.050)
Plant age ⩾ 20 years	–0.031	–0.187*	–0.049	–0.057
	(0.052)	(0.096)	(0.068)	(0.048)
Share of skilled workers	0.227***	–0.241***	0.398***	0.022
	(0.052)	(0.084)	(0.060)	(0.043)
Share of apprentices	–0.405***	–0.578**	0.140	–0.528***
	(0.146)	(0.274)	(0.226)	(0.103)
Share of part-time workers	0.293***	1.176***	0.200**	0.519***
	(0.084)	(0.118)	(0.098)	(0.057)
Share of female workers	–0.155**	–0.154	–0.306***	–0.244***
	(0.067)	(0.103)	(0.080)	(0.047)
Exporting activity	0.028	0.024	0.021	-0.019
	(0.023)	(0.045)	(0.025)	(0.020)
R^2	0.559	0.061	0.213	0.219
Number of observations	15,503			

Notes: IAB Establishment Panel, 1999–2016. The dependent variable the is standardised plant wage effect. Reported numbers are coefficients from OLS and RIF regressions with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

Table 18: Level and dispersion of plant wage premia and workers' relative bargaining power (wage premium OLS and RIF regressions)

	(1) Mean	(2) Variance	(3) First decile	(4) Ninth decile
Log of workers' relative	0.040***	0.016	0.050**	0.027**
bargaining power (γ_{it})	(0.013)	(0.028)	(0.021)	(0.012)
Quasi rent per worker	0.001**	–0.001*	0.001***	0.001***
(in € 100,000)	(0.000)	(0.000)	(0.000)	(0.000)
Log employment	0.187***	–0.097***	0.181***	0.143***
	(0.016)	(0.029)	(0.020)	(0.014)
Plant age 5–9 years	–0.082	0.361**	–0.523***	0.009
	(0.056)	(0.182)	(0.115)	(0.071)
Plant age 10–14 years	–0.124**	0.409**	–0.695***	–0.020
	(0.058)	(0.179)	(0.119)	(0.067)
Plant age 15–19 years	–0.035	0.167	–0.503***	–0.030
	(0.065)	(0.186)	(0.127)	(0.071)
Plant age $\geqslant$ 20 years	–0.011	0.269*	–0.405***	0.015
	(0.051)	(0.159)	(0.085)	(0.063)
Share of skilled workers	0.270***	–0.210	0.423***	0.047
	(0.061)	(0.139)	(0.105)	(0.054)
Share of apprentices	–0.009	–3.141***	1.883***	–0.668***
	(0.251)	(0.521)	(0.483)	(0.149)
Share of part-time workers	–0.087	1.554***	–0.575**	0.437***
	(0.136)	(0.244)	(0.241)	(0.098)
Share of female workers	–0.429***	–0.186	–0.810***	–0.199***
	(0.098)	(0.203)	(0.173)	(0.077)
Exporting activity	0.102***	–0.111	0.141***	0.018
	(0.036)	(0.072)	(0.047)	(0.032)
R^2	0.528	0.076	0.258	0.169
Number of observations	6,830			

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is the standardised plant wage effect. Reported numbers are coefficients from OLS and RIF regressions with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region, year, and two-digit sector dummies as well as a dummy for a single-plant company.

A Estimating plants' production function

Our estimation approach to plants' production function (20) follows Ackerberg *et al.* (2015) and rests on the following timing assumptions. We assume that plants decide on their capital input k_{it} one period ahead at time $t-1$, which reflects planning and installation lags and causes capital to be predetermined. Among the variable factors of production, we assume that labour n_{it} is less variable than intermediate inputs m_{it} in that it is determined by plants at time $t-b$ with $0<b<1$. Hence, plants choose labour after capital but prior to intermediate inputs, where the latter is in line with plants requiring time to train new workers, with significant firing or hiring costs, or with long-lasting labour contracts in internal labour markets or unionised plants.

