Centralized vs. Decentralized Wage Formation: The Role of Firms' Production Technology*

Boris Hirsch[a], Christian Merkl[b], Steffen Mueller[c], and Claus Schnabel[d]

Abstract: This paper investigates theoretically and empirically how firms' production technology affects the choice of their preferred wage formation regime. Our theoretical framework predicts, first, that the larger the total factor productivity of a firm, the more likely it is to opt for centralized wage formation where it can hide behind less productive firms. Second, the larger a firm's scale elasticity, the higher its incentive to choose centralized rather than decentralized wage setting due to labor cost and straitjacket effects. As firms in Germany are allowed to choose their wage formation regime, we confront these two predictions with representative establishment data for West Germany. We find that establishments with centralized bargaining agreements indeed have economically and statistically significantly larger total factor productivities and scale elasticities than comparable establishments outside the centralized bargaining regime.

JEL-Classification: J50

Keywords: collective bargaining, bargaining coverage, Germany

* We would like to thank Christian Haefke, Jörg Lingens, Dennis Snower, two anonymous referees, and the editor for useful suggestions. We further appreciate the comments received from participants in the EALE 2014 conference in Ljubljana and seminar participants in Kiel, Nuremberg, and Würzburg.

[a] University of Erlangen–Nuremberg, Chair of Labour and Regional Economics, and IZA, Lange Gasse 20, 90403 Nuremberg, Germany, email: boris.hirsch@fau.de

[b] University of Erlangen–Nuremberg, Chair of Macroeconomics, Kiel Institute for the World Economy, and IZA, Lange Gasse 20, 90403 Nuremberg, Germany, email: christian.merkl@fau.de

[c] Halle Institute for Economic Research, Kleine Märkerstraße 8, 06108 Halle (Saale), Germany, steffen.mueller@iwh-halle.de

[d] University of Erlangen–Nuremberg, Chair of Labour and Regional Economics, and IZA, Lange Gasse 20, 90403 Nuremberg, Germany, email: claus.schnabel@fau.de

1 Introduction

Although collective bargaining at different levels is the predominant wage formation mechanism in most continental European and various other countries, the economic rationale for alternative bargaining regimes is not fully understood yet. From a macroeconomic perspective, Calmfors and Driffill (1988) show in a seminal paper that centralized wage bargaining agreements may internalize various types of externalities that arise from decentralized wage setting at firm level since bargaining parties at central level cannot escape negative macroeconomic effects such as unemployment (see also Danthine and Hunt, 1994). If the gains from such an internalization are sufficiently large, centralization will emerge as the preferred wage-setting arrangement (for a review of this strand of literature, see Flanagan, 2003). Boeri and Burda (2009) argue from an institutional perspective that in countries with larger firing costs collective bargaining agreements rather than decentralized wage setting may be the preferred option for a large share of workers and firms.

But why is it that in a country with the same institutions applying to all actors some firms choose to be part of a centralized collective bargaining agreement while others do not? A number of papers have tried to interpret the preferred level of wage setting as an explicit decision by individual firms, taking into account various aspects such as transaction costs and employee voice, asymmetric information, flexibility in work organization and pay, dampening competition by imposing similar wages, and power factors (see, e.g., Ramaswamy and Rowthorn, 1993; Freeman and Gibbons, 1995; Lindbeck and Snower, 2001; Arrowsmith *et al.*, 2003; Zagelmeyer, 2004; Willman *et al.*, 2007). In this microeconomic perspective, those firms for which the advantages of decentralization (such as tailoring wages to the specific situation of the firm, higher employer bargaining power, and increased firm flexibility) outweigh the amenities of traditional centralized bargaining (such as lower transaction costs and taking wages out of competition) opt for decentralized wage setting at the firm level (Schnabel *et al.*, 2006).

Our paper contributes to the literature by offering new theoretical hypotheses how heterogeneous production technology across firms affects their choice for centralized or

decentralized wage formation. In our theoretical model (Section 2), we argue that firms with larger total factor productivity and larger scale elasticities are *ceteris paribus* more likely to opt for centralized wage formation. We assume that the centralized wage does not react to firm-specific outcomes but is rather based on some industry average or some other aggregate reference point.[1] This allows us to show three theoretical effects which affect firms' choice of the optimal wage formation regime.

First, under centralized wage formation firms with larger total factor productivity have the possibility to hide behind the sector-level average ("hide effect"). Thus, those firms' profitability increases.[2] Second, for a given wage (e.g. determined by centralized wage formation) a firm with a larger scale elasticity faces lower labor costs per unit of production ("labor cost effect"). Thus, a larger scale elasticity makes it more likely that firms prefer centralized over decentralized wage formation, as the latter takes this larger scale elasticity into account.

Third, while all previous effects have been derived in an entirely static environment, there is an additional dynamic effect. When firms are subject to aggregate fluctuations and face some short-run price rigidity, scale elasticities matter even more.[3] Under centralized bargaining, the wage will not respond to firm-specific circumstances and thus firms face a steeper marginal cost curve (in terms of firm-specific output) than under decentralized wage formation. Hence, a centralized bargaining agreement may form a straitjacket to firms in dealing with firm-specific demand shocks.[4] As the scale elasticity determines the

---

1 Of course, even under centralized bargaining firms may have some room for manoeuvre to cut wages if they pay wages above the level stipulated in the centralized agreement or if they can make use of an opening clause enabling them to cut contract wages by a small amount in cases of emergency (given union approval). All we need for our argument to hold is that this room for manoeuvre is rather limited and smaller than under decentralized wage formation, and this is clearly the case in Germany (see Jung and Schnabel, 2011; Ellguth *et al.*, 2014*a*).

2 Boeri and Burda's (2009) model hypothesizes that firms which employ workers in the upper part of the skill distribution would prefer the collective bargaining agreement. Although the outcome of Boeri and Burda's and our model may be observationally equivalent under some circumstances, the economic rationale is very different. In addition, we provide an empirical test and condition on the skill composition of firms' workforces.

3 For evidence in favor of short-run price rigidities in the Euro zone, see for example Altissimo *et al.* (2006).

4 This result is complementary to the theoretical results by Jimeno and Thomas (2013) who show that sectoral-level bargaining agreements and the associated wage compression lead to higher unemployment. In contrast to us, Jimeno and Thomas use a search and matching model with idiosyncratic shocks and do not model different production technologies explicitly.

steepness of the marginal costs curve, which becomes flat as the elasticity approaches unity, this "straitjacket effect" plays a lesser role the larger the scale elasticity and even vanishes for firms with constant returns to scale. Similar to the "labor cost effect", the "straitjacket effect" makes it more likely for firms with larger scale elasticities to opt for centralized wage formation.

Thus, our simple theoretical model unambiguously predicts that firms with larger total factor productivity and larger scale elasticities are *ceteris paribus* more likely to opt for centralized bargaining. We argue that German institutions offer an exceptional case for an empirical investigation of these predictions (Section 3). German labor law allows firms to choose whether they want to be part of a centralized collective bargaining agreement or not, and we present evidence that although a large number of firms are covered by multi-employer agreements at sectoral level, many firms prefer wage setting at the firm level.

