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UNION DENSITY EFFECTS ON PRODUCTIVITY AND WAGES*

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We exploit changes in tax subsidies for union members in Norway to identify the effects of changes in firm-level union density on productivity and wages. Increased deductions in taxable income for union members led to higher membership rates and contributed to a lower decline in union membership rates over time in Norway. Accounting for selection effects and the potential endogeneity of unionisation, the results show that increasing union density at the firm level leads to a substantial increase in both productivity and wages. The wage effect is larger in more productive firms, consistent with rent-sharing models.

Do unions promote or hinder productivity growth? Theoretically, there are several reasons to support both views. Union rent seeking may impede capital investment, workers may shirk where unions provide insurance against dismissal, and union bargaining may be detrimental to manager–worker collaboration. On the other hand, unions may provide a 'voice' for workers, which improves information flows and increases tenure, raising the returns to firm investments in human capital, and local union bargaining may promote efficient provision of effort.

Empirically, it is difficult to identify the effect of unions on productivity. The drawbacks to the observational studies assessing union effects on firm performance are discussed in detail in Section 1, but the chief one is the absence of exogenous variance in unionisation required to draw causal inferences. Firms are often organised for reasons linked to their performance. First, union formation and membership may be highly dependent on the potential rents to be reaped, so it can pay more to invest in unionisation and membership in more productive firms. This may explain why unions tend to organise large, productive establishments early in their life-cycle (Dinlersoz, Greemwood and Hyatt, 2017). On the other hand, in firms facing downsizing or closure, the value of membership may also be high since unions tend to offer legal services and help with conflict resolution. Secondly, union members may be highly selected. Again, the direction of selection is not clear: less productive workers are more likely to queue for union jobs because they gain more from union efforts to standardise wages but, because the supply of union jobs exceeds demand for those jobs, employers can pick the best workers from

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those queueing for the union jobs (Abowd and Farber, 1982). Regardless of the direction of the selection, it has proven difficult to come up with a research design that convincingly deals with this problem.

To our knowledge, only DiNardo and Lee (2004), and the follow-up studies by Lee and Mas (2012), Frandsen (2012) and Sojourner *et al.* (2015) have offered credible evidence on causal effects, based on a quasi-experimental research design. They use a regression discontinuity design related to union recognition in the United States: we discuss their contributions in more detail below. We contribute to the literature using exogenous variance in the price of union membership to identify the effects of changes in firm union density on firm productivity and wages. We do so using data for Norwegian firms over the period 2001–12.

Exogenous shifts in the net price of union membership arise due to changes in the tax treatment of union membership. As with most normal goods, the demand for union membership (or the service this membership provides) is negatively related to its price, and thus the demand for union membership fluctuates with the size of tax subsidies. We know of no other studies using this source of exogenous price variance as a means of instrumenting for union membership. Note that while workers sort endogenously across firms, and occupational composition is endogenously determined by firms, the changes in tax treatment are exogenous to firms and as this affects each worker's demand for unionisation, it also induces exogenous variation in unionisation across firms.

We calculate the potential subsidy relative to the net union price—a subsidy ratio—for each individual worker in the economy and take the average for each firm based on the occupational composition of the firm at the start of our observation period. Subsequent values of the firm-specific subsidy ratio are then calculated using the tax treatment changes over time. The firm average of the subsidy ratio is used as an instrument for union density in our productivity and earnings regressions. Our instrument can be interpreted as an interaction between the subsidy amount (exogenously determined by the government) and the union membership fee (determined by the unions), and we control for the union membership fee in all our instrumental variables regressions. To ensure that we account for potential selection of workers into firms we also control for key characteristics of the workforce of the firm, and for average worker fixed effects from earnings regressions on individual workers.

We find that increases in union density lead to substantial increases in firm productivity having accounted for the potential endogeneity of unionisation. We find that unions claw back part of that additional productivity through a higher union wage premium, and that this premium is larger in more productive firms, which is consistent with rent sharing.

The remainder of the article is organised as follows. Section 1 briefly reviews the theoretical and empirical literature and elaborates on the role of union density and union institutions in helping to understand heterogeneity in union effects. Section 2 provides some information on the institutional context around unionisation and bargaining in Norway. Section 3 introduces a simple theoretical model of union membership. Section 4 describes the Norwegian tax system and the relationship with union membership. Section 5 describes our data. Section 6 outlines the empirical approach. Section 7 discusses the relationship between unionisation and union tax subsidies. Results and interpretations are presented in Section 8 before concluding in Section 9 with a discussion about the implications of the results for our understanding of union effects more generally.

1. Theory and Previous Empirical Literature

The literature exploring union effects on economic outcomes is one of the oldest and most extensive in economics. It goes back at least as far as Adam Smith's *The Wealth of Nations*, which he wrote in 1776. The bulk of the literature treats unions as labour cartels, intent on strengthening the bargaining power of their members by threatening the supply of labour to firms if employers prove unwilling to accede to their wage demands. As such, they have the potential to extract rents from employers resulting in the payment of above-market wages. As Adam Smith (1776, pp. 71–2) pointed out in *The Wealth of Nations*, employers are also liable to form cartels, not only to limit price competition, but also to offset union bargaining power.[1]

The wage outcome of union bargaining will depend on various factors. These include the relative bargaining power of the two parties, which, in turn, is related to potential conflict outcomes, the price elasticity of demand for labour, the elasticity of demand for labour with respect to capital, the substitutability of non-union for union labour and worker support for the union, usually captured by the percentage of workers who are union members. *Inter alia*, the economic implications of a bargained outcome for the firm depend on the intensity of market competition faced by the firm, the rents available to the firm and its ability to attract and retain labour. Nevertheless, on the assumption that worker bargaining power rises, on average, in the presence of trade unions, it seems reasonable to assume union bargaining will raise wages above the counterfactual market wage set at the intersection between labour supply and demand.

The implications of a union bargained wage for employment outcomes will depend, in part, on whether unions bargain solely over wages—as in the right-to-manage model in which employers set employment conditional on the union bargained wage (Oswald, 1982; Pencavel, 1984)—or over wages and employment simultaneously (efficient bargaining) leading to potentially Pareto efficient outcomes (McDonald and Solow, 1981; Hendricks and Kahn, 1991). Employment outcomes will also depend on what utility the union is seeking to maximise. The union will be cognisant of potential negative employment consequences where bargained wages are set 'too high'.

There are multiple channels by which trade unions may affect labour productivity, and these effects may cut in different directions. More able workers may queue for union jobs where they pay above market wages, a worker selection effect that may raise labour productivity in the union sector. If selected from the queue by a unionised employer an employee may be less likely to quit compared to a non-union scenario given the wage wedge between the union job and the employee's outside options, in turn affecting employers' propensity to invest in human capital. If unionised labour is more expensive than non-unionised labour this may induce employers to substitute capital for labour, leading to capital intensification that is productivity enhancing.

A separate channel is the union 'voice' effect, first identified by Freeman (1976) and Freeman and Medoff (1984), whereby unions aggregate and convey the preferences and knowledge of workers to management in a manner that can be more efficient than eliciting individual workers' voices, or failing to engage with workers at all.[2] While the voice effect depends on some

[1] Smith argues that 'Masters [employers] are always and everywhere in a sort of tacit, but constant and uniform, combination not to raise wages of labour above their actual rate . . . sometimes [they] enter into particular combinations to sink wages of labour even below this rate . . . Such combinations, however, are frequently resisted by a contrary defensive combination of workmen, who sometimes, too, without any provocation of any kind, combine, of their own accord, to raise the price of their labour' (Smith, 1776, pp. 71–2).

[2] Freeman and Medoff (1984) adapt Hirschman's (1970) exit-voice-loyalty model, originally used by Hirschman primarily to understand consumer preferences, to an employment relations setting, emphasising its productivity-enhancing potential, as well as increasing employer pay-offs to human capital investments as employees resort to voice over exit when confronting workplace problems.

formal organisational arrangements, such as institutionalised regular consultations, it does not necessarily depend on the existence of collective wage bargaining. In Germany, for instance, works councils are not involved in wage bargaining, but are found to be positively related to wages (Addison, Teixeira and Zwick, 2010) and productivity (Mueller, 2012).

Unions may also serve to alleviate agency problems in a similar way as performance pay schemes (Vroman 1990; Barth *et al.*, 2012), improve efficiency by reducing sub-optimal excessive hiring of workers (Bauer and Lingens, 2013) or provide efficient effort levels within a framework of local bargaining (Barth, Moene and Willumsen, 2014). Unions can also induce employers to invest in training, and thereby increase the productivity of workers (Acemoglu and Pischke, 1999; Dustmann and Schönberg, 2009).

Unions may also be detrimental to labour productivity. Wage-effort bargaining may result in the sub-optimal deployment of labour through 'restrictive practices' (Metcalf, 1989). Where union bargaining breaks down, resultant strike action or actions short of strikes, such as go-slows, may adversely affect productivity. Unions' ability to insure workers against arbitrary employer actions, while potentially conducive to job security and thus improvements in productivity, may also lead to workers taking unauthorised absences, or 'shirking' in other ways. Unions' ability to extract rents from new investments may lead to a 'hold-up' problem whereby investors, aware of the issue, may invest less than they might otherwise have done, leading to sub-optimal capital investments (Grout, 1984). In the worst case, investors may react adversely to the threat of unionisation, taking evasive action by investing in the non-union sector.

The empirical literature has, until recently, been dominated by Anglo–US studies in which sectoral bargaining is uncommon in the private sector and unions organise on a workplace-by-workplace or firm-by-firm basis. Consequently, the focus has been establishing the economic effects of unions obtaining bargaining rights at workplace level, and the bargaining strength of unions at workplace level, often proxied by the proportion of employees in membership.

There are four limitations to this literature. First, it is an empirical literature dominated by studies that identify the partial correlation between unionisation and economic outcomes, the assumption being that selection into union status is captured by observed features of the worker or, if panel data are available, by time-varying observed traits and time-invariant unobserved traits.[3] It has proven difficult to account for potentially endogenous selection into union status due to a lack of credible instruments. Secondly, most studies have relied on data collected from individual workers in household surveys such as the Current Population Survey (CPS) for the United States. Necessarily, these studies omit important features of the firm employing the workers, so that analysts have found it difficult to tackle biases associated with omitted variables influencing union status and the economic outcomes of interest. Studies using linked employer–employee data tend to find that the omission of these variables upwardly biases estimates of union effects on wages (Bryson, 2002; Blanchflower and Bryson, 2004).

Thirdly, limited availability of firm-level data has prevented analysts from undertaking workplace-level or firm-level analyses, thus limiting what analysts have been able to say about outcomes that are best investigated at this level, such as profitability.[4]

Fourthly, the particularities of the institutional setting characterising the liberal economies of the USA, the UK, Canada, Australia and other Anglo–US economies mean it is difficult to

[3] This is evident from Hirsch's (2004) review of the literature on unions and productivity.

[4] In principle, one can aggregate workers from worker-level data to construct firms where unique firm identifiers are available, but data are rarely available for the full population of workers in a firm and, in any case, such data rarely contain firm-level economic metrics other than wages.

know whether findings from those countries generalise to other settings characterised by more centralised and co-ordinated bargaining regimes. They may not read over directly since sectoral and national bargaining arrangements are likely to affect the costs and benefits of unionisation for specific firms. For example, the meta-studies of Doucouliagos and Laroche (2003) and Doucouliagos *et al.* (2017) reveal quite mixed evidence on the association between unions and productivity both between the Anglo–US economies and other countries, but also within these groups of countries (e.g., between the USA and the UK) and even between industries.[5]

The empirical regularities regarding the union wage premium stem from a literature that is dominated by observational studies capturing the partial correlation between union status and wages in cross-sectional data or, in some cases, the association between changes in union status and wages with panel data.[6] The union wage premium—or what might more appropriately be termed the union wage 'gap', to use Lewis's (1963; 1986) terminology—varies across groups of workers, over time, and is counter-cyclical (Lewis, op. cit.). Since union bargained wages apply to all covered workers, union bargained wages tend to be a public good rather than a private incentive good payable only to union members. Even so, studies often find a union wage premium among members in covered workplaces, which may partly reflect an upward bias associated with omitted variables affecting selection into membership status and wages, or else the effects of heterogeneous union bargaining power (Booth and Bryan, 2004). The latter arises where membership simply proxies higher union density, something that is not observed in studies which cannot link employees to the workplaces that employ them.

Unionisation also slows the rate of employment growth in workplaces. This finding, which Addison and Belfield (2004) termed the 'one constant' in the empirical union literature, when set alongside the persistence of a union wage premium, is consistent with right-to-manage models in which employers set employment levels conditional on the bargained wage. However, union effects are rarely sufficient to affect workplace survival (Bryson, 2004), suggesting either that unions seek to maximise the wage bill (some weighted function of wages and employment), that they successfully organise firms with surplus rents, or that wage effects are partially offset by productivity improvements.

Recently analysts in the United States have sought to identify the causal impact of union bargaining on workplace performance using a regression discontinuity design comparing economic outcomes in workplaces where the union vote just exceeded the majority threshold required for representation with workplaces where the vote felt just short of the required majority. Using this method, DiNardo and Lee (2004) find little impact of new unionisation on business survival, employment, output, productivity or wages over the period 1984–2001. When interpreting this result, one must bear three points in mind. First, the vote for representation captures an 'intention to treat' through union representation that does not always materialise in practice. This is because, under the US system, the majority vote requires the employer to negotiate with the newly formed union in good faith to arrive at new contractual terms and conditions. However, unions never get to 'first contract' in a high percentage of cases (Ferguson, 2008), suggesting that the regression discontinuity captures a lower bound estimate. Secondly, if union bargaining power is increasing in the demand for unionisation, as the literature on union density effects suggests, the margin just-being-unionised is likely to capture effects associated with weaker trade unions.

[5] On the other hand, the meta-studies yield quite a coherent picture on the relationship between unions and investments: these associations are negative.