With respect to unobservable productivity, we assume that ω_{it} evolves according to an endogenous first-order Markov process. In particular, we assume that the plant's decision to engage in exporting activity might endogenously affect future productivity, which is at the heart of the Melitz (2003) model and amply supported by existing evidence (e.g. Helpman, 2006; Bernard *et al.*, 2007, 2012). Consequently, we can decompose ω_{it} into its expectation conditional on the information I_{it-1} available to the plant in $t-1$ and a random innovation to productivity denoted by ξ_{it}:

$$\begin{aligned}\omega_{it} &= \mathrm{E}[\omega_{it}|I_{it-1}] + \xi_{it} \\ &= \mathrm{E}[\omega_{it}|\omega_{it-1}, EXP_{it-1}] + \xi_{it} \\ &= g(\omega_{it-1}, EXP_{it-1}) + \xi_{it}\end{aligned} \tag{A.1}$$

In (A.1), EXP_{it-1} denotes plant i's export status in $t-1$, $g(\cdot)$ denotes some function, and ξ_{it} is assumed to be mean independent of the plant's information set I_{it-1} in $t-1$.

Given these timing assumptions, plant i's demand for intermediate inputs in t directly depends on n_{it} as well as on the other state variables k_{it}, EXP_{it}, and ω_{it}:

$$m_{it} = m_t(n_{it}, k_{it}, EXP_{it}, \omega_{it}) \tag{A.2}$$

Crucially, productivity ω_{it} is the only unobservable entering the demand function.[13] Provided strict monotonicity of the demand function $m_t(\cdot)$ with respect to ω_{it}, we can invert the demand function m_t to infer ω_{it} from observables as:[14]

$$\omega_{it} = m_t^{-1}(m_{it}, n_{it}, k_{it}, EXP_{it}) \tag{A.3}$$

Enriching our empirical model by an idiosyncratic error term ϵ_{it} that comprises unpredictable output shocks as well as potential measurement error in output and inputs gives

$$y_{it} = f(n_{it}, m_{it}, k_{it}; \boldsymbol{\beta}) + \omega_{it} + \epsilon_{it} \tag{A.4}$$

with $y_{it} = q_{it} + \epsilon_{it} = f_{it} + \omega_{it} + \epsilon_{it}$, where we assume ϵ_{it} to be mean independent of current and past input choices.[15] In our empirical specification, we approximate the unknown regression function $f(\cdot)$ by means of a second-order Taylor polynomial and estimate the coefficients of a translog production function (including a full set of region dummies and a linear time trend, which we will omit in the following for notational ease)

$$\begin{aligned} y_{it} = {} & \beta_0 + \beta_n n_{it} + \beta_m m_{it} + \beta_k k_{it} + \beta_{nn} n_{it}^2 + \beta_{mm} m_{it}^2 + \beta_{kk} k_{it}^2 \\ & + \beta_{nm} n_{it} m_{it} + \beta_{nk} n_{it} k_{it} + \beta_{mk} m_{it} k_{it} + \omega_{it} + \epsilon_{it}, \end{aligned} \tag{A.5}$$

where the regression constant β_0 measures the mean efficiency level across plants.

[13] Adding the plant's export status EXP_{it} as an observed shifter to the plant's demand for intermediate inputs m_{it} while excluding it from the production function addresses a fundamental identification problem for the output elasticity of intermediate inputs and thus permits us to use Ackerberg *et al.*'s control function approach in the estimation of a gross output production function. To provide intuition for this problem, note that absent such a shifter the plant's demand for intermediate inputs would be $m_{it} = m_t(n_{it}, k_{it}, \omega_{it})$. In that case, unobserved productivity ω_{it} would be the only demand shifter except for the other inputs in the production function n_{it} and k_{it}. Since the output elasticity of intermediate inputs is identified from the co-movement of output and intermediate inputs holding constant the other inputs n_{it} and k_{it}, the only source of variation in the demand for intermediate inputs left would be unobserved productivity ω_{it}. Unobserved productivity ω_{it}, though, shifts both output and the demand of intermediate inputs, rendering the output elasticity of intermediate inputs unidentified in this case.

[14] Levinsohn and Melitz (2006) show that strict monotonicity of $m_t(\cdot)$ with respect to ω_{it} holds as long as more productive plants do not set excessively higher price-cost mark-ups.

[15] Note that the output elasticities of labour and intermediate inputs are given by $(\varepsilon_N^Q)_{it} = \partial f(\cdot)/\partial n_{it}$ and $(\varepsilon_M^Q)_{it} = \partial f(\cdot)/\partial m_{it}$, respectively, and are thus independent of productivity shocks by definition.