We confront our theory with data from the IAB Establishment Panel (Section 4), a representative annual survey of about 16,000 German establishments with information on firms' bargaining status as well as on revenues/value added, labor input, and investment. Fixed-effects estimations of production functions for the period 1996 to 2010 confirm our two theoretical hypotheses. First, establishments which are covered by centralized bargaining agreements at sectoral level have substantially larger scale elasticities, i.e. the estimated sum of the coefficients of a Cobb–Douglas production function is economically and statistically significantly different from that of establishments which choose some local arrangement at firm level (either firm-level bargaining or individual wage setting). Second, establishments with a larger total factor productivity are significantly more likely to be covered by centralized bargaining.

Our results are important for several reasons. Our simple theoretical framework (supported by the empirical evidence for Germany) offers a systematic and intuitive answer for how production technologies and wage formation mechanisms interact.[5] Furthermore,

[5] That (changes in) work organization and technology may play a role for collective bargaining agreements has been noted before. See, e.g., Lindbeck and Snower (2001) who stress the increasing importance of multi-tasking favoring decentralized wage setting. Ortigueira (2013) argues that equipment-specific technical progress and equipment–skill complementarity combined with the

since in Germany firms may choose their preferred bargaining regime (and may thus opt out of centralized bargaining as recommended by Jimeno and Thomas, 2013), this provides interesting insights for other countries where opting out of the centralized wage formation regime is not possible (yet). Our work suggests that opting out is particularly important for firms and sectors with low total factor productivity and low scale elasticities.

2 Theoretical Model

We provide a model that allows us to analyze firms' rationale to determine wages on the centralized or decentralized level. We assume that firms are heterogeneous in terms of their production functions (i.e. they differ in terms of the total factor productivity and the scale elasticity) and that the production function is fixed for a firm's entire life span. Thus, technology is a primitive of the economy and impossible to change for an existing firm. There are various reasons why heterogeneous firms with different production functions (e.g. high and low productivity firms) may coexist, such as segmented submarkets, deviations from perfect competition on the product market, convex costs of attracting additional workers, or overhead costs that increase convexly with firm size. However, a detailed analysis of the coexistence and entry/exit of different technology firms is beyond the scope of our paper. Instead, we analyze the rationale of firms with different production technologies to be part of a centralized bargaining agreement. This corresponds well to our empirical approach where we investigate whether the bargaining regimes chosen by firms with different production technologies follow the patterns predicted by our model.

Suppose a firm producing a good from its homogenous labor input with $q = an^{\alpha}$, where $0 < \alpha \leq 1$ denotes its scale elasticity and a its total factor productivity. We further assume that the firm supplies its good under monopolistic competition and that it faces a CES demand function for its good with $q(p) = (p/P)^{-\eta}Q$, where $\eta > 1$ denotes the elasticity of substitution, p the firm's price, and capital letters aggregate variables. To produce some quantity q, the firm needs labor input $n(q) = (q/a)^{1/\alpha}$ and pays real labor costs $w_R(q)n(q)$, where $w_R(q)$ is the real wage paid by the firm depending on the wage-setting regime R.

unemployment benefit program have affected centralized wage bargaining in Sweden.

Hence, the firm's real profits in regime R at price p are

$$\pi(p) = \frac{p}{P}q(p) - w_R(q(p))n(q(p)) = \left(\frac{p}{P}\right)^{1-\eta}\frac{Q}{P} - w_R(q(p))\left[\left(\frac{p}{P}\right)^{-\eta}\frac{Q}{a}\right]^{\frac{1}{\alpha}}. \tag{1}$$

With respect to the real wage paid by the firm we consider two polar cases: Either the firm chooses to be covered by a centralized bargaining agreement, or wages are set decentrally at the firm level (either with a union or directly with employees). Under centralized bargaining, we assume the wage is some fixed

$$w_C(q) = \bar{w} \tag{2}$$

and therefore does not react to firm-specific circumstances. The underlying assumption is that the firm is small relative to the entire sector, so that the centralized wage is set outside the firm reflecting some weighted average of the productivities of the firms inside the centralized bargaining agreement.[6]

In contrast, under decentralized wage formation we assume the real wage to be a weighted average of the firm's average revenue product of labor (in real terms) and some fixed amount b, i.e.

$$w_D(q) = \gamma\frac{\eta-1}{\eta}an(q)^{\alpha-1} + (1-\gamma)b = \gamma\frac{\eta-1}{\eta}a\left(\frac{q}{a}\right)^{\frac{\alpha-1}{\alpha}} + (1-\gamma)b \tag{3}$$

with $0 < \gamma < 1$. This wage rule readily follows from a standard bargaining setup in which the employer and workers bargain over the firm's returns, workers' outside option amounts to some b, and γ determines how returns are split.[7] Other than under centralized wage

[6] We are agnostic on how the wage $\bar{w}$ in the sectoral agreement emerges. The crucial assumption needed for our argument to hold is that the centralized wage depends less on a single firm's productivity than the wage under decentralized wage setting. For Germany, Gürtzgen (2009) provides empirical evidence that centralized wage bargaining is associated with a lower responsiveness of wages to firm-specific conditions than local wage setting.

[7] It is also easy to modify the wage rule to have bargaining over the marginal returns of an additional worker, in which case we had that the wage is a weighted average of the marginal revenue product and the worker's fallback position. Doing so would not change the model's predictions qualitatively as we will briefly describe in Appendix A.1.

formation, the decentralized wage does react to firm-level demand conditions with

$$w'_D(q) = \gamma \frac{\eta - 1}{\eta} \frac{\alpha}{1 - \alpha} \left(\frac{q}{a}\right)^{\frac{\alpha - 1}{\alpha}} < 0 = w'_C(q). \tag{4}$$

Consider now the choice of the firm whether to join a centralized bargaining agreement. Obviously, the firm will choose the wage formation regime that yields higher profits. Hence, the firm compares its profits π_C and π_D resulting under optimal price setting in both regimes. These follow from maximizing real profits (1) with respect to the price p. The first-order condition of this problem states

$$\begin{aligned} \pi'(p_R) = (1 - \eta) \left(\frac{p_R}{P}\right)^{-\eta} \frac{Q}{P} + \frac{\eta}{\alpha} w_R(q(p_R)) \left[\left(\frac{p_R}{P}\right)^{-\eta} \frac{Q}{a}\right]^{\frac{1}{\alpha}} \frac{1}{p_R} \\ + w'_R(q(p_R)) \left(\frac{p_R}{P}\right)^{-\eta} \frac{Q}{p_R} \left[\left(\frac{p_R}{P}\right)^{-\eta} \frac{Q}{a}\right]^{\frac{1}{\alpha}} = 0 \end{aligned} \tag{5}$$

or, after substituting in $q_R = (p_R/P)^{-\eta} Q$ and some simple algebraic manipulations,

$$p_R = \frac{\eta}{\eta - 1} \left[\frac{a w_R(q_R)}{\alpha} \left(\frac{q_R}{a}\right)^{\frac{1 - \alpha}{\alpha}} + w'_R(q_R) \left(\frac{q_R}{a}\right)^{\frac{1}{\alpha}}\right] P. \tag{6}$$

Since the firm supplies its good under conditions of monopolistic competition, we obtain the well-known result that the price is a constant mark-up over the firm's marginal costs which are given by the latter terms of the right-hand side of (6).