[6] The latter have rarely considered the endogeneity of union switching but for an examination of the implications of union endogenous switching in relation to pay satisfaction, see Bryson and White (2016).

This is precisely what Lee and Mas (2012) find in a follow-up study that shows that, using an event study approach, the equity value of newly unionised firms drops markedly after 15–18 months—something that is not apparent using a regression discontinuity design. They reconcile results in Lee and Mas (2012) with those in DiNardo and Lee (2004) by showing that the negative relationship between cumulative abnormal returns and unionisation rises with the vote share in support of the union. The implication is that firms' owners have a strong expectation that new unionisation will have an impact on firms' economic performance, especially when union bargaining power is great.

Thirdly, unions are known to focus their attention on raising the wages of low earners, providing the rationale for Frandsen's (2012) quantile regression investigation. He uses the same regression discontinuity as DiNardo and Lee and Lee and Mas and finds large countervailing effects of new unionisation on wages in different parts of the wage distribution, with unions using their bargaining power to compress wages by increasing the wages of the lower paid and reducing the returns to skill at the top of the distribution. A recent paper using the same identification strategy found negative effects of unionisation on staffing levels in nursing homes but no effects on care quality, suggesting positive labour productivity effects (Sojourner *et al*., 2015).

In a number of European countries the vast majority of workers and firms are covered by collective bargaining. In Austria and France, for example, more than 95% of workers have their pay set directly through collective bargaining—often at national or sectoral level—or else collectively bargained rates are extended to them under statutory procedures (OECD, 2016; 2017). In other major European countries, coverage is lower, e.g., Germany (Fitzenberger, Kohn and Lembcke, 2013), but still higher than what one would expect from union density at the firm level.

Setting wages and terms and conditions at sectoral or national level necessarily involves the aggregation of firm and worker preferences above firm level. It is unclear, *a priori*, whether a bargained outcome set beyond the firm will operate to the benefit or disadvantage of a specific firm. It depends, in part, on where the firm sits in the firm wage hierarchy and on the firm's ability to withstand wage hikes. The bargained rate may be particularly beneficial to a firm where its competitors struggle to pay the new rate. At the macro level, sectoral and national bargaining are liable to compress wage dispersion since the uncovered sector is small, thus taking wages out of competition—at least at the lower end of the labour market, where the bargained rates bite—potentially minimising any adverse effects of bargained rates on firm performance.

The situation is more complicated in those countries where firms may be subject to national or sector bargained rates *and* local bargaining, at either firm or plant level. Often local bargaining builds on national or sector bargained rates. How they do so depends on the degree of co-ordination across bargaining levels, as studies have shown, but also on the bargaining strength of local unions and thus their ability to bid up wages beyond the centrally set wage.[7] Studies confirm the importance of union density at plant or firm level in these circumstances. For example, Breda (2015) shows that the union wage premium in France rises with workplace union density where the workplace has a high market share, consistent with workers extracting surplus rents via their local bargaining power. Fitzenberger *et al*. (2013) also find that union wage effects rise with union density in covered workplaces (although higher union density is associated with lower wages in uncovered firms).

The setting for our empirical investigation is Norway, a country in which firms may be covered by collective bargaining at local level (workplace or firm), sector level, national level

[7] For a review of this literature, see Bryson (2007).

or a combination of local and sector/national bargaining. We provide more institutional detail regarding unionisation and collective bargaining in Section 2. In contrast to France, where union membership is well below 10%, but in common with other Scandinavian countries, Norway has high levels of union membership. Half of all private sector employees are union members, while mean union density is 40% in private-sector workplaces (Bryson, Dale-Olsen and Barth, 2015).

Although wages rise for all Norwegian workers where workplace union density is higher (Bryson, Dale-Olsen and Nergaard, 2019), there is no evidence on the causal impact of union density on productivity and wages in Norway, and even studies of correlations are scarce. Barth, Naylor and Raaum (2000) and Balsvik and Sæthre (2014) provide evidence on the relationship between union density and wages. Both studies estimate that when union density increases by 10 percentage points then wages increase by 0.7–0.8%. Barth *et al*. (2000) point out that any effect of individual union membership disappears when adding controls for union density, which implies that the bargained wage at the workplace is a public good.

Unions are in secular decline. Membership has been falling for decades in much of the developed world (Schnabel, 2012; OECD, 2017), and collective bargaining is under threat, even in countries such as Germany where sectoral bargaining was previously regarded as a fixed feature of the economic landscape (Addison *et al*., 2011). Two salient facts go largely unnoticed in discussions of the economic implications of these changes. The first is that unions continue to procure a wage premium for covered employees both in Anglo-Saxon countries (Blanchflower and Bryson, 2007) and in Continental European countries such as France (Breda, 2015). Secondly, the negative correlation between unionisation and workplace or firm performance, apparent in the 1970s and 1980s (Metcalf, 1989; Hirsch, 2007), had largely disappeared by the 1990s—at least in Britain, where much of the research was conducted (Blanchflower and Bryson, 2009).

This has led to speculation as to why. Some maintain that declining union density, together with a changed economic environment—notably, increased global competition—began to undermine unions' ability to monopolise the supply of labour (Brown, Bryson and Forth, 2009). Certainly, it is the case that where negative associations persist, they are confined to workplaces with strong bargaining power, by virtue of either high union density or the presence of multiple bargaining units (Pencavel, 2004; Bryson, Forth and Laroche, 2011). Some point to a reorientation of union strategies resulting in partnerships with employers born of union weakness (Frege and Kelly, 2003). In France, the negative association between unionisation and workplace performance is confined to a small number of militant unions (Bryson *et al*., 2011). Others point to differential union survival among firms and industries with higher rents (Brown *et al.*, 2009) permitting unions to extract rents without obvious detrimental impacts on the workplace.

Our contribution to this literature is to exploit tax reforms that exogenously shift the price of union membership as a means of identifying union causal effects on workplace productivity and wages in Norway. Our theoretical model in Section 2 outlines how tax subsidies may affect individual union membership. Although tax subsidies for union membership exist in other countries such as France and the United States, no empirical evidence exists on the relationship between taxation and the demand for union membership.

However, a related literature links the demand for fringe benefits, such as health care, savings plans, company cars, stocks and stock options, to the taxation of these goods and services. For example, Gruber and Lettau (2004) estimate that removing the subsidisation of employer-provided health care would reduce insurance spending by 45%. Similarly, Gutiérrez-i-Puigarnau and Van Ommeren (2011) find that the subsidisation of a 'company' car by the tax system leads to households demanding a more expensive car and driving more miles privately. Beneficial

tax treatment increases employees' demand for stock options (Austin *et al*., 1998) as well as employers' supply, since employees tend to exercise stock options when corporate taxable income is high, shifting corporate tax deductions to years with higher tax rates (Babenko and Tserlukevich, 2009).

2. Institutional Features of Unions and Bargaining in Norway

Unions have a strong influence on wages and working conditions in Norway. According to the most recent study, which is based on the 2003 Norwegian Labour and Enterprise Survey, union density is around 55% among employees in non-state employers, and 87% are employed in workplaces with at least one union present (Barth *et al.*, 2014). Some 79% of employees in non-state employers work for employers that are members of an employer's association and 87% of employees work in firms that have collective agreements. These figures reflect high unionisation rates in large firms that account for the majority of employees. In our sample mean firm-level union density is 25%, whereas mean union density among employees is 55%.

Norway has strong co-ordination in wage bargaining, with both central bargaining at the national level and pattern bargaining at the sectoral level. Nevertheless, according to Barth *et al*. (2014) 78% of all employees work in plants with subsequent local bargaining, of which 80% of these local-bargaining-plants bargain over a host of topics, such as productivity agreements, downsizing, reorganisation, on-the-job training, working hours and pensions in addition to pay. Collective agreements are settled at both the aggregate and at workplace levels. Local bargaining is conducted under a peace clause agreed at the higher level, implying that workers are not allowed to strike during the subsequent local bargain. Still, with two-tier bargaining, which is dominant in manufacturing and several other sectors, 40% of blue-collar and 60% of white-collar wage growth between 1995 and 2010 was determined locally rather than at a higher level.

According to labour law, a union with a sufficient number of members represented at a firm can demand a collective agreement. In practice, this threshold varies between 10% and 25% union membership among workers within the relevant occupational group at the firm. Large employers are also more likely to organise in employers' associations. With collective agreements, a set of local formal consultation procedures are set in place. Increased union density is also associated with informal consultation procedures (see below).

3. A Simple Model of Union Membership

To motivate our choice of instrument, we consider the worker's choice between becoming a union member or not. The union provides two kinds of services attractive to workers: they may increase the wage, and they may provide various forms of insurance and legal services at discounted prices. Assume that the utility of each worker can be expressed by a Cobb–Douglas utility function given by (1), depending on insurance I and consumption (or a composite good) C:

$$U = I^{\alpha} C^{(1-\alpha)}, \tag{1}$$

Each worker faces a budget set as expressed by (2), which differs depending on union membership:

$$\begin{aligned} &\text{Union:} \quad p^U I + C + F - S = W_U, \\ &\text{Non-union:} \; p^N I + C = W_N, \end{aligned} \tag{2}$$

Where C is the numeraire good, $p^U \leq p^N$ are the prices of insurance for union and non-union members, F is the union membership fee, S is a tax subsidy amount on union membership, and the Ws are wages.

We allow for heterogeneity across workers by discounting the monetary costs $(F - S)$ by a factor $(1 + \varepsilon)$. The term is added to represent workers' attitudes and psychic rewards from being member of a union. The average worker considers only the monetary costs and benefits of joining ($\varepsilon = 0$), whereas some workers discount the costs of joining ($\varepsilon < 0$), for instance because they believe in collective action, have a political leaning towards the left, feel a responsibility towards fellow workers, or enjoy being part of the group; while other workers may have the opposite attitudes and rather tend to exaggerate the costs of joining ($\varepsilon > 0$). The cost of membership may also be attenuated or magnified by both the union's and management's actions towards membership and non-membership. In this simple setting the indirect utility functions are given by (3):

$$\begin{aligned} &\text{Union:} \quad V^U = \tilde{\alpha}\left[\frac{1}{p^U}\right]^{\alpha}\left[W_U - (F - S)(1 + \varepsilon)\right], \\ &\text{Non-union:}\ V^N = \tilde{\alpha}\left[\frac{1}{p^N}\right]^{\alpha} W_N. \end{aligned} \tag{3}$$

where $\tilde{\alpha} = [\alpha^{\alpha}(1 - \alpha)^{1-\alpha}]$ is a function of the parameters of the utility function. Let the bargaining power of the union be represented by the difference, Δ, between the union and non-union wage as expressed by (4):

$$W_U = \Delta + W_N, \tag{4}$$

We assume that union dues may be used to improve on workers' bargaining power, for instance through the size of strike funds, such that: $\Delta = \delta F + d$ with $\delta > 0$. The worker becomes a union member if $V^U - V^N > 0$. This utility differential can be expressed as by (5):

$$V^U - V^N = K\left\{\Delta + g - (F - S)(1 + \varepsilon)\right\}, \tag{5}$$

whose sign is independent of $K = \tilde{\alpha}[\frac{1}{p^U}]^{\alpha} > 0$. $g = (1 - [\frac{p^U}{p^N}]^{\alpha})W_N$ is the value of the price discount on insurance for union members and Δ is the difference between union and non-union wage. We may write the condition that $V^U - V^N > 0$ as:

$$\delta - 1 + \delta\left(\frac{S}{F - S}\right) + (d + g)\frac{1}{F - S} > \varepsilon, \tag{6}$$

We define $\frac{S}{F-S}$ as the subsidy ratio. Equation (6) shows that conditional on the union membership fee, the probability of becoming a union member is increasing in the subsidy ratio. The choice of becoming a union member may thus be analysed using a simple regression model of union membership on the inverse of the net union membership fee and the subsidy ratio: $\mathrm{P(U = 1)} = \mathrm{c} + \alpha\frac{1}{F-S} + \beta\frac{S}{F-S} + \mathrm{u}$.[8]

[8] Given this functional form, the relationship between membership and S and F are given by $\frac{\partial U}{\partial S} = [\frac{1}{F-S}]^2[\alpha + \beta F] > 0$ and $\frac{\partial U}{\partial F} = -[\frac{1}{F-S}]^2[\alpha + \beta \mathrm{S}] < 0$, where $F > S$. Note that the positive marginal effect of S on membership could be stronger than the negative marginal effect of F, since the former solely changes the monetary costs of membership, while the latter partly offsets the increased costs by increasing the bargaining power through strike funds, for example.

Table 1. *Subsidy of Union Membership. (NOK).*

	Deduction	Subsidy	Union fee
2001	900	250	3,430
2002	900	250	3,580
2003	1,450	410	3,740
2004	1,800	500	3,860
2005	1,800	500	3,990
2006	2,250	630	4,060
2007	2,700	760	4,240
2008	3,150	880	4,360
2009	3,150	880	4,510
2010	3,660	1,020	4,640
2011	3,660	1,020	4,820
2012	3,750	1,050	4,980

Notes: Deduction is the maximum deduction in taxable income. The subsidy amount is 28% of the deduction in income. The average union fee is calculated from our raw data (see Section 4). All measures in NOK (in 2011 1£ = 9.032NOK and 1$ = 5.607NOK).

4. The Norwegian Tax System and the Union Membership Fee

Union membership is subsidised in Norway as a deduction on taxable income. Table 1 shows the development of the deductions allowed for union membership given by the tax system over the period 2001–12. Column 1 is the gross deduction. Employees benefit from the subsidy amount reported in Column 2, calculated as 28% of the deduction in income, since that is the marginal tax rate on income after deductions.[9] The third column shows the average gross fee.

Across time, the average union fee changes due to changes in union membership fees and changes in firm and workforce composition. The subsidy amount rose more than four-fold over the period, whereas the average membership fee rose 1.5 times, such that the subsidy was equivalent to 7% of the average membership fee in 2001, rising to 21% in 2012.