Plugging equation (A.3) into (A.4) results in a first-stage regression equation

$$\begin{aligned} y_{it} &= f(n_{it}, m_{it}, k_{it}; \boldsymbol{\beta}) + m_t^{-1}(m_{it}, n_{it}, k_{it}, EXP_{it}) + \epsilon_{it} \\ &= \varphi_t(n_{it}, m_{it}, k_{it}, EXP_{it}) + \epsilon_{it} \end{aligned} \tag{A.6}$$

that we exploit to separate the productivity shock ω_{it} from the idiosyncratic ϵ_{it}, that is to eliminate the part of output y_{it} that is driven by unanticipated shocks, measurement error, or any other random noise. This first stage uses the regression equation (A.6) together with the moment condition $\mathrm{E}[\epsilon_{it}|I_{it}] = 0$ to obtain an estimate $\widehat{\varphi}_{it}$ of the composite term $\varphi_t(n_{it}, m_{it}, k_{it}, EXP_{it}) = f_{it} + \omega_{it}$ or, in other words, an estimate of the plant's output net of idiosyncratic factors $q_{it} = y_{it} - \epsilon_{it}$. For a given coefficient vector $\boldsymbol{\beta}$, we can then estimate ω_{it} (up to a constant) as:

$$\begin{aligned} \widehat{\omega}_{it}(\boldsymbol{\beta}) &= \widehat{m}_t^{-1}(m_{it}, n_{it}, k_{it}, EXP_{it}) \\ &= \widehat{\varphi}_{it} - \beta_n n_{it} - \beta_m m_{it} - \beta_k k_{it} - \beta_{nn} n_{it}^2 - \beta_{mm} m_{it}^2 - \beta_{kk} k_{it}^2 \\ &\quad - \beta_{nm} n_{it} m_{it} - \beta_{nk} n_{it} k_{it} - \beta_{mk} m_{it} k_{it} \end{aligned} \tag{A.7}$$

For the identification of the production function coefficients $\boldsymbol{\beta}$, the second stage then uses the timing assumptions of our framework to set up the moment conditions:

$$\mathrm{E}[\xi_{it}(\boldsymbol{\beta})(n_{it-1}, m_{it-1}, k_{it}, n_{it-1}^2, m_{it-1}^2, k_{it}^2, n_{it-1}m_{it-1}, n_{it-1}k_{it}, m_{it-1}k_{it})'] = \mathbf{0} \tag{A.8}$$

In order to exploit these moment conditions, we have to recover the innovations to plant productivity ξ_{it}. Based on equation (A.7), we arrive at a consistent non-parametric estimate of the conditional expectation $\mathrm{E}[\omega_{it}|\omega_{it-1}, EXP_{it-1}]$ by taking the predicted values of a non-parametric regression of $\widehat{\omega}_{it}(\boldsymbol{\beta})$ on $\widehat{\omega}_{it-1}(\boldsymbol{\beta})$ and EXP_{it-1}. The residuals from this regression, in turn, provide us with consistent estimates of ξ_{it}. Based on these and the moment conditions (A.8), we then estimate $\boldsymbol{\beta}$ by standard GMM and rely on the Delta method for the standard errors (e.g. Wooldridge, 2010).

B Results for product market setting switches

Table B.1: Transition matrix for plants' product market setting

Product market setting in t	Product market setting in $t+1$	
	Marginal cost	Price mark-up
Marginal cost	78.7	21.3
Price mark-up	16.8	83.2

Notes: IAB Establishment Panel, 1999–2016, percentages of 31,795 plant-year observations, weighted using sample weights in t. Based on the estimates of the price-cost mark-up (equation 26), we classify observations to product market settings using equation (18).

Table B.2: Transition matrix for the product market setting of plants covered (uncovered) by collective agreements

Product market setting in t	Product market setting in $t+1$	
	Marginal cost	Price mark-up
Marginal cost	79.5 (78.4)	20.5 (21.6)
Price mark-up	11.8 (20.6)	88.2 (79.4)

Notes: IAB Establishment Panel, 1999–2016, percentages of 31,795 plant-year observations, weighted using sample weights in t. Based on the estimates of the price-cost mark-up (equation 26), we classify observations to product market settings using equation (18).