We now turn to a firm that is indifferent between the two wage formation regimes. Since the firm supplies under conditions of monopolistic competition and since indifference to regimes requires equal profits across regimes, this firm must charge the same prices and thus encounter the same marginal costs and produce the same quantities under centralized and decentralized wage formation, i.e. $p^* = p_D = p_C$ and $q^* = q_D = q_C$. Hence,

$$p^* = \frac{\eta}{\eta - 1} \left[\frac{a w_R(q^*)}{\alpha} \left(\frac{q^*}{a}\right)^{\frac{1 - \alpha}{\alpha}} + w'_R(q^*) \left(\frac{q^*}{a}\right)^{\frac{1}{\alpha}}\right] P. \tag{7}$$

Our core question now is: How does the firm's decision over bargaining regimes change if its production technology exhibits an incrementally larger total factor productivity a or

scale elasticity α. To arrive at unambiguous results, we will in the following abstract from the (empirically uninteresting and irrelevant) case with $q^*/a = n^\alpha < 1$, i.e. $n < 1$, and thus impose that the firm employs at least one worker. In the following, we will distinguish three different effects of production technology on the firms' decision to join centralized bargaining which we term (i) the "hide effect", (ii) the "labor cost effect", and (iii) the "straitjacket effect". In the main text, we will just provide intuitions for these three effects while we give formal proofs of our findings in the appendix.[8]

First, consider a production technology with a larger total factor productivity a. Intuitively, if a is larger, this will lead to lower marginal costs at the given production q^* as the term in brackets in equation (7) gets smaller. The firm optimally responds by lowering prices and extending output. However, since $w'_C = 0 > w'_D$, the drop in the firm's price, the rise in its output, and the resulting increase in its profits are more pronounced under centralized wage formation where the wage does not respond to a larger productivity level of the firm. Hence, centralized bargaining becomes more attractive, *ceteris paribus*. Put differently, centralized wage formation allows a high-productivity firm to hide behind the centralized wage, and we thus refer to this effect as the "hide effect".[9]

Second, consider a production technology with a larger scale elasticity α. If α is larger, this will again lead to lower marginal costs at the given q^*. And again, the resulting drop in prices and expansion in output and profits are more pronounced under centralized bargaining. Intuitively, this happens because a larger scale elasticity as well increases the wage under decentralized bargaining (3) as makes it less responsive to firm-specific output, i.e. its derivative with respect to output (4) falls in absolute value.

Third, when additionally allowing for fluctuating output, there is also a "straitjacket effect" related to the convexity of the firm's cost function. To illustrate this effect, assume

---

[8] Note that the firm's optimal price is a function of firm-specific marginal costs, which in turn depend on the price (under decreasing returns to scale). We take this repercussion into account in our formal derivations of the "hide effect" and the "labor cost effect" in Appendices A.1 and A.2 by applying the implicit function theorem.

[9] Although we are probably the first to formally model this "hide effect", the possibility of hiding behind a centralized agreement oriented towards the less productive (and usually smaller) firms in an industry has been recognized before in the industrial relations literature (see, e.g., Kohaut and Schnabel, 2003). In a case study of a large firm in the German metalworking industry, Arrowsmith *et al.* (2003) report that the firm is committed to centralized bargaining because it feels that the powerful metalworkers' union would achieve more when bargaining at the firm level.

that at the beginning of the period the indifferent firm sets some optimal price p^* according to an intertemporal price-setting rule.[10] Now suppose that the firm faces mean-zero random demand shocks the periods thereafter that cause the firm's output q to deviate from the profit-maximizing output. Since the wage does not respond to firm-specific demand shocks under centralized bargaining, firm-specific marginal costs are steeper under centralized than under decentralized wage formation (see Appendix A.3). When random demand rises, costs increase by more under centralized than under decentralized wage formation. Although the costs under centralized bargaining also drop by more when the firm is hit by a negative demand shock, according to Jensen's inequality the expected costs under centralized bargaining, where costs are more convex, increase by more than under decentralized wage formation.

Consequently, introducing demand fluctuations causes the indifferent firm to opt out the centralized bargaining agreement. In a nutshell, the "straitjacket effect" states that centralized bargaining agreements put additional costs on firms when coping with firm-specific fluctuating demand. Yet, the "straitjacket effect" plays a lesser role if the scale elasticity is larger because the magnitude of α determines the steepness of the marginal costs curve. The larger α, the flatter are marginal costs. Further, if α is unity, marginal costs will be flat in both wage formation regimes, so that the "straitjacket effect" vanishes for firms with constant returns to scale. Hence, the "straitjacket effect" and the "labor cost effect" point at the same direction, that is firms with a higher scale elasticity are more prone to opt for centralized wage bargaining, *ceteris paribus*.

Taken together, we can derive the following two hypotheses.[11] (i) We expect firms

[10] In the working paper version, we show the optimal price-setting rule when the firm sets the optimal price according to a Taylor (1980) price rigidity (and omit the analytical derivations here for brevity). All that is needed for the logic behind the "straitjacket effect" to hold is that empirically firm-level prices do not adjust every period, and this is corroborated by the data (see, e.g., Altissimo *et al.*, 2006, for Europe).

[11] Note that our model abstracts from fixed transaction costs that are likely to be involved in bargaining. If these were the same across wage formation regimes, incorporating these would be trivial. Yet, if they differed across regimes—and the most realistic case seems to be that transaction costs involved in centralized bargaining are lower than with decentralized wage formation—, this would complicate matters a lot without offering additional insights. The reason for this is that once transaction costs are smaller under centralized bargaining the indifferent firm will charge smaller prices under decentralized wage formation involving smaller marginal costs as well as larger output levels to make up for larger transaction costs. While this would not change the logic behind our three effects, deriving these would get considerably more intricate.

opting for centralized bargaining to show a higher average scale elasticity for two reasons. First, the higher is the scale elasticity, the lower are marginal costs under centralized bargaining relative to decentralized wage setting and the more attractive centralized bargaining gets ("labor cost effect"). Second, the higher is the scale elasticity, the flatter is the firm's marginal cost curve and, therefore, the less likely it is that a centralized bargaining agreement becomes a straitjacket under fluctuating firm-level demand ("straitjacket effect"). (ii) We expect firms opting for centralized bargaining to have a higher average total factor productivity. This holds because centralized bargaining is more attractive for high-productivity firms as the bargained wage reflects some weight of productivities of those firms within the agreement ("hide effect"). These two hypotheses will be confronted with German establishment data in Section 4.