The government determines the size of the subsidy at the end of the previous tax year. No explicit pronouncements are made as to why the tax subsidy changes, but it is linked to changes in political power in Norway. The tax subsidy associated with union membership was cut by 50% between 1998 and 1999 by the Liberal–Conservative Bondevik-coalition government (from 1800 NOK to 900 NOK) leading to union protests. In the October 2005 election the Labour Party gained power at the expense of a Liberal–Conservative coalition. It retained power in the election of 2009. In Figure 1 we see the development of gross union membership deductions (left-hand axis) and the Labour Party's and the Conservative Party's share of seats in the Norwegian parliament (right-hand axis).

5. Data

We exploit population-wide administrative register data provided by Statistics Norway and Statistics Norway's Capital Data Base. *The administrative register data*, collected by the Norwegian Tax Authorities and Social Services, comprise the whole Norwegian population of workers, workplaces and firms during the period 2001–12 (around 2,500,000 worker observations each year) and provide information on individuals and jobs including

[9] Norway has a progressive tax system, but the progressivity arises at the level of gross taxable income. For income after deductions, the tax rate is flat at 28% over the period we consider.

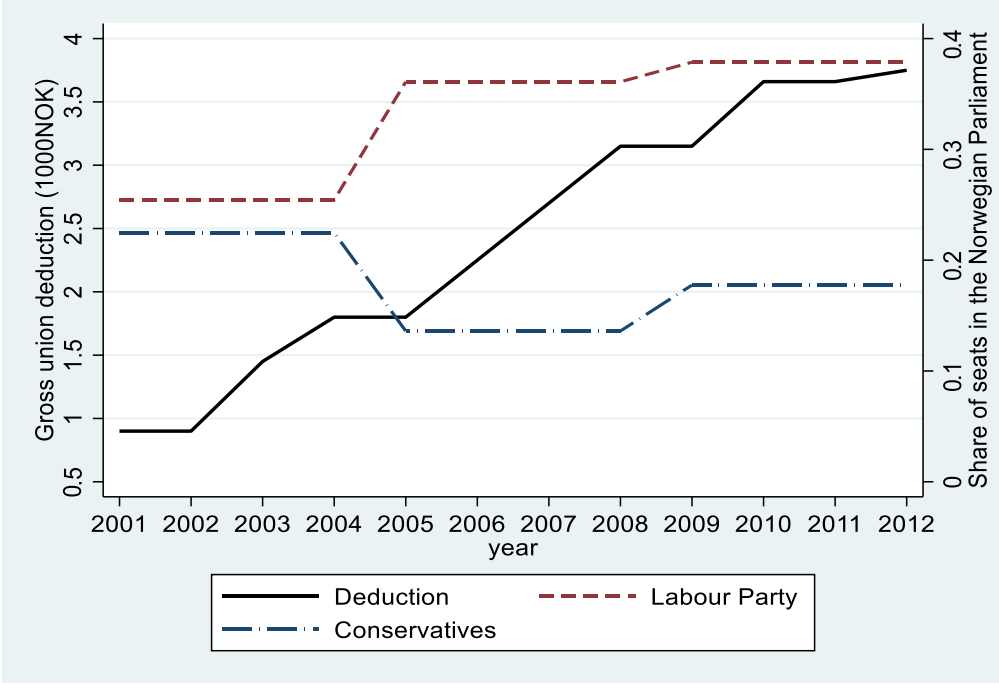

Fig. 1. *Deduction in Taxable Income (1,000 NOK) and % Elected Seats in Parliament.*
Notes: Gross union income deduction (in 1,000 NOK) is measured on the left-hand axis. The Labour Party's and the Conservative Party's elected number of seats in the parliament are measured (share of 169) on the right-hand axis.

income, earnings, work hours, occupations,[10] wages and union membership fees. Unique identifiers exist for individual workers, workplaces and firms, thus allowing us to track these units over time.

Workers' hourly wage is constructed from the tax data based on job- and spell-specific annual earnings, spell length and contracted weekly working hours.

Workers' union status is apparent from the administrative tax data containing annual union fees. To avoid volatility in union fees arising from spells of non-employment, we focus on employees who, by 15 October, had reported taxable income in year t, $t \in (2001, 2012)$, above 1 G (G is the Social Service's baseline figure, 1 G is equivalent to £8,685 in 2011). This restricts the analyses to roughly 2,000,000 jobs each year or 24,200,641 observations over the whole period.

Since it is not possible to know the union fee for union non-members, we have followed the simple rule of designating each worker a job class (or union) based on their main economic activity (two-digit SIC code X three-digit occupational code, resulting in a total of roughly 7,000

[10] Occupational codes are recorded from 2003, but these also identify occupations for some of the workers employed in 2001–2. Of roughly 24 million observations, 286,000 workers have unidentified occupations, including 200,000 in 2001 and 70,000 in 2002. For workers with missing information on occupation, we impute occupational codes based on three-digit educational qualification codes (occupational codes and educational qualification codes do not overlap).

cells). We calculate the average union fee for each job class based on union members only, and then link this fee to every worker in the job class.[11]

The Capital Data Base provides information on value added and revenues, and capital, labour, and intermediate good inputs, together with their prices. The value added measure used in our firm productivity analyses is the log of operating income less operating costs, wage costs, depreciation and rental costs. Since the Capital Data Base reports information on firms, we use this as our unit of observation.[12]

Since the Capital Data Base utilises the same firm identifier as the public administrative register data, we can link these data sources together. To utilise the public administrative register data in our firm-level analyses, we take firm-averages of job and worker-level information for workers aged 20–60 years. The coverage of the Capital Data Base is only complete for manufacturing. Thus, our final data set contains 6,000–6,500 firm observations each year and, when linked to the administrative data, the final regressions comprise around 8,000 firms and more than 60,000 observations.[13] Most, but not all, are drawn from the manufacturing sector.

6. Empirical Approach

Consider the following simple Cobb–Douglas production function expressed by (7):

$$Y_{it} = Ae^{\omega_i + u_{it} + \gamma_t + \beta^D D_{it}} \left(L_{ls} + \beta^{hs} L_{hs}\right)^{\beta^L} K^{\beta^k} \tag{7}$$

where Y is value added for firm i at time t, ω_i is a firm specific productivity level known to the firm and potential union members as they choose the level of transitory inputs and make decisions on union membership, but not observed by us, γ_t represents technological change, D_{it} is union density of firm i at time t, ls represents low-skilled and hs high-skilled workers respectively, K is capital, and u is a stochastic term representing idiosyncratic shocks that are unknown to the firm when it makes its decisions. The coefficient β^D captures the effect of union density on productivity.

The chief estimation problem we address is the *potential endogeneity of union density*, which, as discussed above, may occur for a variety of reasons, with different implications for the direction of any bias when making causal inferences. Workers are more likely to unionise, and unions more likely to invest in membership drives, when potential rents over which the union wishes to bargain are high. On the other hand, when firms face difficulties, union membership may provide important insurance and services related to the risk of job loss, inducing a potential negative relationship between membership and productivity.

While workers sort endogenously across firms, and occupational composition is endogenously determined by firms, the changes in the tax treatment are exogenous to firms, and as this affects each worker's demand for unionisation, this induces exogenous variation in union density across

[11] For private-sector jobs and for public-sector jobs in the later part of our observation period, the administrative register data provide information on standard occupational codes, but in the beginning of our observation period public sector occupations were categorised based on a simplified system. Potentially, if public firms turn private, jobs might retain their old occupational code. However, this influences fewer than 1% of the jobs in the Capital Data Base.

[12] Our data allow us to identify single and multi-workplace firms. The Capital Data Base comprises over 90% single workplace firms. When repeating the analyses of Sections 5–7 on single-workplace firms, we find no qualitative changes compared to those reported.

[13] Descriptive information on the data used in the firm-level analyses is reported in Appendix Table A3. Aggregate union density in our data is roughly 60%, reflecting the fact that the manufacturing sector is more unionised than the private sector in general.

firms over time.[14] The potential endogeneity of union density in (7) is then solved by instrumenting D by the firm average across workers of the subsidy ratio, i.e., the ratio of the union subsidy relative to the net union membership fee.

To avoid potential endogeneity problems in the way the union fee may be set following changes in the subsidy, and to avoid potential endogenous responses in the occupational composition of firms over time, we calculate our instrument as follows. The idea is to capture the average subsidy ratio of the firm, i.e., $s/(f-s)$, where s is the subsidy amount and $(f-s)$ is the net membership fee after tax deduction. s varies over time while f varies both over time and across job classes. In order to use only variation in the subsidy amount, we fix f for each firm by calculating the average price paid in the first year of observation for the firm. The average subsidy ratio that we calculate for a given firm at time t is thus given by:

$$S\_ratio_t = \frac{s_t}{\overline{f_0} - s_t}$$

where s_t is the subsidy amount in year t, the average union membership fee of the first year of observation is given by $\overline{f_0} = \sum_g \alpha_{g,0}\, f_{g,0}$ where $\alpha_{g,0}$ and $f_{g,0}$ are the share of workers in job class g and the gross union membership fee, respectively, in the first observation year. We fix fees at the baseline to take account of potentially endogenous movement in union fee setting as unions respond to the changes in public subsidy.[15]

Identification thus rests on variation in the tax subsidy over time interacted with the inverse of the net union fee faced by workers at the firm (where the gross union fee is held constant at its first value in the panel). This instrument, the subsidy ratio, is defined at the firm X year level, and varies with the tax system and the number of workers in different job classes the first time the firm is observed in the data and their initial union fee. In Section 7 we discuss the relationship between unionisation and the subsidy ratio, as well as our instrument, closer.

Since the net union membership fee could be associated with productivity (e.g., through worker wages as indicated by our theoretical model), we condition on the inverse of the (initial) net union membership fee in all regressions.

Our observation period coincides with an economic upswing and since the subsidy rises over time, this could influence our estimation. Another concern could be that economic changes coincided with other changes in tax policy. To account for such time varying changes, all regressions include year dummies so we only use within-year variation to identify the parameters of the model.

A further threat to the identification strategy arises if the *workers who sort into union membership differ in their productivity* from those who do not: this might induce a correlation between union density and productivity.[16] We thus take care to include in several of our specifications

[14] Our empirical approach does not preclude the existence of multiplier or social interaction effects. Although unions are usually unable to prevent non-members from benefiting from union bargained terms and conditions (Olson, 1965; Booth, 1994), free-riding behaviour does not affect our identification strategy.

[15] We have rerun our estimates allowing fees to vary over time: our results are robust to this approach.

[16] The wage standardisation policies of unions result in systematic differences in the wage premium workers can expect. Those with lower potential earnings get the biggest premium relative to their market outside options. Thus, if outside options reflect productivity, wage standardisation would induce negative sorting since it would be the least productive workers who would queue for union jobs. However, as Abowd and Farber (1982) show, if supply of union jobs is less than the demand, employers would cherry-pick from the queue, with the result that union workers originate from the middle of the productivity distribution. It is standard in the union wage premium literature to find that the raw union-non-union wage gap closes with the addition of human capital in the wage equation, indicating positive selection into union status based on worker observed traits. But debate continues as to whether efforts to account for unobserved

below a comprehensive set of controls to account for workers' productivity including the share of workers in different age brackets, the share of workers in different occupations, the share of workers with higher education, as well as the firm averages of the individual worker fixed effects from individual earnings regressions in order to net out any effects arising from time-varying differences in worker quality which may be correlated with unionisation.

Finally, a second estimation problem, familiar to those estimating firm production functions, is the *endogeneity of transitory inputs*. In sensitivity analyses presented in Table 4 we address this issue using Petrin, Levinsohn and Wooldridge's (Wooldridge, 2009) control function approach by including a proxy for time-varying productivity, ω_{it} using lagged values of capital and materials and their interactions directly in the production function, and instrumenting for low- and high-skilled labour using lagged values.

7. Union Membership and the Subsidy Ratio

In this section we establish empirically the relationship between the subsidy ratio and union membership as outlined in our theoretical discussion in Section 2. This relationship is crucial for the validity of our instrument to be used in the following productivity analyses. As discussed above, the interaction between the inverse of the union membership fee and the subsidy amount provides variation in the subsidy ratio across firms within the same year, even if the subsidy amount in a given year is the same for all workers. In this section we show that variation in the subsidy ratio affects the union density of the firm.

Our data contain the union membership fees paid by all union members, as reported to the tax authorities. Figure 2 shows the subsidy ratio for three equal-sized groups—low wage, medium wage and high wage—based on the wage distribution among union members employed in the Capital Data Base Firms.[17] The subsidy ratio amounts to 5–10% in the beginning of the period, increasing to around 15–30%. For all three groups the subsidy appears sizeable enough to affect union membership.

Since we calculate membership fees among union members by job class, we may allocate a potential fee to non-members as well, using information on their job class. We thus use information on membership fees to calculate the subsidy ratio for all workers.

The distribution of the subsidy ratio for all workers employed by Capital Data Base firms is presented in Figure 3A. The distribution is shown for four different years: 2001, 2004, 2008 and 2012. The figure shows that the subsidy ratio rises from a little under a median of 10% at the beginning of the period to between 25% and 30% at the end of the period. We also see that the distribution of the subsidy ratio becomes more dispersed over time.

Figure 3B shows similar densities as Figure 3A, but this time averaged over Capital Data Base firms, conditional on the job-class composition of the firm in the first year, in other words, the densities of the firm average of the subsidy ratio that we use to instrument for union density below. We again see a similar development of the distribution across firms as across individuals of the subsidy ratio over time.

differences between union and non-union workers can tell us something about the underlying ability of workers in the two sectors (Robinson, 1989). For Norway, Mastekaasa (2013) shows that workers with a higher probability of experiencing sick leave spells sort into union membership and arguably health, absenteeism and productivity could be related.