Table B.3: Transition matrix for the product market setting of plants with (without) a works council

Product market setting in t	Product market setting in $t+1$	
	Marginal cost	Price mark-up
Marginal cost	83.1 (78.4)	16.9 (21.6)
Price mark-up	9.8 (17.6)	90.2 (82.4)

Notes: IAB Establishment Panel, 1999–2016, percentages of 31,795 plant-year observations, weighted using sample weights in t. Based on the estimates of the price-cost mark-up (equation 26), we classify observations to product market settings using equation (18).

Table B.4: Average marginal effects from probit regressions for a switch in the plant's product market setting

	(1) Mark-up to marginal-cost pricing	(2) Marginal-cost to mark-up pricing
Collective bargaining	–0.023***	–0.002
	(0.007)	(0.009)
Works council	–0.020**	–0.021*
	(0.009)	(0.011)
Log employment	0.007**	–0.027***
	(0.004)	(0.004)
Plant age 5–9 years	0.000	–0.003
	(0.014)	(0.018)
Plant age 10–14 years	0.004	–0.003
	(0.014)	(0.019)
Plant age 15–19 years	–0.011	–0.010
	(0.014)	(0.019)
Plant age $\geqslant$ 20 years	0.001	–0.014
	(0.013)	(0.017)
Share of skilled workers	–0.046***	0.009
	(0.014)	(0.018)
Share of apprentices	0.191***	0.068
	(0.043)	(0.055)
Share of part-time workers	0.039**	–0.020
	(0.019)	(0.023)
Share of female workers	0.022	–0.018
	(0.018)	(0.022)
Exporting activity	–0.015**	0.001
	(0.007)	(0.009)
Log Likelihood	–6734.7	–4731.3
Number of observations	18,826	12,498

Notes: IAB Establishment Panel, 1999–2016. The dependent variable is a dummy variable that indicates a switch in the product market setting in the respective direction for two consecutive observations of the same plant. Reported numbers are average marginal effects with standard errors clustered at the plant level in parentheses. ***/**/* denotes statistical significance at the 1%/5%/10% level. Further covariates included in all specifications are region dummies, two-digit sector dummies, and a dummy for a single-plant company.

C Measuring employer wage premia and surplus

To measure employer wage premia and plant surplus, we follow Card *et al.* (2018) and Hirsch and Mueller (2020). Our measure of wage premia builds on the two-way fixed-effects decomposition by AKM, which splits up a worker's individual wage into a worker-specific and a plant-specific component. Specifically, the log wage of worker m in period t is decomposed as:

$$\ln W_{mt} = \eta_m + \theta_{i(m,t)} + \mathbf{X}'_{mt}\boldsymbol{\beta} + \upsilon_{mt} \tag{C.1}$$

In (C.1), η_m is a permanent log wage component specific to worker m, $\theta_{i(m,t)}$ is a permanent log wage component specific to plant i employing worker m at time t, $\mathbf{X}'_{mt}\boldsymbol{\beta}$ is a time-varying log wage component stemming from time-varying worker characteristics $\mathbf{X}_{mt}$ that are rewarded equally across plants, and υ_{mt} is an idiosyncratic log wage component.

In the AKM framework, η_m reflects the worker's permanent human capital, such as education and ability, $\mathbf{X}'_{mt}\boldsymbol{\beta}$ mirrors the worker's time-varying human capital, such as experience, that affects the worker's productivity no matter where the job is held, and $\theta_{i(m,t)}$ is the percentage wage premium paid to every worker of plant i. The crucial assumption for this interpretation of the AKM decomposition to hold is that the idiosyncratic log wage component υ_{mt} is unrelated to the sequence of employers $\{i(m,t)\}_t$, for which Card *et al.* (2013) provide supporting evidence in their AKM-type wage decomposition for Germany. For a critical assessment of the validity of the AKM framework in the U.S. context, we refer to Lamadon *et al.* (2019).