It could be argued, though, that centralized bargaining may form a straitjacket in even another sense, i.e. when it comes to recruiting high-ability workers suitable to perform a complex mix of tasks. In this case, centralized agreements may prevent firms from offering adequate pay packages to these workers (Lindbeck and Snower, 2001). If high-ability workers and firm productivity are complements, this restraint will provide an incentive for high-productivity firms to stay out of centralized bargaining, potentially offsetting the "hide effect". However, within the German institutional framework, detailed in the next section, collectively set wages are lower bounds only and firms are free to pay higher wages to individual workers, which is particularly prevalent for high-ability workers (Jung and Schnabel, 2011). Therefore, we do not think this effect to play much of a role in the German context.

3 Institutional Background

In Germany, the constitutionally protected principle of bargaining autonomy gives (organizations of) employers and employees the right to regulate wages and working conditions without state interference. Firms have three options for wage setting: First, they may apply collective agreements negotiated at sectoral level between employers associations and trade unions. While these sectoral negotiations mostly take place in

regional bargaining districts, the regional negotiations within one sector are closely coordinated by the officials of the appropriate sectoral trade union and employers association, so that variations between them are small. Collectively agreed norms are minimum terms, which means that firms covered by collective agreements cannot undercut upon these terms and conditions (unless specifically allowed to do so in "opening clauses" for cases of emergency whose enactment typically needs union approval). Second, firms may conduct bargaining at firm level with a union (but not with a works council), resulting in a firm-specific agreement. Collective agreements at firm or sectoral level are legally binding and they are usually applied to the entire workforce in a firm or sector, not only to union members. Third, firms may decide not to make use of collective bargaining and rather lay down their wages and working conditions in labor contracts settled individually with employees.

In terms of our theoretical model, the first option (i.e. a collective agreement at sectoral level) is equivalent to centralized collective bargaining that does not take account of firm characteristics and conditions. Options 2 and 3 represent two ways of decentralized wage formation, by negotiating either with a union or directly with employees, which both enable firms to tailor wages and working conditions to their specific economic situation. Note that even if a strong union and a heavily unionized workforce coerce a firm to conclude a collective agreement, the firm is still free to choose either a sector-level or a firm-level agreement, in such a way opting for centralized or decentralized wage setting. In contrast, even if its workforce is not heavily unionized (yet) a highly productive and profitable firm may choose to join a centralized collective agreement and hide there in order to avoid that its workforce starts unionizing and extracting firm-specific rents.

The presence and coverage of these three bargaining regimes in our sample are shown in Table 1 based on information on West Germany from the representative IAB Establishment Panel described below.[12] It can be seen that in 2010, the final year of

[12] We concentrate on West Germany since post-communist East Germany has a completely different history of wage formation where the state was setting wages and no collective or individual bargaining was possible. Related to this, it is unclear whether the transformation process of East Germany from a socialist planned economy to a market economy was completed in the early years covered by our data. Even today bargaining coverage is substantially lower in East than in West Germany (see Ellguth and Kohaut, 2012).

our investigation, sectoral-level collective agreements applied in about 33 percent of establishments in the private sector, covering 53 percent of employees. Coverage rates of employees are higher than those of establishments since larger plants are more likely to make use of sectoral collective bargaining. Single-employer collective agreements at firm level were found in just 2 percent of establishments, employing about 7 percent of workers. 65 percent of plants and 40 percent of employees were not covered by a collective agreement, which means that their wages and working conditions were laid down in individual contracts. Coverage rates are a little bit higher in manufacturing which will be in the focus of our empirical analysis. These numbers indicate that unlike the situation in the US or the UK, collective bargaining in Germany is still mainly conducted at the sectoral level (although wage setting at the firm level is gaining ground).[13]

Table 1: Collective bargaining coverage in West Germany (percentage of establishments and employees covered in 2010)

Establishment size interval	Sector-level collective agreement		Firm-level collective agreement		No collective agreement	
(number of employees)	Private Sector	Manu-facturing	Private Sector	Manu-facturing	Private Sector	Manu-facturing
Less than 50	31.3	31.6	1.8	1.7	66.9	66.7
50 to 199	53.4	38.7	8.2	8.5	38.4	52.9
200 and above	66.5	65.7	10.6	12.6	22.9	21.8
All establishments	32.6	33.4	2.2	2.7	65.2	63.9
All employees	52.6	56.7	7.4	10.8	40.0	32.5

Notes: The data set used is the 2010 wave of the IAB Establishment Panel, own calculations using weighted data.

[13] For a comparison and analysis of collective bargaining structures in Germany and Britain, see Schnabel *et al.* (2006).

4 Empirical Analysis

4.1 Data

We use the IAB Establishment Panel provided by the Institute for Employment Research (*Institut für Arbeitsmarkt- und Berufsforschung*, IAB) of the German Federal Employment Agency (*Bundesagentur für Arbeit*).[14] This is a representative sample of plants (not companies) that employ at least one worker covered by social security at the 30th June of a year and comprises all sectors of the German economy. Each year since 1993 (1996), the IAB Establishment Panel has surveyed several thousand plants in West (East) Germany. Response rates of plants which have been interviewed repeatedly exceed 80 percent. The data are collected on the basis of a questionnaire and personal interviews with the owner or managers. We will use information on the number of workers, value added (defined as sales minus the costs of intermediate inputs), capital stock, workforce composition, coverage by sectoral or firm-level collective wage agreements, works council existence, the plant's age and legal status, being a single plant, and exporting activity.[15]

As information on collective bargaining coverage is fragmentary in the earlier panel waves, we use data encompassing the years 1996 to 2011. Each wave of interviews provides retrospective information on value added in the previous year. Hence, we run our regressions for the years 1996 to 2010. To end up with a sample of comparable plants (in terms of production technology, industrial relations, and the interpretation of value added), we focus on manufacturing plants only. Table 2 shows definitions and descriptive statistics for plants making use of centralized sector-level bargaining or of decentralized local bargaining (comprising firm-level agreements and no collective agreements).

4.2 Returns to Scale

We investigate our first hypothesis that plants covered by centralized bargaining agreements have larger scale elasticities by running some standard productivity

[14] Details about the data are given by Kölling (2000) and Ellguth *et al.* (2014*b*).
[15] Capital stock is approximated using the approach outlined in Mueller (2008, 2010).

Table 2: Descriptive statistics for the regression sample

	Centralized bargaining		Decentralized wage formation	
Variable description	Mean	St.dev.	Mean	St.dev.
Log value added	15.84	2.26	14.75	1.87
Log employment	4.90	1.83	3.98	1.56
Log capital stock	15.70	2.52	14.46	2.15
Percentage of skilled workers	62.48	22.68	57.57	25.55
Percentage of part-time workers	8.75	12.69	12.62	16.30
Percentage of apprentices	4.88	6.04	4.00	5.57
Young plant (< 5 years)	0.02	0.15	0.05	0.21
Single plant	0.63	0.48	0.82	0.38
Limited Liability	0.79	0.40	0.79	0.41
Exporter	0.66	0.48	0.63	0.48
Observations	7,452		4,946	

Notes: The data set used is the IAB Establishment Panel, 1996–2010. Establishments are West German manufacturing plants.

regressions. To estimate returns to scale, we use the regression

$$\log y_{it} = \beta_1 \log n_{it} + \beta_2 \log k_{it} + \mathbf{x}'_{it}\boldsymbol{\gamma} + a_i + e_t + \varepsilon_{it}, \tag{8}$$

where y_{it} denotes the value added of firm i in period t, n_{it} its total employment, and k_{it} its capital stock. Since log employment and log capital enter (8) linearly, we arrive at a Cobb–Douglas specification. Furthermore, $\mathbf{x}_{it}$ is a vector of controls comprising the percentages of skilled workers, part-time workers, and apprentices, a_i is a plant fixed effect, e_t is a year fixed effect, and ε_{it} is the idiosyncratic error component.