[17] Both Figure 2 and Figure 3 reveal quite similar patterns if not limited to Capital Data Base firms.

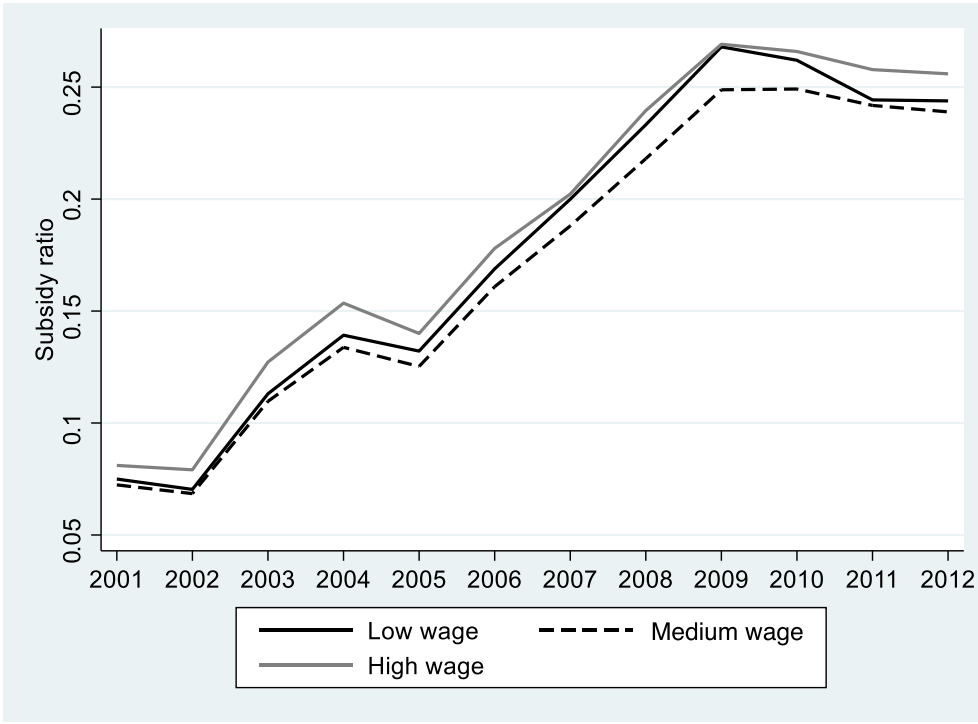

Fig. 2. *The Subsidy Ratio among Union Members in different parts of the Wage Distribution.*
Notes: The equal-sized wage groups are defined based on the union member wage distribution employed in the Capital Data Base firms. The lines show the subsidy ratio for union members at different points in the wage distribution.
Source. Own calculation based on population-wide administrative tax data. See Section 5.

In Table 2 we show results from linear probability models of union membership on the subsidy ratio, estimated at the level of the individual worker.[18] In Model 1 the regressions include dummies for the job classes used to measure union fees, year dummies and an intercept, as well as the inverse of the net union fee, as suggested by (6).[19] We see that a 10 percentage point increase in the subsidy ratio yields a 1.08 percentage point increase in the probability of union membership. Additional controls for demography, income and unobserved worker and job heterogeneity increase the size of the subsidy effect even further.

Since the subsidy amount and the gross union fee enter both the subsidy ratio and the term for the inverse of the union fee, it is not straightforward to see the marginal effect of each. In the

[18] The regressions are based on observations of workers employed by the Capital Data Base firms, between 20 and 60 years of age, with taxable income year t, t∈(2001,2012), above 1 G (G is the Social Service's baseline figure, 1 G is equivalent to £8685 in 2011).

[19] The subsidy ratio is the interaction between the subsidy amount and the inverse of net union fee. The model also includes both main effects, namely the subsidy amount and the inverse of the net union fee. The subsidy amount is absorbed by the year dummies, In Table A1 in Appendix A, we present simpler models including a quadric trend instead of year dummies, allowing identification of the linear term for the subsidy amount as well. The results in Table A1 shows a positive effect of the subsidy amount when appearing alone in the equation, but when the subsidy ratio is added, the linear term turns insignificant while the subsidy ratio shows up highly significant as in the above specifications with year dummies.

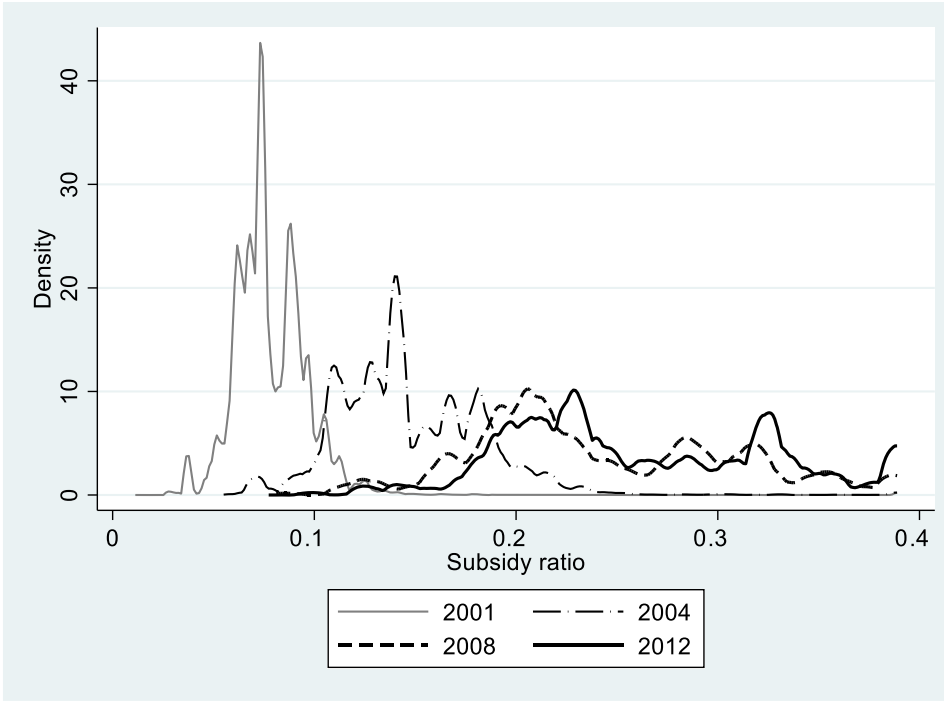

Fig. 3A. *The Distribution of the Subsidy Ratio by Year. Across Workers in Capital Data Base Firms.*
Notes: Kernel density estimates based on epanecknikov kernel.
Source. Own calculation based on administrative tax data. See Section 5.

lower panels of Table 2 we therefore show marginal effects of the gross union membership fee and of the subsidy amount on union membership.[20] The marginal effects depend on the level of the subsidy and the net union fee, and we have estimated effects for: (*i*) a 100 Nok increase in the subsidy for those on average union fees; and (*ii*) an increase in average gross fee of 10%. For each 100 Norwegian krone in subsidy, the probability of union membership for those facing average fees increases by 3–7 percentage points. An opposite relationship is seen for the marginal effect of increasing the average gross union fee by 10%: the probability of union membership falls by 0.05 to 0.7 percentage points for those originally facing average fees.

7.1. *Who Changes Membership Status Because of Tax Subsidies?*

Figure A1 in Appendix A shows the relationship between the subsidy ratio and union density as predicted by Model 3 of Table 2 on top of the density distribution of the subsidy ratio. We see the positive relationship between the subsidy ratio and unionisation. The overall variation in membership probability is only 6 percentage points, illustrating that the subsidy ratio is not the main reason why workers unionise. Still, the government's tax subsidy on union fees clearly influences the unionisation rate.[21]

[20] See footnote 8 for the formulas.
[21] Figure A2 in Appendix A shows the predicted unionisation rate in our sample of workers and firms with and without the tax policy reforms.

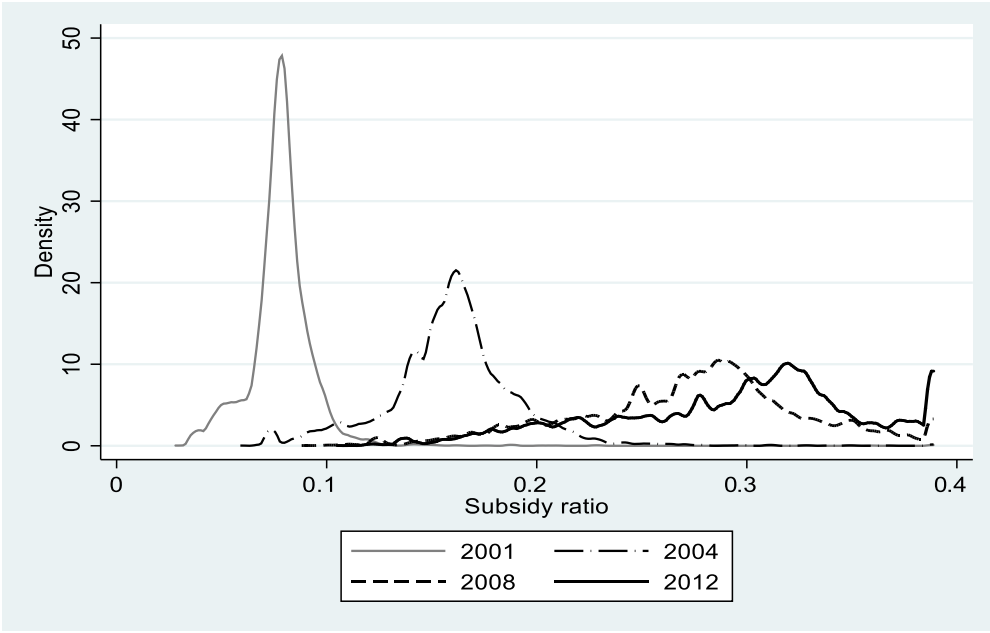

Fig. 3B. *The Distribution of the Subsidy Ratio Over Time. Across firms.*
Notes: Kernel density estimates based on epanecknikov kernel.
Source. Own calculation based on administrative tax data. See Section 5.

Some workers are union members regardless of the subsidy. In line with the literature we denote these workers as always-members. Other workers do not join unions regardless of the subsidy. They are never-members. Compliers are workers whose membership status is actually affected by the subsidy ratio. To find out who are most affected by changes in the tax subsidy, we estimate the probability of union membership for different sub-samples. In Table 3 we show results from models equivalent to Model 3 of Table 2, estimated on different sub-samples depending on individual and firm characteristics. This allows us to characterise the compliers, the never-takers and the always-takers.[22] An always-taker is a union member even with the lowest possible subsidy ratio, while a never-taker is a union member even at the highest level of the subsidy ratio. The compliers are defined as the group in between.

In Table 3 we also present the predicted probabilities of being compliers and always-takers (which then can be used to derive the predicted probabilities of being never-takers). The last column in Table 3 expresses the relative risk. We see that the complier probability is larger among employees at smaller and medium-sized firms, where union workers are in a minority, and also among employees who are younger, male, immigrants and more highly paid.

[22] We follow Imbens and Rubin (1997) and Abadie (2003) as implemented by Dahl, Kostøl and Mogstad (2014). Their analysis concerns the impact of a dichotomous treatment with a continuous instrument, whereas our study uses the aggregate union membership at the firm level as the treatment. Appendix A Table A2 provides additional information on the compliers. We have estimated the probability of union membership using all the controls except the subsidy ratio (Model 3 of Table 2), and then used these estimates to predict the probability. We then estimate separate first stage regressions for the four quartiles of predicted union membership. For all quartiles we see that the subsidy rate affect union membership positively, and for the third quartile this is strongly significant. Thus the results in Table A1 and in Table 3 support a monotonicity assumption.

Table 2. *The Impact of Subsidising Union Membership on the Probability of Union Membership.*

	Model 1	Model 2	Model 3	Model 4	Model 5
Subsidy ratio	0.0758*	0.1024**	0.1322***	0.2120***	0.2033***
	(0.0449)	(0.0430)	(0.0437)	(0.0656)	(0.0649)
Inverse of net union fee	−5.0150	−5.3290	−5.9752	−2.4679	−2.1358
	(3.2562)	(3.3212)	(4.2643)	(1.5306)	(1.3706)
Controls					
Years	Yes	Yes	Yes	Yes	Yes
Job class (FE)	Yes	Yes			
Educational qualification (FE)		Yes			
Women, immigrant			Yes		
Seniority (in years), Log age			Yes	Yes	Yes
Education—job class (FE)			Yes		
Worker—job class (FE)				Yes	
Job—job class (FE)					Yes
NXT	2,460,383	2,460,383	2,460,383	2,304,882	2,281,211
Marginal effects on the probability of union membership of increasing the subsidy by 100 Nok at average fees					
2001	0.0025*	0.0034**	0.0044***	0.0072***	0.0069***
	(0.0015)	(0.0015)	(0.0015)	(0.0022)	(0.0022)
2012	0.0024*	0.0033**	0.0042***	0.0069***	0.0065***
	(0.0014)	(0.0014)	(0.0014)	(0.0021)	(0.0013)
Marginal effects on the probability of union membership of increasing the average gross fee by 10					
2001	−0.0005	−0.0007*	−0.0009**	−0.0017***	−0.0017***
	(0.0003)	(0.0004)	(0.0004)	(0.0005)	(0.0005)
2012	−0.0024	−0.0033**	−0.0043***	−0.0071***	−0.0068***
	(0.0015)	(0.0014)	(0.0015)	(0.0022)	(0.0021)

Notes: Job class: 3,831 units (three-digit occupation X two-digit industry); Educational qualifications: 75 fixed effects (two-digit code). Education—job class FE, Worker—job class FE and Job—job class FE: control for 27,692, 452,588 and 477,395 fixed effects, respectively. Note that the marginal effects are estimated based on the average union fees of 3,430 and 4,980 Nok and subsidies of 250 and 1,050 Nok for 2001 and 2012, respectively. Standard errors adjusted for clustering on job class are reported in parentheses. ***, ** and * denote significant at the 1, 5 and 10% levels of significance, respectively.