To measure the plant surplus to be split between employers and workers, we follow Abowd and Lemieux (1993) and use the quasi rent per worker, with the plant's quasi rent Υ_{it} being defined as:

$$\Upsilon_{it} = P_{it}Q_{it} - J_{it}M_{it} - \overline{R}_{it}K_{it} - \overline{W}_{it}N_{it} \tag{C.2}$$

That is, the quasi rent Υ_{it} is revenues $P_{it}Q_{it}$ net of the value of intermediate inputs $J_{it}M_{it}$

and capital inputs $\overline{R}_{it}K_{it}$, where $\overline{R}_{it}$ denotes the competitive rental rate of capital, and net of labour inputs priced at workers' alternative wage $\overline{W}_{it}N_{it}$.[16]

When constructing workers' alternative wage $\overline{W}_{it}$ we follow Abowd and Allain (1996) and calculate workers' outside option as:

$$\ln \overline{W}_{it} = \overline{\ln W}_{st} + (\eta_{it} - \bar{\eta}_{st}) - (\bar{\theta}_{st} - \theta_{st}^{p10}) \tag{C.3}$$

In (C.3), $\overline{\ln W}_{st}$ is the average log wage (i.e. plant-level payroll per worker) in the respective first-digit sector s, η_{it} is the average AKM worker wage effect in plant i, $\bar{\eta}_{st}$ is the average AKM worker wage effect, $\bar{\theta}_{st}$ is the average AKM plant wage effect, and θ_{st}^{p10} its 10th percentile in the one-digit sector. The term $\eta_{it} - \bar{\eta}_{st}$ captures the deviation in worker quality between plant i and the sector average and thus accounts for unobserved quality differences between plants' workforces. Moreover, subtracting the spread between the average AKM plant effect and its 10th percentile $\bar{\theta}_{st} - \theta_{st}^{p10}$ in the respective one-digit sector accounts for the influence of wage premia paid by future employers on workers' current alternative wage. Specifically, we assume that risk averse workers expect to receive just a modest pay premium at the 10th percentile when switching employers. As detailed in Hirsch and Mueller (2020), this way of constructing workers' alternative wage involves quite some decisions, and out of these some may seem somewhat arbitrary. Yet, as also discussed there, in general different choices, such as using the 25th percentile of wage premia rather than the 10th percentile, make only little difference.

[16] Note that we compute the competitive rental rate of capital $\overline{R}_{it}$ from the plant's capital stock and in so doing distinguish between prices for debt and equity at the two-digit sector level because the IAB data do not contain such information at the plant level. Specifically, we use the information on the "cost of equity and capital" for Europe issued by Aswath Damodaran on 5th January 2019 at `http://pages.stern.nyu.edu/~adamodaran` and the 10-year long-term treasury bond rate for Germany to calculate the average rental rate of capital at the two-digit sector. Our average rental rate of capital is 9.9% for the years 1998–2004, 9.0% for 2005–2010, and 6.9% for 2011–2016.

References

Abowd, J. M. and Allain, L. (1996), 'Compensation Structure and Product Market Competition', *Annales d'Économie et de Statistique*, 11(41/42): 207–217.

Abowd, J. M., Kramarz, F., and Margolis, D. N. (1999), 'High Wage Workers and High Wage Firms', *Econometrica*, 67(2): 251–333.

Abowd, J. M. and Lemieux, T. (1993), 'The Effects of Product Market Competition on Collective Bargaining Agreements: The Case of Foreign Competition in Canada', *Quarterly Journal of Economics*, 108(4): 983–1014.

Acemoglu, D. and Autor, D. (2011), 'Skills, Tasks and Technologies: Implications for Employment and Earnings', in D. Card and O. C. Ashenfelter, eds., *Handbook of Labor Economics,* vol. 4b, pp. 1043–1170, Amsterdam: Elsevier.

Ackerberg, D. A., Caves, K., and Frazer, G. (2015), 'Identification Properties of Recent Production Function Estimators', *Econometrica*, 83(6): 2411–2451.

Addison, J. T. (2009), *The Economics of Codetermination: Lessons from the German Experience*, New York: Palgrave Macmillan.

Addison, J. T., Portugal, P., and Varejão, J. (2014), 'Labor Demand Research: Toward a Better Match between Better Theory and Better Data', *Labour Economics*, 30(1): 4–11.