The panel character of our data allows us to take unobserved time-invariant plant heterogeneity into account, such as differences in management quality. To get rid of any biases that may stem from such heterogeneity, we estimate equation (8) using a fixed-effects within estimator. This estimator uses deviations from the within plant mean of all variables to identify regression parameters. The major advantage of this procedure is

that the plant fixed effect cancels out so that any correlation between a_i and explanatory variables will not bias results. We removed all plants that were observed only once during our observation period.

Table 3: Returns to scale from fixed-effects regressions

Establishment size interval	Bargaining regime		
(# employees)	All	Centralized	Decentralized
All	0.75* [0.70,0.79]	0.85* [0.78,0.92]	0.63* [0.56,0.70]
Less than 50	0.57* [0.51,0.64]	0.61* [0.50,0.72]	0.57* [0.47,0.66]
50 to 199	0.79* [0.71,0.88]	0.82* [0.68,0.95]	0.81* [0.68,0.91]
200 and above	0.96 [0.87,1.04]	1.00 [0.90,1.09]	0.45* [0.22,0.68]

Notes: The data set used is the IAB Establishment Panel, 1996–2010. Establishments are West German manufacturing plants. Results are based on equation (8) and control variables include year dummies and the percentages of skilled workers, part-time workers, and apprentices. * denotes statistically significant differences to constant returns to scale at the 5 percent level. 95 percent confidence intervals are shown in brackets.

Table 3 presents estimates of plants' returns to scale (i.e. $\beta_1 + \beta_2$) in the manufacturing sector for subsamples of plants distinguished by bargaining coverage and plant size. As can be seen from the first row of Table 3, plants covered by centralized bargaining have higher returns to scale than those with decentralized wage formation. Plants' scale elasticity is 0.85 under centralized bargaining but just 0.63 under decentralized wage formation (i.e. under firm-level agreements or individual bargaining).[16] As confidence intervals do not overlap, we regard this difference as statistically significant. In line with our theoretical expectations, firms covered by centralized bargaining have higher returns to scale and

[16] We are not the first to find decreasing returns to scale for German plants. Also applying a fixed-effects estimator within a Cobb–Douglas framework for the manufacturing sector but using a different data set, Harhoff (1998) finds scale elasticities around 0.73 (see the coefficients of $\log(L)$ in his Table 3). We also acknowledge the possibility that measurement error might have attenuated our coefficient estimates and, therefore, the estimated level of scale elasticities for both bargaining regimes. However, since our theory only requires us to find a difference in scale elasticities across regimes, the level effect of measurement error is unlikely to play much of a role here.

thus flatter marginal cost curves than firms with decentralized wage formation. As the further rows of Table 3 make clear, this finding holds true for all plant size categories though differences between wage formation regimes are only statistically significant for large plants with at least 200 employees.

4.3 Total Factor Productivity

In a next step, we test whether plants with a higher total factor productivity are more likely to be covered by centralized bargaining, as suggested by our second hypothesis. We estimate a probit model regressing an indicator for being covered by such an agreement on the estimated plant fixed effect a_i from equation (8) reflecting plant i's total factor productivity.[17] As controls we include various standard variables found to matter for firms' wage formation regime in earlier studies (see Schnabel *et al.*, 2006; Addison *et al.*, 2013; Capuano *et al.*, 2014): plant size, workforce composition (percentages of skilled and part-time workers as well as apprentices), plant age, being part of a multi-plant firm, legal form, exporter status, and 15 dummies for two-digit industry.

As Table 4 presenting average partial effects makes clear, plants with larger total factor productivity are indeed significantly more likely to be covered by centralized bargaining. In line with theory, a 10 percent larger total factor productivity is associated with a 1.1 percentage points larger probability of such an agreement when not controlling for other determinants of plants' wage formation regime (model 1). When we include the variables found to be associated with centralized bargaining in previous studies, the coefficients of these controls are statistically highly significant and in line with the literature (model 2). Even then, the average partial effect of an increase in total factor productivity by 10 percent still amounts to 0.4 percentage points and is statistically significant at the 5 percent level.[18] This suggests that productivity is an additional, hitherto neglected factor

[17] Interpreting the fixed effect a_i as plant i's total factor productivity is standard in the literature on plant productivity. Of course we are aware that differences in plants' fixed effects may also reflect unobserved differences in output prices (Griliches and Mairesse, 1999).

[18] A related exercise distinguishes between plants always or never observed to have centralized bargaining (alwaystakers/nevertakers), plants that opted out/in (leavers/joiners), and those with irregular patterns (miscellaneous) and estimates a multinomial logit explaining the choice between these five time-invariant categories using TFP and the full set of covariates as in Table 4. Average marginal effects show that a 10 percent increase in total factor productivity increases the propensity

associated with plants' choice of a wage formation mechanism.

To scrutinize our results, we further perform some checks of robustness: We exclude (i) the crisis years 2009 and 2010 to see whether our results are driven by unusual

Table 4: Probit regression for the probability of being covered by centralized bargaining

	Model 1	Model 2
Total factor productivity	0.113**	0.037*
	(0.011)	(0.016)
50–199 employees	—	0.062*
		(0.026)
At least 200 employees	—	0.226**
		(0.032)
Percentage of skilled workers	—	0.001**
		(0.000)
Percentage of part-time workers	—	–0.003**
		(0.001)
Percentage of apprentices	—	0.007**
		(0.001)
Young plant (< 5 years)	—	–0.110**
		(0.029)
Single plant	—	–0.118**
		(0.021)
Limited liability	—	–0.082**
		(0.022)
Exporter	—	–0.107**
		(0.021)
Dummies for 15 sectors	—	✓
Observations	12,398	

Notes: The data set used is the IAB Establishment Panel, 1996–2010. Establishments are West German manufacturing plants. The dependent variable is 1 if the plant is covered by a sector-level collective agreement and 0 otherwise. Total factor productivity is the estimated plant fixed effect from regression model (8). Reported numbers are average partial effects. **/* denotes statistical significance at the 1/5 percent level. Standard errors are clustered at the plant level.

to be an alwaystaker *ceteris paribus* by 0.4 percentage points but decreases the propensity to be a nevertaker (leaver) by 0.2 (0.1) percentage points. All these effects are statistically significant at the 1 percent level. For joiners we obtain a small and economically irrelevant negative effect (–0.05 percentage points), which is identified by just 17 plants and therefore arguably of limited validity. All in all these patterns are in line with the predictions of our model.

economic conditions; (ii) plants belonging to multi-plant firms as the decision to join a collective wage agreement is made at the firm level, which may cloud the relation to local plant conditions in multi-plant firms; and (iii) small plants with no more than ten employees as for them employment protection legislation did not apply in the later years of our analysis. Both our estimates for the scale elasticities (for all subgroups) and our estimates using total factor productivity to explain the bargaining regime are robust to these checks. The only exception refers to excluding plants belonging to multi-plant firms in the regressions presented in Table 4. Though we still obtain a positive and highly significant marginal effect in model 1 of Table 4, the effect in model 2 remains positive but now turns insignificant. However, additionally excluding very small plants (with no more than 10 workers) recovers the significant marginal effect of 0.04 presented in model 2 of Table 4 (detailed results are available on request).