How, then, does the relationship between the subsidy ratio and unionisation manifest itself at the firm level? In Figure 4 we have divided the subsidy ratio into 20 equal-sized bins, computed the means of the subsidy ratio and union density within each bin and created a scatterplot of these data points.[23]

Even in this rough non-parametric example, we see a strong positive relationship between the subsidy ratio and union density, although overall variation in union density is no more than 2 percentage points. Note that even if the predicted union membership probability is around 0.58 among individuals, the predicted union density level is about 0.27 among firms. The reason for this discrepancy is that workers in larger firms, who count heavily in the distribution across workers, but not in the distribution across firms, have much higher membership probabilities.

[23] Beforehand the observations have been residualised, by running a regression of union density on year dummies and fixed firm effects, thus measuring the relationships as deviations from firm mean and taking into account variation across years.

Table 3. *Does Union Membership Take-up Induced by Tax Changes Differ between Worker and Firm Groups?*

	First stage	Pr(Xi = xi)	Pr(complier|Xi = xi)	Pr(always union|Xi = xi)	$\frac{\Pr(Xi = xi\|complier)}{\Pr(Xi = xi)}$
Individual characteristics					
Young	0.2263***	0.5345	0.0761***	0.5536***	1.8489
	(0.0557)				
Old	0.0312	0.4655	0.0105	0.6247***	0.2551
	(0.0518)				
Men	0.1494***	0.7505	0.0503***	0.6000***	1.0735
	(0.0471)				
Women	0.1107*	0.2495	0.0365*	0.5480***	0.7789
	(0.0645)				
Natives	0.1548***	0.8983	0.0521***	0.5996***	0.9387
	(0.0480)				
Immigrants	0.2579	0.1017	0.0855	0.4898***	1.5405
	(0.1773)				
Low wage	0.1319**	0.5417	0.0444**	0.5897***	0.9716
	(0.0629)				
High wage	0.1411**	0.4583	0.0472***	0.5834***	1.0328
	(0.0588)				
Low earnings	0.0580	0.5125	0.0194	0.5758***	0.4501
	(0.0691)				
High earnings	0.2023***	0.4875	0.0681***	0.5973***	1.5786
	(0.0499)				
Firm characteristics					
Manufacturing—low tech	0.1210*	0.6210	0.0408*	0.5930***	1.0001
	(0.0632)				
Manufacturing—high tech	0.1345**	0.2338	0.0448**	0.5858***	1.0980
	(0.0649)				
1–25 employees	0.2125***	0.1916	0.0726***	0.2754***	1.0885
	(0.0707)				
26–100 employees	0.3098***	0.2189	0.1037***	0.5463***	1.5547
	(0.0759)				
101–500 employees	0.1892**	0.2667	0.0635**	0.6983***	0.9520
	(0.0879)				
>500 employees	0.1216	0.3228	0.0408	0.7167***	0.6117
	(0.0775)				
0–25% union members	0.0804*	0.1718	0.0268*	0.0865***	0.6700
	(0.0427)				
26–50% union members	0.2801***	0.1370	0.0932***	0.4128***	2.3300
	(0.0792)				
>50% union members	0.0973**	0.6912	0.0327**	0.7445***	0.8175
	(0.0417)				

Notes: Job class: 3,831 units (three-digit occupation X two-digit industry). Education—job class FE: control for 27,692 fixed effects. Note that the estimated models are equivalent to Model 3 of Table 2, but estimated separately for each group as indicated by row heading.***, ** and * denote significant at the 1, 5 and 10% levels of significance, respectively.

8. Results

8.1. *The Impact of Union Density on Productivity*

Our starting point for the productivity analyses is the estimation of a Cobb–Douglas production function with homogenous production technology across industries. Union density is measured in percentages to ease interpretation. The results are shown in Table 4.

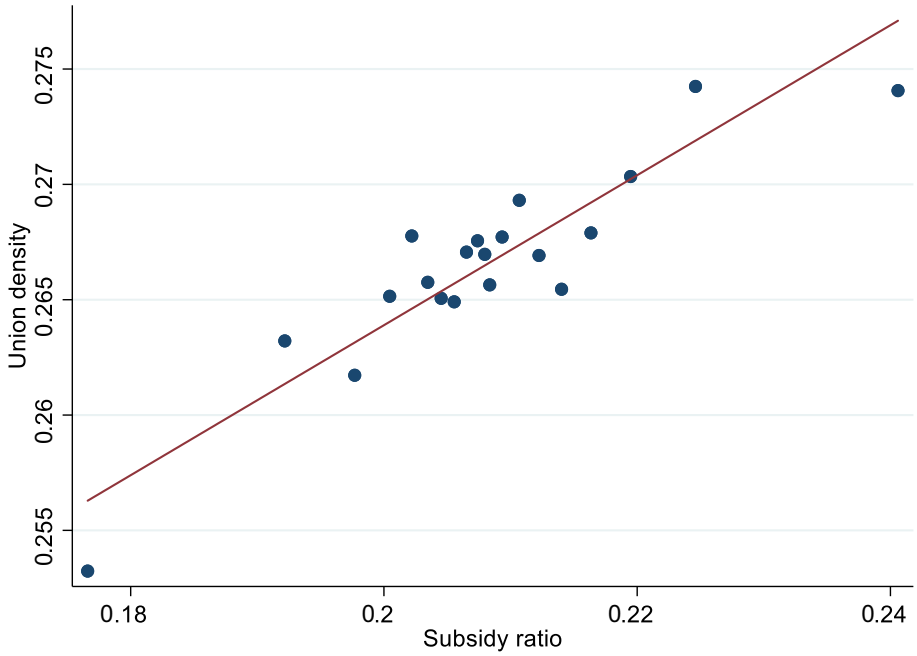

Fig. 4. *Firm-Level Union Density and the Union Subsidy Ratio.*
Notes: The figures are based on averages of 20 equal-sized binned observations of the subsidy ratio and union density, where both variables are measured as residuals from regressions including year dummies and fixed firm effects.

Table 4. *Union Density and Productivity.*

	Model 1 OLS	Model 2 FE	Model 3 IV	Model 4 IV
Union density	−0.0004***	0.0001	0.019**	0.019**
	(0.0001)	(0.0002)	(0.008)	(0.007)
Basic	Yes	Yes	Yes	Yes
Firm FE		Yes	Yes	Yes
High-skilled				Yes
First-stage union density				
Subsidy ratio			32.084***	32.147***
			(8.076)	(8.0779)
Tests weak instruments				
Cragg–Donald F:			73.36	76.66
Kleibergen–Paap F:			15.78	15.84
Number of observations	67,010	65,516	65,516	65,516

Notes: Dependent variable: log value added. Union density is measured in %. Controls: Basic: log capital, log workforce size, inverse of the historical net union fee, and years. High-skilled (educational qualification) indicates that the share of high-skilled workers are added as a control. Robust standard errors adjusted for firm-level and year clustering are reported in parentheses. ***, ** and * denote 1, 5 and 10% levels of significance, respectively.

Table 5. *Union Density and Productivity. IV Estimates. Robustness Checks.*

	Model 1	Model 2	Model 3	Model 4 LPW	Model 5 LPW
Union density	0.020**	0.020**	0.025***	0.017**	0.016**
	(0.008)	(0.010)	(0.010)	(0.007)	(0.007)
Basic, High-skilled, Occupational shares, workforce age vigintile shares, average worker effects	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Linear industry trends	Yes	Yes	Yes	Yes	
Linear skill trends		Yes		Yes	
First-stage union density					
Subsidy ratio	29.378***	26.164***	29.120***	28.382***	32.589***
	(7.813)	(7.843)	(7.610)	(9.267)	(9.164)
Tests weak instruments					
Cragg–Donald F:	64.13	46.74	52.66	40.96	49.41
Kleibergen–Paap F:	13.67	11.13	14.64	9.38	12.65
Number of observations	65,404	65,404	65,404	52,875	52,875

Notes: Sample: Models 1–3: All (Capital Data Base (CDB)), Models 4–5: Firms in CDB operating in SIC-industries 14–15, 17–20, 22, 24–36, 45, 51–52 and 74. Dependent variable: Models 1–3: log value added, Models 4–5: the residual from the industry-specific GMM-IV-regressions of Table A4. Union density is measured in %. Controls: *Basic*: log capital, log workforce size, inverse of net union fee and years. *High- skilled* (educational qualification) denotes the share of high-skilled workers. *Occupational share* denotes shares of workers in one-digit occupational class. *Average worker effect* is the firm average of the estimated fixed worker effects from a worker-level log hourly wage regression on year dummies (10) and age vigintile (19) dummies. *Industry time-trends* control for one-digit industry linear time trends. *Skill trends* control for low, medium-low, medium, medium-high and high-skilled linear time trends, where skills are defined based on job cell (occupation *X* industry) wages. Robust standard errors adjusted for firm-level and year clustering are reported in parentheses. ***, ** and * denote 1, 5 and 10% levels of significance.

The first model shows results from an OLS regression of value added on capital, labour (number of employees), the inverse of the net union fee[24] and year dummies. Firms with higher union density appear to be less productive than firms with low union density. The negative relationship between union membership and productivity becomes positive, but not statistically significant when we add firm fixed effects (Model 2). In Models (3) and (4) union density is instrumented using the firm-average of the subsidy ratio. We reject the null hypothesis of weak instruments. As in the individual regressions reported in Table 2, our instrument influences union density positively. A one standard deviation increase in the subsidy ratio is associated with about 1.5 percentage points increase in union density.

In the IV models union density is positively and strongly associated with firm productivity. The results imply that an increase in union density of 1 percentage point raises firm productivity by 1.7–1.8%. The inclusion of heterogeneous labour (high and low skilled) in Model 4 makes little difference.

In Table 5 we undertake robustness tests focusing on three possible sets of confounders. The first is the possible correlation between workers' productive characteristics and union membership. The second is heterogeneous technology and technical change. The third is the standard endogeneity problem related to time varying inputs.

[24] Since our instrument, the subsidy ratio is calculated as the subsidy amount interacted with the inverse of the historical union fee, we include the inverse of the historical union fee as a control variable in all specifications in this article. In FE specifications this variable is absorbed by the fixed effect.

Heterogeneous Workers and Jobs. A major worry in this literature is a potential correlation between workers' skills and union membership. In Table 5 we add the average individual fixed wage effects by firm. These are calculated from auxiliary log wage regressions, including firm and individual fixed effects to the productivity equation. Occupation and the age of workers are also possible confounders as they are both likely to be correlated with union membership and productivity. To account for this, we also include the share of workers in each one-digit occupation, and the share of workers in each vigintile (20) of age. All of these are time varying variables that capture changes in the composition of the work force along dimensions that may be correlated with union density over time. The relation between union density and productivity is not affected by the inclusion of these controls.

Heterogeneous Technology and Technical Change. From Model 2 onwards, we allow for industry specific trends (two-digit industries). In Model (5) the analysis is based on tfp estimates from industry specific productivity analyses that allow for industry specific effects for the two types of labour and capital. In Model (3) we add three different skill-specific trends, where skill groups are defined as low, medium and high skilled according to job cell (occupationXindustry) average wages in the labour market.

Endogeneous Inputs. In Models (4 and 5) we use the Levinsohn–Petrin–Wooldridge (LPW) control function approach (see Wooldridge 2009) to control for endogeneity of the time varying inputs.[25] We estimate a set of auxiliary regressions (see Table A4 in the Appendix) conducted separately for firms operating in SIC-industries 14–15, 17–20, 22, 24–36, 45, 51–52 and 74, where we include a proxy for lagged unobserved time varying productivity, ω_{it-1} using lagged values of capital and materials and their interactions directly in the production function, and instrumenting for the L and share of skilled workers (based on educational qualification above high school) using lagged values. This proxy, derived from the firm's first order condition in period $t-1$, effectively controls for ω_{it-1} in the equation, and thus removes the correlation between the lagged high- and low-skilled labour and the error term. We then use the residuals from these regressions as dependent variables in Models 4 and 5. Since the auxiliary regressions are conducted within two-digit industries and are based on lagged values, we lose a considerable number of observations. Still, the point estimate in Model 5 is sizeable, albeit slightly smaller than the point estimate in the Model 3.

8.2. *Union Wage Effects*

We have found a positive effect of union density on firm productivity. What is the effect on wages? Table 6 reports results from log hourly earnings regressions, estimated at the firm level. The dependent variable is the firm level average each year of the residual hourly wage from log hourly wage regressions including year dummies (10), worker vigintile age dummies (19), as well as worker fixed effects, estimated at the individual level.[26] Model 1 indicates a small negative correlation between union density and wages reminiscent of the negative correlation

[25] Saturating the model with even more controls reflecting composition and human capital such as firm average seniority, share of women and share of immigrants yields similar results (not shown), i.e., it enlarges the point estimate even further. Although the standard errors increase strongly, potentially indicating limits to data, the point estimates always remains significant.

[26] Individual fixed effects are estimated using information on all workers in Norway during the period 2001–12, and is not restricted to those covered by the Capital Data Base. In these firm-level regressions in Subsection 8.2 we require that each firm should be linked to at least two valid wage observations at the individual level.