Addison, J. T., Schnabel, C., and Wagner, J. (2001), 'Works Councils in Germany: Their Effects on Establishment Performance', *Oxford Economic Papers*, 53(4): 659–694.

Addison, J. T., Teixeira, P., and Zwick, T. (2010), 'German Works Councils and the Anatomy of Wages', *Industrial and Labor Relations Review*, 63(2): 247–270.

Azar, J., Marinescu, I., and Steinbaum, M. (2021), 'Labor Market Concentration', *Journal of Human Resources*, forthcoming.

Bachmann, R. and Frings, H. (2017), 'Monopsonistic Competition, Low-Wage Labour Markets, and Minimum Wages – An Empirical Analysis', *Applied Economics*, 49(51): 5268–5286.

Behrens, M. (2009), 'Still Married after All These Years? Union Organizing and the Role of Works Councils in German Industrial Relations', *Industrial and Labor Relations Review*, 62(3): 275–293.

Bellmann, L., Lochner, B., Seth, S., and Wolter, S. (2020), AKM Effects for German Labour Market Data, FDZ-Methodenreport 01/2020, Institute for Employment Research, Nuremberg.

Benmelech, E., Bergman, N., and Kim, H. (2021), 'Strong Employers and Weak Employees: How Does Employer Concentration Affect Wages?', *Journal of Human Resources*, forthcoming.

Berger, D. W., Herkenhoff, K. F., and Mongey, S. (2019), Labor Market Power, NBER Working Paper No. 25719, National Bureau of Economic Research, Cambridge, MA.

Bernard, A. B., Jensen, J. B., Redding, S. J., and Schott, P. K. (2007), 'Firms in International Trade', *Journal of Economic Perspectives*, 21(3): 105–130.

Bernard, A. B., Jensen, J. B., Redding, S. J., and Schott, P. K. (2012), 'The Empirics of Firm Heterogeneity and International Trade', *Annual Review of Economics*, 4(1): 283–313.

Bond, S., Hashemi, A., Kaplan, G., and Zoch, P. (2020), Some Unpleasant Markup Arithmetic: Production Function Elasticities and their Estimationfrom Production Data, NBER Working Paper No. 27002, National Bureau of Economic Research, Cambridge, MA.

Booth, A. L. (2014), 'Wage Determination and Imperfect Competition', *Labour Economics*, 30(1): 53–58.

Brooks, W. J., Kaboski, J. P., Li, Y. A., and Qian, W. (2019), Exploitation of Labor? Classical Monopsony Power and Labor's Share, NBER Working Paper No. 25660, National Bureau of Economic Research, Cambridge, MA.

Cameron, A. C. and Trivedi, P. K. (2005), *Microeconometrics: Methods and Applications*, New York: Cambridge University Press.

Card, D., Cardoso, A. R., Heining, J., and Kline, P. (2018), 'Firms and Labor Market Inequality: Evidence and Some Theory', *Journal of Labor Economics*, 36(S1): S13–S70.

Card, D., Heining, J., and Kline, P. (2013), 'Workplace Heterogeneity and the Rise of West German Wage Inequality', *Quarterly Journal of Economics*, 128(3): 967–1015.

Council of Economic Advisors (2016), Labor Market Monopsony: Trends, Consequences, and Policy Responses, Issue Brief October 2016, Council of Economic Advisors, Washington, DC.

Crépon, B., Desplatz, R., and Mairesse, J. (2005), 'Price-Cost Margins and Rent Sharing: Evidence from a Panel of French Manufacturing Firms', *Annales d'Économie et de Statistique*, 20(79/80): 583–610.

De Loecker, J., Goldberg, P. K., Khandelwal, A. K., and Pavcnik, N. (2016), 'Prices, Markups, and Trade Reform', *Econometrica*, 84(2): 445–510.

Dobbelaere, S. and Kiyota, K. (2018), 'Labor Market Imperfections, Markups and Productivity in Multinationals and Exporters', *Labour Economics*, 53(1): 198–212.

Dobbelaere, S., Kiyota, K., and Mairesse, J. (2015), 'Product and Labor Market Imperfections and Scale Economies: Micro-Evidence on France, Japan and the Netherlands', *Journal of Comparative Economics*, 43(2): 290–322.