5 Conclusions

Our paper has provided a fresh perspective on firms' optimal choice of the wage formation regime focussing on heterogeneities in production technology. We show, first, that the more productive a firm, the larger is the incentive to opt for centralized wage formation. The reason is that centralized wages will be based on the average industry productivity or some other reference group but not on firm-specific productivity. Thus, highly productive firms can hide behind less productive firms and thus increase their profitability ("hide effect"). Second, the larger the scale elasticity of a firm, the larger is the incentive to opt for centralized wage formation. For a given wage, a firm with a larger scale elasticity faces lower labor costs per unit of production. Yet, the larger scale elasticity also leads to a larger decentralized wage that partly offsets the cost savings, and thus decentralization gets less attractive to the firm ("labor cost effect"). Third, under fluctuating demand and some form of short-run price rigidity, there is an additional "straitjacket effect". As the centralized wage is unresponsive to firm-specific demand shocks, firms face steeper marginal costs under centralized bargaining, and demand fluctuations raise the (intertemporal) average costs to a larger extent than under decentralized wage formation. Yet, the larger the scale

elasticity, the flatter are marginal cost curves, and the less important the "straitjacket effect" gets. As with the "labor cost effect", a larger scale elasticity renders centralized bargaining more attractive.

Our simple model provides some new answers to the long-standing question why within a country some firms choose to be part of a centralized bargaining agreement while others do not. A typical example is Germany where labor law allows firms to choose their preferred wage formation mechanism, offering a unique opportunity to check our hypotheses with German data. Fixed-effects estimations of production functions for establishments with different wage formation choices show that establishments that are covered by centralized sector-level agreements have significantly larger scale elasticities than establishments that opted for decentralized wage formation. In addition, we find that plants with a larger total factor productivity are more likely to be covered by a bargaining agreement at sectoral level, *ceteris paribus*. Both patterns are consistent with our model's hypotheses and suggest that production technology is an additional, previously neglected determinant of firms' choice of a wage bargaining regime.

Although there exist quite a few macroeconomic, microeconomic, and institutional explanations of alternative wage setting regimes that are not fundamentally questioned by our insights, economists so far know relatively little about the interaction of firms' production technology and wage formation mechanisms. Our paper has come up with a simple theory and documented some new and interesting facts. We provide a formal theoretical connection between production technology and the preferred wage formation regime and document the corresponding empirical patterns. Although our data and research design just allow us to identify partial correlations rather than causal relationships, our findings may serve as a starting point for future research. From a theoretical perspective, the model framework can certainly be extended (e.g. by including entry and exit of firms with different production technologies). We expect our key theoretical insights to be unaffected qualitatively. From an empirical perspective, it is certainly of interest whether similar patterns can be found in other countries, particularly those where the process of wage formation has considerably changed over time (e.g. the UK) or has been reformed recently (e.g. Spain).

A Appendix

In this appendix, we formally derive the "hide effect", the "labor cost effect", and "the straitjacket effect". We will do so by analyzing the change in the indifferent firm's profits under either centralized or decentralized wage formation following from a different production technology (i.e. a production technology involving larger total factor productivity a or a larger scale elasticity α) or from introducing firm-specific demand shocks. If profits increase more (or drop less) in one of the regimes, we will conclude that the indifferent firm will turn to this rather than the alternative regime.

A.1 Hide effect

To show the "hide effect" related to a production technology involving a larger a, first note that the decentralized wage and its derivative are given by (3) and (4), respectively. Hence, the optimal price p_D satisfying equation (6) is, substituting in $q_D = (p_D/P)^{-\eta}Q$,

$$\begin{aligned} p_D &= \frac{\eta}{\eta-1}\left[\frac{aw_D(q_D)}{\alpha}\left(\frac{q_D}{a}\right)^{\frac{1-\alpha}{\alpha}} + w_D'(q_D)\left(\frac{q_D}{a}\right)^{\frac{1}{\alpha}}\right] \\ &= \frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}(1-\gamma)b\left(\left(\frac{p_D}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}} + \gamma\frac{\eta-1}{\eta}\right]P. \end{aligned} \tag{A.1}$$

In our baseline specification, decentralized wage formation the wage-setting rule contains the average revenue product. Note that if decentralized bargaining were over the marginal returns of an additional worker, the real wage would a weighted average of the marginal revenue product (in real terms) and the worker's fallback position,

$$w_D(q) = \gamma\frac{\eta-1}{\eta}\alpha a n(q)^{\alpha-1} + (1-\gamma)b = \gamma\frac{\eta-1}{\eta}\alpha a\left(\frac{q}{a}\right)^{\frac{\alpha-1}{\alpha}} + (1-\gamma)b. \tag{A.2}$$

As a result, the last term in brackets in equation (A.1) would be $\alpha\gamma\frac{\eta-1}{\eta}$ rather than $\gamma\frac{\eta-1}{\eta}$. This change, however, would not alter any of the following results qualitatively.

In contrast, under centralized bargaining $w_C(q) = \bar{w}$, $w'_C(q) = 0$, and thus

$$\begin{aligned} p_C &= \frac{\eta}{\eta-1}\left[\frac{a w_C(q_C)}{\alpha}\left(\frac{q_C}{a}\right)^{\frac{1-\alpha}{\alpha}} + w'_C(q_C)\left(\frac{q_C}{a}\right)^{\frac{1}{\alpha}}\right] \\ &= \frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}\bar{w}\left(\left(\frac{p_C}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\right]. \end{aligned} \tag{A.3}$$

Define the following constant functions reflecting the equilibrium price-setting conditions in the respective wage formation regime $R = C, D$

$$\Psi_D(p_D) \equiv \frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}(1-\gamma)b\left(\left(\frac{p_D}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}} + \gamma\frac{\eta-1}{\eta}\right]P - p_D \equiv 0, \tag{A.4}$$

$$\Psi_C(p_C) \equiv \frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}\bar{w}\left(\left(\frac{p_C}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\right]P - p_C \equiv 0. \tag{A.5}$$