Table 6. *The Impact of Union Density on Firm-Average Log Hourly Wage.*

	Model 1 OLS	Model 2 FE	Model 3 IV	Model 4 IV	Model 5 IV	Model 6 IV	Model 7 IV	Model 8 IV
Union density (U)	−0.0003***	−0.0006***	0.014***	0.021***	0.017***	0.011***	0.017***	0.018***
	(0.0001)	(0.0001)	(0.004)	(0.006)	(0.005)	(0.004)	(0.005)	(0.004)
Ln value added per worker (VA)					0.137***	0.183***	0.172***	0.164***
					(0.007)	(0.042)	(0.051)	(0.025)
U X VA								0.0039**
								(0.0015)
Basic	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE		Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry time-trends, skill trends, high-skilled, age vigintile shares, occupational shares, average worker effects				Yes	Yes		Yes	Yes
Endogenous right-hand-side variables								
Union density			Yes	Yes	Yes	Yes	Yes	Yes
VA					No	Yes	Yes	Yes
Union density X VA								Yes
Excluded instruments:								
Subsidy(S)/Net union fee(F)			Yes	Yes	Yes	Yes	Yes	Yes
Ln capital (LnC)						Yes	Yes	Yes
S/F X LnC								Yes
Cragg–Donald F:			83.85	57.18	62.13	38.98	27.55	18.65
Kleibergen–Paap F:			20.20	17.61	19.12	9.79	8.64	5.83
Number of observations	62,691	61,370	61,300	61,266	60,205	60,239	60,205	60,205

Notes: The table reports OLS, FE and 2nd-stage IV estimates from two-stage regressions. See Table A5 for first-stage estimates. Dependent variable: Log hourly wage is the firm average of the residuals from a worker-level log hourly wage regression on year dummies (10) and age vigintile (19) dummies. Union density is measured in %. Log value added per worker is standardised, i.e., measured as the deviation from the global mean divided by the global standard deviation. Controls: *Basic*: inverse of the net union fee, log workforce size, and years. *Industry time-trends* control for one-digit industry time trends. *Skill trends* control for low, medium–low, medium, medium–high and high-skilled linear time trends, where skills are defined based on job cell (occupation X industry) wages. *High-skilled* (educational qualification) denotes the share of high-skilled workers. *Occupational share* denotes shares of workers in one-digit occupations. *Age vigintile shares* denotes shares of workers in age groups. *Average worker effect* is the firm average of the estimated fixed worker effect from a worker-level log hourly wage regression on year dummies (10) and age vigintile (19) dummies. Robust standard errors adjusted for firm-level and year clustering are reported in parentheses. ***, ** and * denote 1, 5 and 10% levels of significance.

between union density and productivity reported in Model 1 in Table 4. The correlation remains negative having conditioned on firm fixed effects in Model 2, but the estimate becomes slightly larger.

A very different picture emerges when we instrument for union density in Models 3–8.[27] Union density is strongly positively related to firm wages. The coefficients imply that a 1 percentage point increase in density increases wages by about 1.0–1.5%, depending on the model specification. The effect is apparent across specifications that include controls for heterogeneous skills, unobserved worker quality, and firm value added per worker.[28] Once again, we see that the instrument for union density in most specifications passes the standard tests for a weak instrument.

Firm-level value added is included both as an exogenous variable (Model 5) and as an instrumented variable (Models 6–8).[29] Comparing the coefficients for union density from Models 4, 5 and 7, we find that about one fifth of the union density effect may be attributed to rent sharing, but that a considerable effect remains.

To establish the extent to which union density increases the level of rent sharing in the firm, we interact firm union density with firm value added per worker in Model 8, having instrumented for both density, value added and the interaction. Both contribute positively to firm wages as evaluated at zero union density and average labour productivity. The interaction is precisely estimated and positive, indicating that the causal impact of higher union density on wages is larger in more productive firms, which is consistent with rent-sharing.

To ease interpretation, we have calculated the wage elasticities at different points in the productivity (value added per worker) and union density distributions (Figures 5 and 6). Figure 5 shows the marginal effect of union density is increasing as firms become more productive.

From the 10th percentile in the productivity distribution to the 90th, the marginal effects of union density double. Similarly, the marginal impacts of increased productivity more than double when going from zero unionisation to the 90th percentile in the union density distribution.

Figure 6 illustrates how these effects translate into wage levels. The top half of the figure shows how average wages change for low- and high-productivity firms across the distribution of union density. The bottom half of the figure shows the distribution of firms' union density across workers in the economy, for low-productivity firms (black bars) and high-productivity firms (khaki transparent bars). Wages increase with increasing unionisation for both high- and low-productivity firms, but at a faster rate for the high productivity firms than the low-productivity firms such that, at the top of the union density distribution the wage gains are nearly twice as large in high-productivity firms as they are in low-productivity firms.

[27] As in the value-added regressions, we instrument for union density with the subsidy ratio. Appendix Table A5 presents the first stage estimates for the IV.

[28] As for the value added regressions we have tested out specifications controlling for linear skill trends, and several variables capturing workforce composition such as firm-average seniority, share of women and share of immigrants. While linear skill trends significantly affected value added, in these wage regressions they are highly insignificant and their inclusion as controls does not qualitatively affect our main results regarding the relationship between union density and wages. The same is true for the other composition variables. If anything, by saturating the model we only achieve to enlarge the effect of union density on wages.

[29] Again, the instrument for union density is the subsidy-ratio. Following a rich literature we instrument for value added per worker utilizsng lagged log investments. For roughly 4000 newly established firms (and thus with missing lagged log investments), we use log total capital instead.

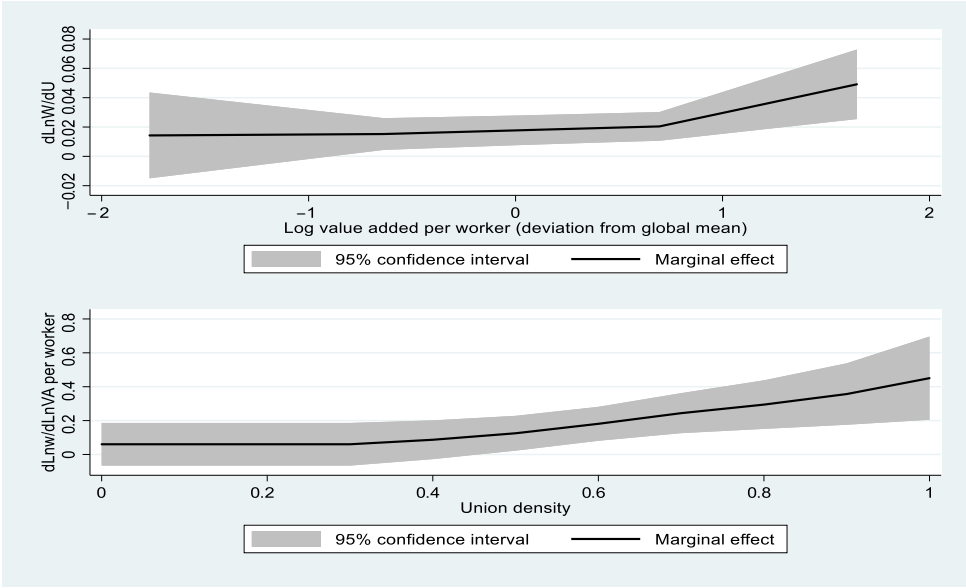

Fig. 5. *Marginal Effects with Productivity (Value Added per Worker) and Union Density Interactions. Mean and 95% Confidence Intervals.*

Notes: Marginal effects from Model 8 in Table 6. The marginal effects are calculated at 10-percentile intervals of the value added per worker- and union density distributions, respectively.

8.3. *Interpreting the Results and Some Caution: The Nuts and Bolts of Labour-Management Relations*

What are the mechanisms driving the positive effects of union density on productivity and wages? How does union membership affect decisions, organisation and bargaining power at the firms? If treatment effects are heterogeneous, our positive effects obtained using instrumental variables recover the local average treatment effects (LATE), rather than an average treatment on the treated effect (ATT). The size of our effects may indicate that the subsidy ratio affects membership where it matters the most for productivity, and that the effect of union density on productivity and wages may not necessarily be as strong in firms where membership is not as sensitive to changes in the subsidy ratio.

While our data cannot tell us much about the underlying mechanisms, the complier analysis in Table 3 offers some suggestions. It shows that the effect of the subsidy ratio on membership is relatively small in firms with few union members (<25%), large in the range between 25 and 50%, and small in firms with high union density (>50%). It is also larger in firms with fewer than 100 employees, and among younger workers.

Our conjecture is that union membership matters the most for productivity *where it affects the organisational and formal framework around management-labour relations the most*. A simple descriptive analysis of cross-sectional data from an employer survey on institutional features of local management–worker relations provides some support for this conjecture (the results and data are detailed in the appendix). In Appendix B we use a principle component analysis to identify three components of management–worker relations (see Table B2). The first is associated

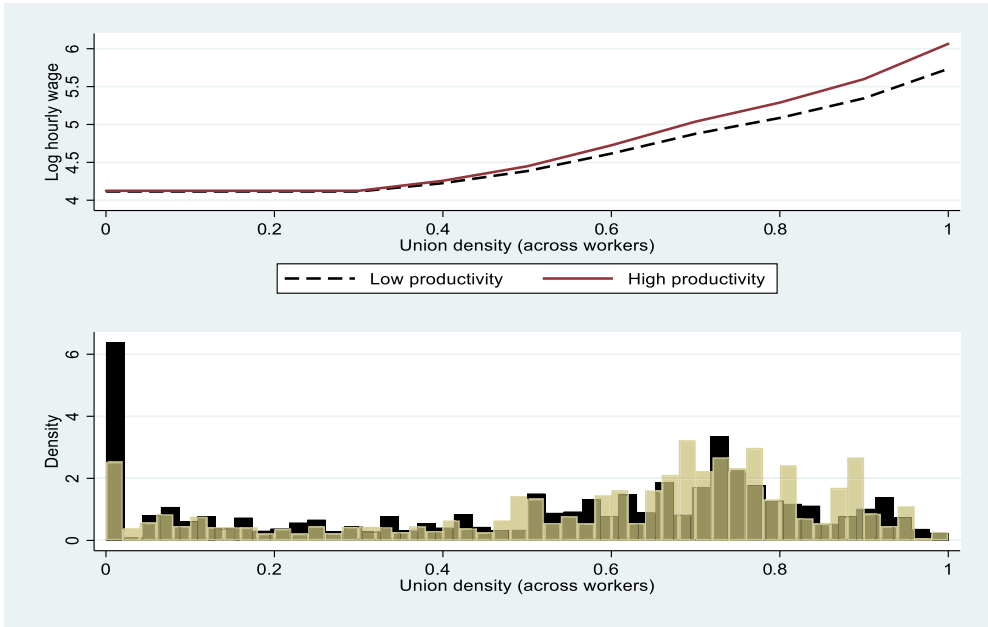

Fig. 6. *Predicted Log Mean Wage and Union Density by Value Added per Worker. Lower Panel: Union Density Distribution Across Workers.*

Notes: Top figure shows average wage based on estimates of Model 8 in Table 6. Low- and high-productivity firms are defined as belonging to the 20th and 80th percentile (+/− 2.5%) of the value added per worker-distribution. The bottom figure shows a histogram over the distribution of unionised workers, for low-productivity firms (black bars) and for high-productivity firms (khaki-transparent bars, grey in print). Note that the transparent bars appear darker where the black bars shine through.

with *formalisation with local wage bargaining,* including the existence and scope of collective bargaining, employer organisation and the existence of formal work committees. The second is associated with *formalisation with sectoral wage bargaining* including the same institutions but with wage bargaining at the sectoral level. The third is associated with the existence of local *joint consultative committees*; i.e., consultations outside the formal bargaining framework.

Using a simple spline regression (see Table B3 in Appendix B), we find that the relationship between union density and the existence of formalised collective bargaining arrangements, including local bargaining over non-wage topics, and the establishment of works committees, is stronger in workplaces with less than 50% union density. Furthermore, we find a stronger relationship between union density and the existence of joint consultative committees in the interval between 25 and 50% union density, which is also where we find the largest impact of the subsidy ratio on union density.

Taken together, these results suggest the estimated productivity and wage effects arise to a large extent from variation in union density among firms where organisational features of labour–management relations appear to be sensitive to union density. The effect, it seems, is not due to the simple marginal effect of an additional union member. Rather, the effect is likely to arise when firms' density approaches the thresholds liable to trigger more formalised arrangements for bargaining and consultation. It may well be that increasing union density at very low levels

has little impact on productivity and wages, perhaps because a sufficient level of membership is not there to provide formal channels of influence. Similarly, it may be that increasing union density at high levels has little impact on productivity and wages, perhaps because a sufficient level of membership is already there to establish and maintain strong formal channels of influence.

9. Conclusion

We find that increasing union density leads to improved firm level productivity in Norway. The negative relationship between union density and productivity apparent in OLS estimates disappears and becomes weakly positive but non-significant once we control for firm fixed effects. However, it becomes statistically significant and strongly positive when we use exogenous variation in the average tax subsidy on union membership fees of the workers in the firm to instrument for union density.

The OLS results are not surprising. If a high risk of job loss increases the demand for union services (and thus membership), or if less productive workers sort into union membership, we would expect to find a negative correlation. Our IV-approach takes this into account. By exploiting variation in union density caused by the exogenous variation in the subsidy of union membership, we identify a positive causal impact on productivity. The effect is quite sizeable. If the subsidy of union density had been kept at the 2001 level, union membership rates would have been roughly 2–3 percentage points lower, implying that our firms would have experienced productivity growth 4–6 percentage points lower over the subsequent 11 years. This amounts to about 10% of the average growth of 4.4% per year in value added in the industries covered by our data over the period. Caution should be exercised, however, in interpreting our results as equally valid across the board; as discussed above, it may well be that identification is based on variation in the data arising where union membership matters the most.

What possible mechanisms might explain this causal relationship? These local productivity effects could be caused by Freeman and Medoff's voice effect, in combination with efficient bargaining effects. The complier analyses show that the tax reforms induce more workers from smaller firms with moderate unionisation to join a union. Effects for large firms, from highly unionised firms and from firms with no unions whatsoever are smaller. We have also found that the type of firms where the subsidy ratio has the strongest impact on union density are the same type of firms where the association between union density and organisational features such as the existence and scope of collective agreements, employer organisation, consultations and joint consultative committees is the strongest. It is thus likely that the productivity effects we identify to some extent arise from a sufficient number of workers unionising to establish and maintain formal channels of influence.