Dobbelaere, S., Lauterbach, R., and Mairesse, J. (2016), 'Micro-Evidence on Product and Labor Market Regime Differences between Chile and France', *International Journal of Manpower*, 37(2): 229–252.

Dobbelaere, S. and Luttens, R. I. (2016), 'Gradual Collective Wage Bargaining', *Labour Economics*, 40(1): 37–42.

Dobbelaere, S. and Mairesse, J. (2013), 'Panel Data Estimates of the Production Function and Product and Labor Market Imperfections', *Journal of Applied Econometrics*, 28(1): 1–46.

Dobbelaere, S. and Mairesse, J. (2018), 'Comparing Micro-Evidence on Rent Sharing from Two Different Econometric Models', *Labour Economics*, 52(1): 18–26.

Doraszelski, U. and Jaumandreu, J. (2018), 'Measuring the Bias of Technological Change', *Journal of Political Economy*, 126(3): 2973–3016.

Dustmann, C., Ludsteck, J., and Schönberg, U. (2009), 'Revisiting the German Wage Structure', *Quarterly Journal of Economics*, 124(2): 843–881.

Eberle, J., Jacobebbinghaus, P., Ludsteck, J., and Winter, J. (2011), Generation of Time-Consistent Industry Codes in the Face of Classification Changes: Simple Heuristic Based on the Establishment History Panel (BHP), FDZ-Methodenreport 05/2011, Institute for Employment Research, Nuremberg.

Ellguth, P. and Kohaut, S. (2017), 'Tarifbindung und betriebliche Interessenvertretung: Aktuelle Ergebnisse aus dem IAB-Betriebspanel 2016', *WSI Mitteilungen*, 70(4): 278–286.

Ellguth, P. and Kohaut, S. (2018), 'Tarifbindung und betriebliche Interessenvertretung: Aktuelle Ergebnisse aus dem IAB-Betriebspanel 2017', *WSI Mitteilungen*, 71(4): 299–306.

Ellguth, P., Kohaut, S., and Möller, I. (2014), 'The IAB Establishment Panel – Methodological Essentials and Data Quality', *Journal for Labour Market Research*, 47(1): 24–41.

Falch, T. and Strøm, B. (2007), 'Wage Bargaining and Monopsony', *Economics Letters*, 94(2): 202–207.

Félix, S. and Portugal, P. (2016), Labor Market Imperfections and the Firm's Wage Setting Policy, IZA Discussion Paper No. 10241, IZA Institute of Labor Economics, Bonn.

Firpo, S., Fortin, N. M., and Lemieux, T. (2009), 'Unconditonal Quantile Regressions', *Econometrica*, 77(3): 953–973.

Fitzenberger, B., Kohn, K., and Lembcke, A. C. (2013), 'Union Density and Varieties of Coverage: The Anatomy of Union Wage Effects in Germany', *Industrial and Labor Relations Review*, 66(1): 169–197.

Freeman, R. B. and Lazear, E. P. (1995), 'An Economic Analysis of Works Councils', in J. Rogers and W. Streeck, eds., *Works Councils: Consultation, Representation, and Cooperation in Industrial Relations,* Chicago, IL: University of Chicago Press.

Guertzgen, N. (2009), 'Rent-sharing and Collective Bargaining Coverage: Evidence from Linked Employer-Employee Data', *Scandinavian Journal of Economics*, 111(2): 323–349.

Hall, R. E. (1988), 'The Relation between Price and Marginal Cost in U.S. Industry', *Journal of Political Economy*, 96(5): 921–947.

Helpman, E. (2006), 'Trade, FDI, and the Organization of Firms', *Journal of Economic Literature*, 44(3): 589–630.

Hirsch, B. (2016), 'Gender Wage Discrimination: Does the Extent of Competition in Labor Markets Explain Why Female Workers Are Paid Less than Men?', *IZA World of Labor*, 310: 1–10.

Hirsch, B., Jahn, E. J., Manning, A., and Oberfichtner, M. (2021), 'The Urban Wage Premium in Imperfect Labor Markets', *Journal of Human Resources*, forthcoming.

Hirsch, B. and Mueller, S. (2020), 'Firm Wage Premia, Industrial Relations, and Rent Sharing in Germany', *Industrial and Labor Relations Review*, 73(5): 1119–1146.