Applying the implicit function theorem for the indifferent firm which charges the same price in both regimes, i.e. $p_C = p_D = p^*$, we obtain

$$\left.\frac{\partial p_D}{\partial a}\right|_{p_D=p^*} = -\frac{\frac{\partial \Psi_D(p^*)}{\partial a}}{\frac{\partial \Psi_D(p^*)}{\partial p_D}} = -\frac{\frac{1}{\alpha}\frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1-\alpha}{\alpha}}}{\alpha}(1-\gamma)b\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\right]P}{\eta\frac{1-\alpha}{\alpha}\frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}(1-\gamma)b\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\frac{P}{p^*}\right]+1}, \tag{A.6}$$

$$\left.\frac{\partial p_C}{\partial a}\right|_{p_C=p^*} = -\frac{\frac{\partial \Psi_C(p^*)}{\partial a}}{\frac{\partial \Psi_C(p^*)}{\partial p_C}} = -\frac{\frac{1}{\alpha}\frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1-\alpha}{\alpha}}}{\alpha}\bar{w}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\right]P}{\eta\frac{1-\alpha}{\alpha}\frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}\bar{w}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\frac{P}{p^*}\right]+1}, \tag{A.7}$$

which are both unambiguously negative. Note that both derivatives are identical, except for $\bar{w}$ displacing $(1-\gamma)b$ and *vice versa*. Defining $A \equiv \frac{1}{\alpha}\frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1-\alpha}{\alpha}}}{\alpha}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\right]P$ and $B \equiv \eta\frac{1-\alpha}{\alpha}\frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\frac{P}{p^*}\right]$ and noting that the centralized bargaining agreement cannot plausibly yield wages below workers' fallback option b, so that $\bar{w} > (1-\gamma)b$ necessarily holds, we get

$$\begin{aligned} \left.\frac{\partial p_C}{\partial a}\right|_{p_C=p^*} - \left.\frac{\partial p_D}{\partial a}\right|_{p_D=p^*} &= -\frac{\bar{w}A}{\bar{w}B+1} + \frac{(1-\gamma)bA}{(1-\gamma)bB+1} \\ &= -\frac{[\bar{w}-(1-\gamma)b]A}{(\bar{w}B+1)[(1-\gamma)bB+1]} < 0. \end{aligned} \tag{A.8}$$

Consequently, the price drops to a larger extent under centralized bargaining than under decentralized wage formation.

The final step is to note that the larger price drop yields higher profits under centralized *vis-à-vis* decentralized wage formation. As can be shown formally (though we do not do so here for the sake of brevity), if p_C drops by more than p_D, we must have that marginal costs under centralized wage formation fall more than marginal costs under decentralized wage formation (because under monopolistic competition prices are a constant mark-up over firm-specific marginal costs). Since marginal revenues (at the optimal quantity) are the same for the two wage formation regimes and since the price elasticity of demand η is above unity, the larger drop in marginal costs under centralized wage formation must yield higher revenues and also higher profits.

A.2 Labor cost effect

To demonstrate the "labor cost effect" related to a production technology involving a larger α, we again apply the implicit function theorem on the two regime-specific price-setting conditions (A.4) and (A.5), evaluating these for the indifferent firm with $p_C = p_D = p^*$,

$$\left.\frac{\partial p_D}{\partial \alpha}\right|_{p_D=p^*} = -\frac{\frac{\partial \Psi_D(p^*)}{\partial \alpha}}{\frac{\partial \Psi_D(p^*)}{\partial p_D}} = \frac{(1-\gamma)b\frac{\partial}{\partial \alpha}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}P\right]}{\eta\frac{1-\alpha}{\alpha}\frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}(1-\gamma)b\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\frac{P}{p^*}\right]+1}, \tag{A.9}$$

$$\left.\frac{\partial p_C}{\partial \alpha}\right|_{p_C=p^*} = -\frac{\frac{\partial \Psi_C(p^*)}{\partial \alpha}}{\frac{\partial \Psi_C(p^*)}{\partial p_C}} = \frac{\bar{w}\frac{\partial}{\partial \alpha}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}P\right]}{\eta\frac{1-\alpha}{\alpha}\frac{\eta}{\eta-1}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}\bar{w}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}\frac{P}{p^*}\right]+1}. \tag{A.10}$$

Note that we have $\frac{a^{-\frac{1}{\alpha}}}{\alpha}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}} = \frac{1}{\alpha}\left(\frac{q^*}{a}\right)^{\frac{1}{\alpha}}\frac{1}{q^*}$ with $q^*/a = (n^*)^\alpha \geq 1$ because we abstract from the irrelevant case where the firm employs less than one worker and impose $n^* \geq 1$. Therefore, the sign of the derivative in the two numerators is unambiguous with $C \equiv \frac{\partial}{\partial \alpha}\left[\frac{a^{-\frac{1}{\alpha}}}{\alpha}\left(\left(\frac{p^*}{P}\right)^{-\eta}Q\right)^{\frac{1-\alpha}{\alpha}}P\right] = \frac{\partial}{\partial \alpha}\left[\frac{1}{\alpha}\left(\frac{q^*}{a}\right)^{\frac{1}{\alpha}}\frac{P}{q^*}\right] < 0$ and the optimal price drops in both wage formation regimes if α rises. As with the "hide effect", both derivatives are identical, except for $\bar{w}$ displacing $(1-\gamma)b$ and *vice versa*. Rewriting the two derivatives in

terms of $B \equiv \eta^{\frac{1-\alpha}{\alpha}} \frac{\eta}{\eta-1} \left[\frac{a^{-\frac{1}{\alpha}}}{\alpha} \left(\left(\frac{p^*}{P} \right)^{-\eta} Q \right)^{\frac{1-\alpha}{\alpha}} \frac{P}{p^*} \right]$ and C and noting, again, that $\bar{w} > (1-\gamma)b$ must hold, we arrive at

$$\begin{aligned} \left. \frac{\partial p_C}{\partial \alpha} \right|_{p_C = p^*} - \left. \frac{\partial p_D}{\partial \alpha} \right|_{p_D = p^*} &= \frac{\bar{w}C}{\bar{w}B + 1} - \frac{(1-\gamma)bC}{(1-\gamma)bB + 1} \\ &= \frac{[\bar{w} - (1-\gamma)b]C}{(\bar{w}B + 1)[(1-\gamma)bB + 1]} < 0. \end{aligned} \tag{A.11}$$

Hence, the price drops to a larger extent under centralized bargaining than under decentralized wage formation, and centralized bargaining is more profitable for a larger α, *ceteris paribus*.

A.3 Straitjacket effect

The marginal costs (in real terms) of the indifferent firm charging $p_C = p_D = p^*$ are

$$mc_R(q) = \frac{a w_R(q)}{\alpha} \left(\frac{q}{a} \right)^{\frac{1-\alpha}{\alpha}} + w_R'(q) \left(\frac{q}{a} \right)^{\frac{1}{\alpha}}. \tag{A.12}$$

Depending on the wage formation regime we thus obtain

$$mc_D(q) = \gamma \frac{\eta - 1}{\eta} \left(\alpha^2 + \frac{\alpha - 1}{\alpha} \right) + \frac{a}{\alpha}(1-\gamma)b \left(\frac{q}{a} \right)^{\frac{1-\alpha}{\alpha}}, \tag{A.13}$$

$$mc_C(q) = \frac{a}{\alpha} \bar{w} \left(\frac{q}{a} \right)^{\frac{1-\alpha}{\alpha}}. \tag{A.14}$$

Differentiation of the respective marginal costs with respect to q yields

$$mc_D'(q) = \frac{1-\alpha}{\alpha^2}(1-\gamma)b \left(\frac{q}{a} \right)^{\frac{1-2\alpha}{\alpha}} > 0, \tag{A.15}$$

$$mc_C'(q) = \frac{1-\alpha}{\alpha^2} \bar{w} \left(\frac{q}{a} \right)^{\frac{1-2\alpha}{\alpha}} > 0, \tag{A.16}$$

if $\alpha < 1$, whereas both derivatives are zero under constant returns to scale with $\alpha = 1$. Hence, if $\alpha < 1$ we arrive at increasing marginal costs in both regimes, and since $\bar{w} > (1-\gamma)b$ marginal costs are steeper under centralized bargaining. All else the same, introducing fluctuating demand under decreasing returns to scale causes the indifferent

firm to opt for decentralized wage formation as it raises expected costs under centralized bargaining, where marginal costs are steeper, to a larger extent than under decentralized wage formation.