We also find a strong positive relationship between firm level wages and union density. The effect is positive and occurs both as an absolute effect and as a rent sharing effect, and the causal impact of union density is greater in more productive firms, as one might anticipate if unions are successful in bargaining over firm rents.

It is not possible to say whether one might expect to see similar positive union effects on productivity and wages in other countries because union effects are likely to be heterogeneous with respect to national systems of employment relations and the institutional underpinnings to union influence—most notably, the presence of different bargaining coverage arrangements and the strength of union presence at workplace or firm level.

The only efforts at capturing the causal effects of unionisation to date are confined to the United States where the employment relations system and union institutions are very different from those in Norway. The tax subsidisation of union membership in the United States[30] and elsewhere nevertheless provides an opportunity for analysts to deploy a similar identification strategy to the one used here to recover causal effects of unionisation on firm-level outcomes.

Appendix A

Table A1. *The Impact of Subsidising Union Membership on the Probability of Union Membership Conditional on Time Trends.*

	Model 1	Model 2	Model 3	Model 4
Time trend	−0.0056***	−0.0094***	−0.0097***	−0.0097***
	(0.0011)	(0.0015)	(0.0015)	(0.0015)
Time trend squared	0.0002***	0.0003***	0.0003***	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Subsidy		0.00003***	8.9e-6	6.5e-6
		(0.00001)	(0.00001)	(0.00001)
Subsidy relative to net union fee			0.091**	0.097**
			(0.038)	(0.039)
Net union fee inverse				−5.133
				(3.308)
Controls				
Job class (FE)	Yes	Yes	Yes	Yes
Educational qualification (FE)	Yes	Yes	Yes	Yes
NXT	2,460,383	2,460,383	2,460,383	2,460,383

Notes: Job class: 3,831 units (three-digit occupation X two-digit industry). Educational qualification: 76 (two-digit codes). ***, ** and * denote 1, 5 and 10% levels of significance.

[30] When completing a tax return in the United States one can deduct dues and initiation fees paid for union membership. These are entered as unreimbursed employee expenses on Line 21 of Schedule A (Form 1040) Itemised Deductions.

Table A2. *Compliers.*

	1.quartile	2.quartile	3.quartile	4.quartile
Pr(Xi = xi)	0.2500	0.2500	0.2500	0.2500
1.stg.est. Intercept	0.2321***	0.5080***	0.6906***	0.8876***
	(3.2e-10)	(1.9e-9)	(3.0e-9)	(1.1e-9)
1.stg.est. instrument	0.0030	0.2703**	0.4099***	0.1448*
	(0.0409)	(0.1227)	(0.0839)	(0.0787)
Pr(complier|Xi = xi)	0.0010	0.0895**	0.1373***	0.0498 *
Pr(always union|Xi = xi)	0.2323***	0.5236***	0.7127**	0.8949***
Pr(never union|Xi = xi)	0.7668***	0.3869***	0.1500***	0.0568*
Pr(Xi = xi|complier)	0.0036	0.3224	0.4944	0.1792
	0.0144	1.2896	1.9776	0.7168
Pr(Xi = xi|complier)/Pr(Xi = xi)				
N	615,221	615,220	615,221	615,220

Notes: Job class: 3,831 units (three-digit occupation X two-digit industry). Education—job class FE: control for 27,692 fixed effects. Note the predicted probability is predicted based on Model 3 of Table 2 excluding the instrument, and data are then sorted into the four quartiles. *1.stg.est. instrument* expresses the estimate associated with the subsidy ratio in separate regressions for each quartile comprising the same controls as Model 3 of Table 2. ***, ** and * denote 1, 5 and 10% levels of significance.

Table A3. *Descriptive Statistics. Firm-Level.*

	lnVA	lnVA per worker	lnC	lnL	Share high-skilled	Union	Subsidy ratio	1,000/net union fee	lnW	Worker fixed effect	N
2001	8.42	5.99	6.92	2.43	0.15	0.29	0.078	0.32	0.02	−0.06	5339
	(1.54)	(0.62)	(2.59)	(1.31)	(0.21)	(0.32)	(0.02)	(0.38)	(0.24)	(0.31)	
2002	8.48	6.03	6.88	2.44	0.16	0.30	0.077	0.31	0.02	−0.05	5174
	(1.53)	(0.58)	(2.62)	(1.32)	(0.21)	(0.32)	(0.02)	(0.38)	(0.26)	(0.30)	
2003	8.37	6.04	6.63	2.32	0.16	0.27	0.12)	0.32	−0.01	−0.04	5722
	(1.54)	(0.60)	(2.68)	(1.31)	(0.22)	(0.31)	(0.03)	(0.35)	(0.25)	(0.30)	
2004	8.41	6.14	6.58	2.27	0.17	0.27	0.160	0.33	−0.02	−0.05	5887
	(1.53)	(0.59)	(2.71)	(1.31)	(0.23)	(0.31)	(0.03)	(0.35)	(0.28)	(0.31)	
2005	8.45	6.17	6.57	2.27	0.18	0.26	0.156	0.32	−0.03	−0.05	6008
	(1.55)	(0.61)	(2.72)	(1.31)	(0.24)	(0.31)	(0.03)	(0.34)	(0.32)	(0.31)	
2006	8.56	6.26	6.60	2.28	0.19	0.26	0.196	0.32	−0.02	−0.07	6102
	(1.57)	(0.65)	(2.77)	(1.32)	(0.25)	(0.31)	(0.04)	(0.33)	(0.32)	(0.31)	
2007	8.68	6.37	6.78	2.32	0.19	0.25	0.240	0.33	−0.01	−0.10	5782
	(1.55)	(0.62)	(2.69)	(1.31)	(0.24)	(0.30)	(0.05)	(0.33)	(0.34)	(0.30)	
2008	8.75	6.40	6.96	2.35	0.19	0.26	0.273	0.32	−0.01	−0.11	5508
	(1.55)	(0.67)	(2.66)	(1.31)	(0.24)	(0.30)	(0.05)	(0.34)	(0.30)	(0.30)	
2009	8.64	6.33	6.95	2.32	0.20	0.26	0.304	0.32	−0.05	−0.12	5478
	(1.59)	(0.69)	(2.72)	(1.31)	(0.25)	(0.30)	(0.06)	(0.33)	(0.31)	(0.31)	
2010	8.69	6.38	6.96	2.32	0.21	0.26	0.300	0.31	−0.07	−0.13	5611
	(1.58)	(0.67)	(2.68)	(1.31)	(0.25)	(0.30)	(0.06)	(0.31)	(0.33)	(0.31)	
2011	8.75	6.44	6.97	2.30	0.21	0.25	0.296	0.30	−0.06	−0.14	5406
	(1.58)	(0.68)	(2.68)	(1.30)	(0.25)	(0.30)	(0.06)	(0.12)	(0.30)	(0.30	
2012	8.81	6.47	6.75	2.34	0.21	0.26	0.292	0.29	−0.06	−0.15	5387
	(1.62)	(0.70)	(2.88)	(1.32)	(0.25)	(0.30)	(0.06)	(0.11)	(0.29)	(0.29)	

Notes: Means and (standard deviations). Population: Firms in Statistics Norway's Capital Data Base linked to individual worker information. LnVA and lnC denote log value added and log capital, respectively. lnL denotes log number of workers. Share high-skilled (educational qualification) denotes the share of high-skilled workers. Union denotes union density. lnW and Worker fixed effect denote the residual and the fixed worker effect from a worker-level log hourly wage regression on year dummies (10) and age vigintile (19) dummies, respectively. Note that the inverse of the net union fee and the subsidy ratio are calculated keeping the gross union price fixed from the first observational year and then letting only the subsidy vary over time.

Table A4. *The Impact of Union Density on Workplace Productivity. Heterogeneous Production Technology Across Industries.*

	lnL	Share high-skilled	lnC	Lagged polynomial
SIC2				
14	0.886***(0.161)	−1.859***(0.748)	−0.027***(0.039)	Yes
15	0.604***(0.025)	0.325***(0.109)	0.072***(0.019)	Yes
17	0.584***(0.042)	−0.029 (0.150)	0.033***(0.012)	Yes
18	0.508***(0.076)	−0.252 (0.224)	0.010 (0.024)	Yes
19	0.539***(0.094)	−0.126 (0.458)	−0.007 (0.055)	Yes
20	0.714***(0.026)	0.082 (0.149)	0.037***(0.013)	Yes
22	0.729***(0.030)	0.156** (0.074)	0.044***(0.009)	Yes
24	0.664***(0.062)	0.149 (0.182)	0.049***(0.042)	Yes
25	0.641***(0.035)	0.464***(0.107)	0.072***(0.020)	Yes
26	0.490***(0.027)	−0.028 (0.102)	0.020 (0.014)	Yes
27	0.797***(0.056)	0.362* (0.188)	0.020 (0.018)	Yes
28	0.720***(0.022)	−0.061 (0.081)	0.046***(0.007)	Yes
29	0.677***(0.034)	0.206** (0.088)	0.075***(0.011)	Yes
31	0.642***(0.052)	0.217** (0.104)	0.038***(0.013)	Yes
32	0.514***(0.093)	0.418** (0.175)	0.017 (0.033)	Yes
33	0.637***(0.048)	−0.127 (0.108)	0.032** (0.015)	Yes
34	0.717***(0.050)	0.601* (0.337)	0.052 (0.040)	Yes
35	0.903***(0.026)	0.412***(0.138)	0.026 (0.016)	Yes
36	0.676***(0.037)	0.203** (0.103)	0.013 (0.011)	Yes
45	0.319** (0.132)	0.528 (0.425)	0.107***(0.039)	Yes
51	0.311***(0.078)	0.092** (0.465)	0.045 (0.028)	Yes
52	0.307***(0.092)	−0.298 (0.204)	0.072** (0.031)	Yes
74	0.665***(0.157)	−0.077 (0.395)	−0.002 (0.056)	Yes
Method:		LPW-GMMIV		

Notes: Estimation of Cobb–Douglas production functions. Method: GMM-IV (based on Wooldridge's improvements on the method of Levinsohn and Petrin). Dependent variable: ln(value added). Column head denote right-hand side variables. LnL and share high-skilled denote log workforce size and share of high-skilled (educational qualification above high school) workers, respectively. LnL and Share high-skilled are instrumented using lagged values. Each row reports results separately for two-digit industries. Lagged unobserved productivity is approximated by a 3rd-order polynomial. Robust standard errors adjusted for firm-level and year clustering are reported in parentheses. ***, ** and * denote significant at the 1, 5 and 10% levels of significance, respectively.

Table A5. *The Impact of Union Density on Workplace Average Log Hourly Wage. First-Stage Estimates.*

	Model 1—OLS	Model 2—FE	Model 3—IV	Model 4—IV	Model 5—IV	Model 6—IV	Model 7—IV	Model 8—IV
First-stage union density								
Subsidy ratio			33.043***	29.816***	31.254***	33.487***	31.089***	26.681***
			(7.735)	(7.105)	(7.148)	(7.281)	(7.146)	(7.575)
Ln capital (lnC))						0.075	0.065	−0.076
						(0.084)	(0.084)	(0.141)
Subsidy ratio X LnC								0.628
								(0.472)
First-stage Ln VA per worker								
Subsidy ratio						0.513***	0.660***	0.437*
						(0.186)	(0.222)	(0.237)
Ln capital (LnC)						0.048***	0.047***	0.040***
						(0.004)	(0.004)	(0.005)
Subsidy ratio X LnC								0.032**
								(0.016)
First-stage union density X Ln VA per worker								
Subsidy ratio								−58.27***
								(11.230)
Ln capital (LnC)								−1.646***
								(0.231)
Subsidy ratio X LnC								7.688***
								(0.999)

Notes: First-stage estimates of the IV wage regressions reported in Table 6. See Table 6 note on other controls and details. Robust standard errors adjusted for firm-level and year clustering are reported in parentheses. ***, ** and * denote 1, 5 and 10% levels of significance.

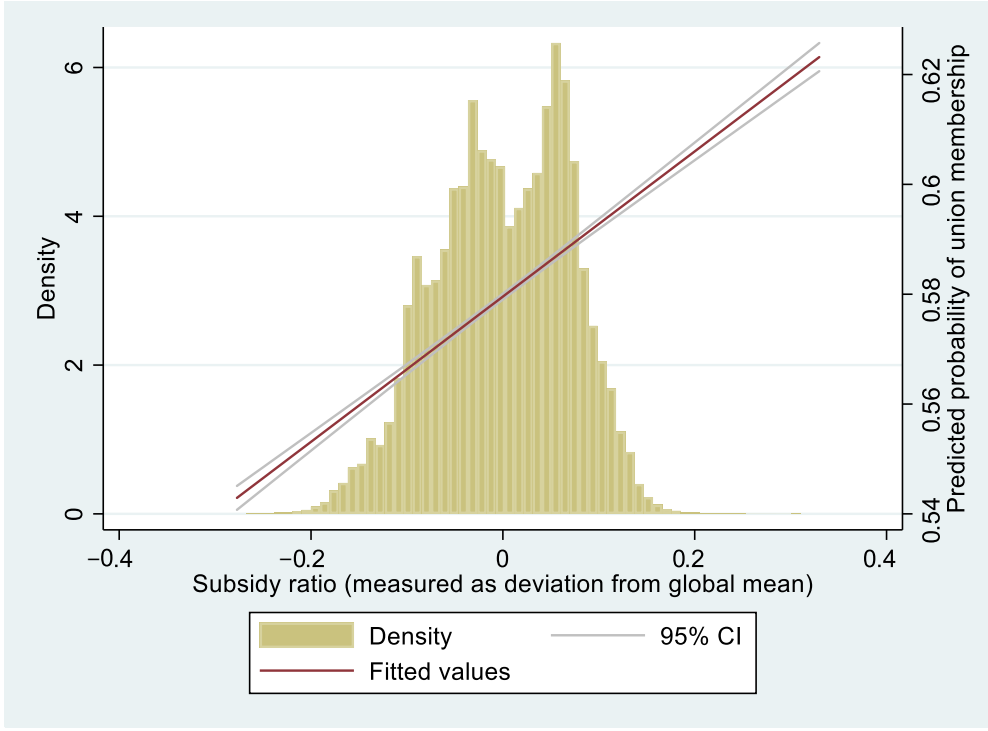

Fig. A1. *Union Membership and the Subsidy Ratio. Worker-Level Analysis.*
Notes: Figures predicted based on estimates of Table 2, Model 3.