Hirsch, B., Schank, T., and Schnabel, C. (2010), 'Differences in Labor Supply to Monopsonistic Firms and the Gender Pay Gap: An Empirical Analysis Using Linked Employer-Employee Data from Germany', *Journal of Labor Economics*, 28(2): 291–330.

Hirsch, B. and Schnabel, C. (2014), 'What Can We Learn from Bargaining Models about Union Power? The Decline in Union Power in Germany, 1992–2009', *Manchester School*, 82(3): 347–362.

Jung, S. and Schnabel, C. (2011), 'Paying More than Necessary? The Wage Cushion in Germany', *Labour*, 25(2): 182–197.

Karabarbounis, L. and Neiman, B. (2014), 'The Global Decline of the Labor Share', *Quarterly Journal of Economics*, 129(1): 61–103.

Kikkawa, A. K., Dhyne, E., and Magerman, G. (2019), Imperfect Competition in Firm-to-Firm Trade, Working Paper No. 363, National Bank of Belgium, Brussels.

Klette, T. J. (1999), 'Market Power, Scale Economies and Productivity: Estimates from a Panel of Establishment Data', *Journal of Industrial Economics*, 47(4): 451–476.

Kohaut, S. and Schnabel, C. (2003), 'Tarifverträge – nein danke!? Ausmaß und Einflussfaktoren der Tarifbindung west- und ostdeutscher Betriebe', *Journal of Economics and Statistics*, 223(3): 312–331.

Lamadon, T., Mogstad, M., and Setzler, B. (2019), Imperfect Competition, Compensating Differentials and Rent Sharing in the U.S. Labor Market, mimeo, University of Chicago.

Levinsohn, J. A. and Melitz, M. J. (2006), Productivity in a Differentiated Products Market Equilibrium, mimeo, Princeton University.

Manning, A. (2011), 'Imperfect Competition in the Labor Market', in D. Card and O. C. Ashenfelter, eds., *Handbook of Labor Economics,* vol. 4B, pp. 973–1041, Amsterdam: Elsevier.

Manning, A. (2021), 'Monopsony in Labor Markets: A Review', *Industrial and Labor Relations Review*, forthcoming.

McDonald, I. M. and Solow, R. M. (1981), 'Wage Bargaining and Employment', *American Economic Review*, 71(5): 896–908.

Melitz, M. J. (2003), 'The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity', *Econometrica*, 71(6): 1695–1725.

Morlacco, M. (2019), Market Power in Input Markets: Theory and Evidence from French Manufacturing, mimeo, University of Southern California.

Mueller, S. (2008), 'Capital Stock Approximation Using Firm Level Panel Data: A Modified Perpetual Inventory Approach', *Journal of Economics and Statistics*, 228(4): 357–371.

Nickell, S. J. and Andrews, M. (1983), 'Unions, Real Wages and Employment in Britain 1951–79', *Oxford Economic Papers*, 35(Supplement): 183–206.

Oberfichtner, M. and Schnabel, C. (2019), 'The German Model of Industrial Relations: (Where) Does It Still Exist?', *Journal of Economics and Statistics*, 239(1): 5–37.

Raval, D. (2020), Testing the Production Approach to Markup Estimation, mimeo, Federal Trade Commission.

Rinz, K. (2021), 'Labor Market Concentration, Earnings Inequality, and Earnings Mobility', *Journal of Human Resources*, forthcoming.

Soares, A. C. (2020), 'Price-Cost Margin and Bargaining Power in the European Union', *Empirical Economics*, 59(5): 2093–2123.

Sokolova, A. and Sorensen, T. (2021), 'Monopsony in Labor Markets: A Meta-Analysis', *Industrial and Labor Relations Review*, forthcoming.

Stole, L. A. and Zwiebel, J. (1996), 'Intra-Firm Bargaining under Non-Binding Contracts', *Review of Economic Studies*, 63(3): 375–410.

Webber, D. (2015), 'Firm Market Power and the Earnings Distribution', *Labour Economics*, 35(1): 123–134.

Wooldridge, J. M. (2010), *Econometric Analysis of Cross Section and Panel Data*, Cambridge, MA: MIT Press, 2nd ed.