Our next question is: How does the steepness of the firm's marginal costs change if its production technology inhibits a larger α? If $\alpha < 1$, then

$$\frac{\partial}{\partial \alpha}\left[\frac{1-\alpha}{\alpha}^{2}\left(\frac{q}{a}\right)^{\frac{1-2\alpha}{\alpha}}\right] = \frac{\alpha(\alpha-2)-(1-\alpha)\ln(q/a)}{\alpha^{4}}\left(\frac{q}{a}\right)^{\frac{1-2\alpha}{\alpha}} < 0, \tag{A.17}$$

and $\bar{w} > (1-\gamma)b$, and thus a larger α causes a more pronounced drop in the steepness of the firm's marginal costs under centralized bargaining than under decentralized wage formation. Hence, the "straitjacket effect" plays less of a role if α is larger. Further, as marginal costs are flat in both regimes if $\alpha = 1$, the "straitjacket effect" is absent for firms with constant returns to scale.

References

Addison, J.T., Bryson, A., Teixeira, P., Pahnke, A., and Bellmann, L. (2013), 'The extent of collective bargaining and workplace representation: Transistions between states and their determinants. A comparative analysis of Germany and Great Britain,' *Scottish Journal of Political Economy*, **60**(2):182–209.

Altissimo, F., Bilke, L., Levin, A., Mathä, T., and Mojon, B. (2006), 'Sectoral and aggregate inflation dynamics in the Euro area,' *Journal of the European Economic Association (Papers and Proceedings)*, **4**(2/3):585–593.

Arrowsmith, J., Marginson, P., and Sisson, K. (2003), 'Externalisation and internalisation of collective bargaining in Europe: Variation in the role of large companies,' *Industrielle Beziehungen*, **10**(3):363–392.

Boeri, T. and Burda, M.C. (2009), 'Preferences for collective versus individualised wage setting,' *Economic Journal*, **119**(540):1440–1463.

Calmfors, L. and Driffill, J. (1988), 'Bargaining structure, corporatism and macroeconomic performance,' *Economic Policy*, **3**(6):13–61.

Capuano, S., Hauptmann, A., and Schmerer, H.J. (2014), Trade and unions: Can exporters benefit from collective bargaining?, Institut für Arbeitsmarkt- und Berufsforschung, Nuremberg, IAB Discussion Paper No. 24/2014.

Danthine, J.P. and Hunt, J. (1994), 'Wage bargaining structure, employment and economic integration,' *Economic Journal*, **104**(424):528–541.

Ellguth, P., Gerner, H.D., and Stegmaier, J. (2014*a*), 'Wage effects of works councils and opening clauses: The German case,' *Economic and Industrial Democracy*, **35**(1):95–113.

Ellguth, P. and Kohaut, S. (2012), 'Tarifbindung und betriebliche Interessenvertretung: Aktuelle Ergebnisse aus dem IAB-Betriebspanel 2011,' *WSI-Mitteilungen*, **65**(4):297–305.

Ellguth, P., Kohaut, S., and Möller, I. (2014*b*), 'The IAB Establishment Panel – methodological essentials and data quality,' *Journal for Labour Market Research*, **47**(1/2):27–41.

Flanagan, R.J. (2003), 'Collective bargaining and macroeconomic performance,' *in* J.T. Addison and C. Schnabel (eds.), 'International Handbook of Trade Unions,' pp. 172–196, Cheltenham: Edward Elgar.

Freeman, R.B. and Gibbons, R.S. (1995), 'Getting together and breaking apart: The decline of centralized collective bargaining,' *in* R.B. Freeman and L.F. Katz (eds.), 'Differences and Changes in Wage Structures,' pp. 345–370, Chicago and London: University of Chicago Press.

Griliches, Z. and Mairesse, J. (1999), 'Production functions: The search for identification,' *in* S. Strøm (ed.), 'Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium,' pp. 169–203, Cambridge: Cambridge University Press.

Gürtzgen, N. (2009), 'Rent-sharing and collective bargaining coverage: Evidence from linked employer–employee data,' *Scandinavian Journal of Economics*, **111**(2):323–349.

Harhoff, D. (1998), 'R&D and productivity in German manufacturing firms,' *Economics of Innovation and New Technology*, **6**(1):29–50.

Jimeno, J.F. and Thomas, C. (2013), 'Collective bargaining, firm heterogeneity and unemployment,' *European Economic Review*, **59**(1):63–79.

Jung, S. and Schnabel, C. (2011), 'Paying more than necessary? The wage cushion in Germany,' *Labour*, **25**(2):182–197.

Kohaut, S. and Schnabel, C. (2003), 'Zur Erosion des Flächentarifvertrags: Ausmaß, Einflussfaktoren und Gegenmaßnahmen,' *Industrielle Beziehungen*, **10**(2):193–219.

Kölling, A. (2000), 'The IAB-Establishment Panel,' *Schmollers Jahrbuch*, **120**(2):291–300.

Lindbeck, A. and Snower, D.J. (2001), 'Centralized bargaining and reorganized work: Are they compatible?' *European Economic Review*, **45**(10):1851–1875.

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.

——— (2010), Capital stock approximation with the perpetual inventory method: Stata code for the IAB Establishment Panel, Institut für Arbeitsmarkt- und Berufsforschung, Nuremberg, FDZ Methodenreport No. 02/2010.

Ortigueira, S. (2013), 'The rise and fall of centralized wage bargaining,' *Scandinavian Journal of Economics*, **115**(3):825–855.

Ramaswamy, R. and Rowthorn, R.E. (1993), Centralized bargaining, efficiency wages, and flexibility, International Monetary Fund, Washington, DC, IMF Working Paper No. 93/25.

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

Taylor, J.B. (1980), 'Aggregate dynamics and staggered contracts,' *Journal of Political Economy*, **88**(1):1–23.

Willman, P., Bryson, A., and Gomez, R. (2007), 'The long goodbye: New eestablishment and the fall of union voice in Britain,' *International Journal of Human Resource Management*, **18**(7):1318–1334.

Zagelmeyer, S. (2004), *Governance Structures and the Employment Relationship*, Berne and Oxford: Peter Lang.