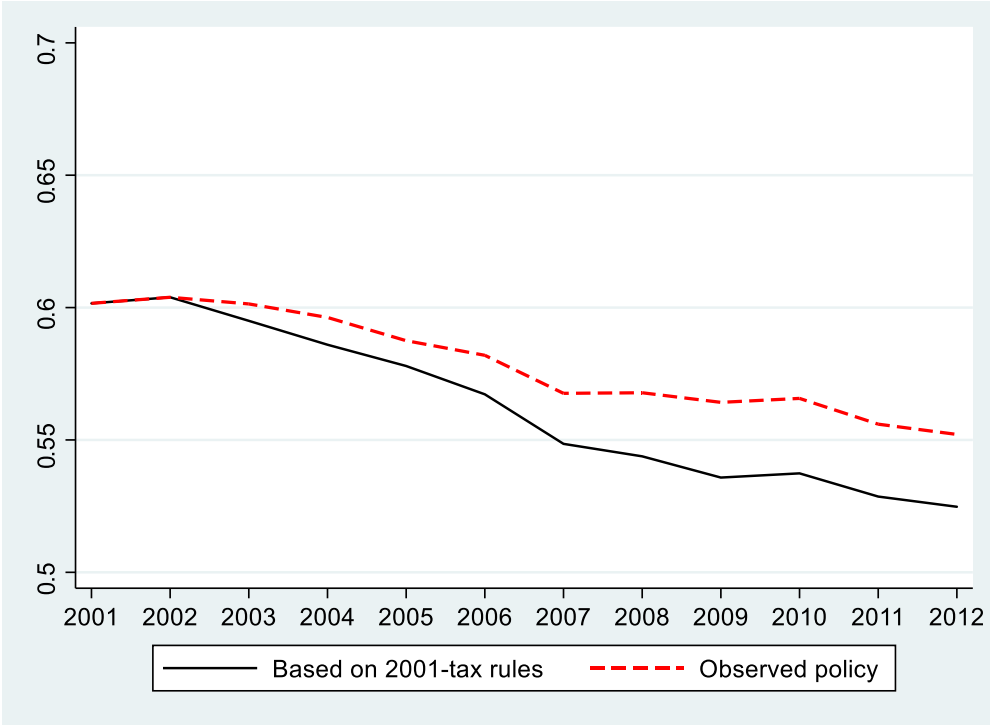

Fig. A2. *The Counterfactual Development in Union Membership Without Tax Policy Reforms: Worker-Level Analysis.*
Notes: Figures predicted based on estimates of Table 2, Model 3.

Appendix B

In this appendix we explore the relationship between union density and the organisation and formalisation of worker–management relations in the workplace. Certain levels of union membership may facilitate or even be necessary in order to establish formalised structures, such as collective agreements and other channels of voice in the workplace. Using data from an enterprise survey, we observe various features of employer–employee relations. A principal component analysis separates out three dimensions of formalise structures of worker–management relations, and we explore how these different formalised channels of voice are related to union density.

Our data are from the Norwegian Labour and Enterprise Survey 2003 (NLES). NLES is, appropriately weighted, representative for the population of Norwegian workplaces with more than ten employees, see, e.g., Barth et al. (2012) and Barth, Moene and Willumsen (2014) for previous use and details of the survey. The questionnaire comprises information on unionisation, collective agreements, mandated work committees (‘bedriftsutvalg’), co-operative committees (‘samarbeidsutvalg’), joint consultative committees (‘kontaktutvalg’), non-wage related bargaining topics, and membership in employer organisation. We measure non-wage bargaining by a

Table B1. *Descriptive Statistics. Norwegian Labour and Enterprise Survey 2003. Manufacturing.*

Variable	Mean	SD
Collective agreement—local	0.71	0.46
Collective agreement—sectoral	0.13	0.33
Non-wage local bargaining topics	0.64	0.48
Works committee	0.18	0.38
Co-operative committee	0.13	0.33
Joint consultative committee	0.48	0.50
Employer organisation	0.78	0.42
Workplace age	31.14	10.84
Workforce size	59.33	123.22
Union density	0.58	0.38
N	454	

Notes: Manufacturing workplaces from the Norwegian Labour and Enterprise Survey 2003. The observations are weighted to be representative for workplaces with more than ten employees.

Table B2. *Principal Components of Collective Agreements, Bargaining Topics and Channels for Employee Voice. Manufacturing Sector 2003.*

Variable	Comp1 'Formalisation with local wage barg.'	Comp2 'Formalisation with sectoral wage barg.'	Comp3 'Joint consultative committee'	Comp4	Comp5	Comp6	Comp7
Collective agreement—local	0.61	−0.33	0.05	0.03	−0.04	−0.09	0.72
Collective agreement—sectoral	−0.49	0.54	0.02	0.08	0.08	−0.18	0.64
Non-wage local bargaining topics	0.43	0.40	0.16	0.33	0.36	−0.57	−0.26
Works committee	0.30	0.40	−0.08	−0.66	0.42	0.36	0.02
Co-operative committee	0.11	0.11	−0.64	0.56	0.22	0.43	0.05
Joint consultative committee	−0.01	0.03	0.74	0.25	0.20	0.53	0.03
Employer organisation	0.31	0.52	0.04	0.05	−0.77	0.17	−0.06
Eigenvalue	1.99	1.33	1.26	0.91	0.71	0.56	0.22

Notes: Manufacturing workplaces taken from the Norwegian Labour and Enterprise Survey 2003. The observations are weighted to be representative for workplaces with more than ten employees.

dummy taking the value of 1 if negotiations with unions are conducted on issues such as productivity, work hours, downsizing, reorganisations, training, and pensions, and 0 otherwise. We construct various other dummy variables that represent the different formalised features of the organisation. Table B1 provides summary statistics on key variables in the survey.

In Table B2 we estimate the principal components associated with these measures. The three components with eigenvalues greater than 1 turn out to be:

1) Local bargaining: local wage barg + non-wage local + works committee + employer org
2) Sectoral bargaining: sectoral wage barg + non-wage local + works committee + employer org
3) Joint consultative committees.

Table B3. *Principal Components Associated with Collective Agreements, Committees and Councils at Different Union Density Intervals. Manufacturing Sector 2003.*

	Formalisation with local wage bargaining (Comp1)		Formalisation with sectoral wage bargaining (Comp2)		Joint consultative committees (Comp3)	
	Mean	SD	Mean	SD	Mean	SD
Union density, 0–25%	−2.072	1.441	−1.118	1.106	−0.524	0.880
Union density, 25.1–50%	−0.781	1.387	−0.244	1.562	0.136	1.152
Union density, 50.1–100%	0.018	1.283	−0.084	1.119	0.118	1.050

Notes: The table shows, for different union density intervals, Mean value (and standard deviations) of selected principal components from Table B2 by different brackets of union density. Column head denotes the principal components (those with Eigenvalue above 1 in Table B2). The population is observations of manufacturing workplaces from the Norwegian Labour and Enterprise Survey 2003. The observations are weighted to be representative for workplaces with more than ten employees.

How do these three principal components vary across different levels of union density? First, in Table B3 we see simple descriptives for these principal components at different intervals of union density; 0–25%, 25–50% and 50–100%. We see that, for all three principal components, the values of the principal components increase as union density increases. We also note that the increase in value appears to be stronger between 0–25% and 25–50% than between 25–50% and 50–100%.

Secondly, we can illustrate these relationships graphically, by constructing averages of 11 equal-sized binned observations of the principal components and union density, where both variables are measured as residuals from regressions including two-digit industry controls, and then plotting this in Figure B1. In this figure we have in addition imposed a discontinuity at a union density of 50%, and fitted lines (between the principal components and union density) based on separate estimations below and above this threshold. Also Figure B1 reveals that the principal components increase less above a union density of 50% than below 50%.

Thirdly, in Table B4, we show results from regression models using the three first principal components as dependent variables and union density in % as the independent variable. We use a specification with three splines (knots at 25 and 50%) and include controls for industry at the two-digit SIC level. Note that the overall slope of the first bracket (0–24) is given by the coefficient for 0–100, the overall slope of the second bracket (25–49) is given by the sum of the coefficients for 0–100 plus the coefficient for 25–100, and the overall slope of the last bracket is given by the sum of all three coefficients. We also include a specification with only two splines, with the cut at 50% union density.

In the interval 0–25%, union density is strongly related to the establishment of a collective trade union agreement, the establishment of mandated works committees, and employers' membership in an employer organisation. Overall, this implies a formalised organisation of labour–management relations (with rights and duties). Collective agreements pertain to specific worker groups defined by their unions. However, when union density increases further, also less formalised meeting areas, such as joint consultative committees, are established. In these committees, employer and worker representatives (across several unions and non-union workers) discuss all matter relevant for workers (but no negotiation occurs, e.g., of wages and hours).

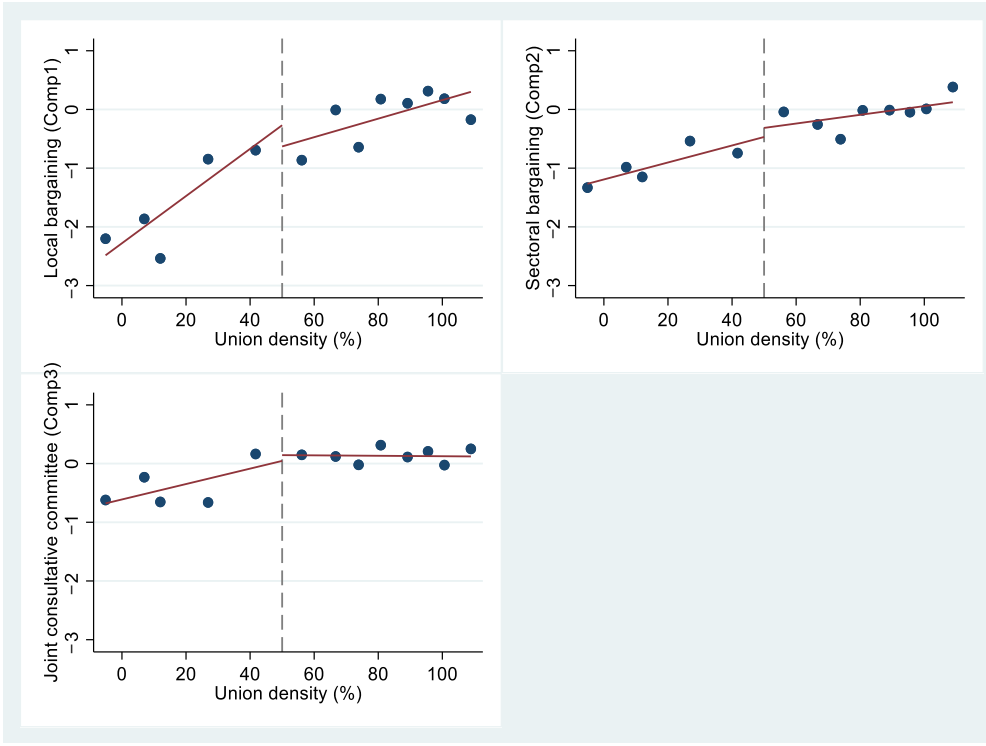

Fig. B1. *The Principal Components and Union Density. Manufacturing Sector 2003. Within Industry.* *Notes:* The figures are based on averages of 11 equal-sized binned observations of the principal components and union density, where both variables are measured as residuals from regressions including two-digit industry controls. We have imposed a discontinuity at a union density of 50%, and the fitted lines are estimated separately below and above this threshold.

Table B4. *The Correlations between the Principal Components and Union Density. Spline Regressions. Manufacturing Sector. 2003.*

	Formalisation with local wage bargaining (Comp1)		Formalisation with sectoral wage bargaining (Comp2)		Joint consultative committees (Comp3)	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Union density (percent)	0.055***	0.043***	0.021	0.022***	−0.004	0.017***
(0–100)	(0.011)	(0.011)	(0.016)	(0.002)	(0.008)	(0.004)
Union density	−0.025		0.003		0.045***	
(25–100)	(0.016)		(0.034)		(0.013)	
Union density	−0.026*	−0.041**	−0.021	−0.019***	−0.047***	−0.020***
(50–100)	(0.014)	(0.015)	(0.020)	(0.003)	(0.011)	(0.007)
Controls:						
Industry (25)	Yes	Yes	Yes	Yes	Yes	Yes
R2-adj	0.41	0.41	0.44	0.45	0.11	0.10
N	454	454	454	454	454	454

Notes: Regression coefficients for union density on the three predicted principal components from Table B2. Dependent variable denoted by column head (each of the first three principal components with Eigenvalue above 1 in Table B2). The population is observations of manufacturing workplaces taken from the Norwegian Labour and Enterprise Survey 2003. Union density is measured in %, by three splines (knots at 25 and 50), where the spline has been created by stata's mkspline. We control for two-digit SIC industry. Standard errors, adjusted for clustering on sampling strata, are reported in parentheses. ***, ** and * denote 1, 5 and 10% levels of significance, respectively.

We note that in the highest bracket of union density, consistently with the pattern observed in the figure, a higher membership is not positively associated with any of the principal components representing formalised organisations, as the estimated slope is around zero. At membership above 50%, most structures of formalisation are already in place, and further increases makes little difference.

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Additional Supporting Information may be found in the online version of this article:

Replication Package

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