Doctoral theses at NTNU, 2023:406

Fredrik B. Kostøl

Trade Unions and Productivity

Empirical Analyses of the Norwegian Labor Market

Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Economics and Management
Department of Economics

NTNU
Norwegian University of
Science and Technology

Fredrik B. Kostøl

Trade Unions and Productivity

Empirical Analyses of the Norwegian Labor Market

Thesis for the Degree of Philosophiae Doctor

Trondheim, December 2023

Norwegian University of Science and Technology
Faculty of Economics and Management
Department of Economics

NTNU
Norwegian University of
Science and Technology

NTNU
Norwegian University of Science and Technology

Thesis for the Degree of Philosophiae Doctor

Faculty of Economics and Management
Department of Economics

ISBN 978-82-326-7510-4 (printed ver.)
ISBN 978-82-326-7509-8 (electronic ver.)
ISSN 1503-8181 (printed ver.)
ISSN 2703-8084 (online ver.)

Doctoral theses at NTNU, 2023:406

Printed by NTNU Grafisk senter

Preface

This thesis is submitted to the Norwegian University of Science and Technology (NTNU) for partial fulfillment of the requirements for the degree of Philosophiae Doctor (PhD). The thesis consists of three independent research papers on how trade unions influence technology adoption, skill formation, and ultimately productivity at the firm level in Norway. The first and third paper are joint work with Elin Svarstad at the Fafo Institute for Labour and Social Research. These papers utilize administrative register data provided by Statistics Norway. The second paper, which is authored by me alone, uses administrative register data provided through the online application *microdata.no*.

Abstract

This thesis is concerned with the question of how trade unions influence the productivity of firms and workers. To answer this question, I utilize rich administrative register data from Norway to investigate how unions influence technology adoption, skill formation, and ultimately productivity at the firm level in three separate research papers. In the first article, we develop a theoretical framework that highlights two important mechanisms through which unions may influence technological change. By exploiting exogeneous variation in the tax rules for union members, we show how unions affect the structural composition of occupations within workplaces by altering relative wages. Moreover, our results suggest that unions influence relative labor demand *conditional* on relative wages. This finding gives support to bargaining theories where unions force firms off their demand curves.

The second article investigates the impact of unions on skill formation, as measured by participation in tertiary vocational education among full-time employees. In contrast to most existing studies, which rely on data from surveys, my data comprise the entire working population over a period of 16 years, allowing me to control for unobserved individual heterogeneity. An increase in the workplace union density is estimated to raise the individual propensity to participate in tertiary vocational education. I also find that workers in unionized establishments enjoy higher salaries during further education, but at the expense of lower post-training wage premiums. In addition, employee turnover is found to be lower in more unionized establishments. Together, these findings give support to the hypothesis that union wage compression provides firms with incentives to sponsor investments in workers' skills in the absence of perfect competition in the labor market.

In the third article, we investigate how unions influence the productivity of firms, and how this relationship is affected by the quality of industrial relations as measured by the presence of a collective agreement. In the absence of an agreement, higher union density is estimated to reduce productivity. However, this effect is moderated, and in some cases turned positive, if a collective agreement is implemented in the firm. Our results indicate that the presence of a collective agreement and a sufficiently high union density combined have a positive impact on firm-level productivity.

Sammendrag

Denne avhandlingen handler om hvordan fagforeninger påvirker produktiviteten til bedrifter og arbeidstakere. For å svare på dette spørsmålet, anvender jeg detaljerte registerdata til å studere hvordan fagforeninger påvirker teknologi, kompetanseutvikling og, til syvende og sist, produktivitet i norske foretak. Avhandlingen er strukturert som tre separate forskningsartikler. I den første artikkelen utvikler vi en teori som forklarer hvordan fagforeninger påvirker teknologisk utvikling gjennom to sentrale mekanismer. Ved å utnytte endringer i reglene for skattefradrag for fagforeningsmedlemskap, viser vi hvordan fagforeninger endrer den strukturelle sammensetningen av yrker innad i virksomheter gjennom å påvirke relative lønninger. Vi finner i tillegg at fagforeninger påvirker den relative etterspørselen etter ulike typer arbeidskraft, selv når vi kontrollerer for relative lønninger.

Den andre artikkelen undersøker om fagforeninger påvirker kompetanseutvikling, målt ved deltakelse i fagskoleutdanning blant heltidsansatte arbeidstakere. I motsetning til eksisterende studier, som i stor grad er basert på spørreundersøkelser, anvender jeg detaljerte data om alle arbeidstakere over en periode på 16 år, noe som lar meg kontrollere for uobserverbare individuelle kjennetegn. Jeg finner en positiv sammenheng mellom organisasjonsgraden på arbeidsplassen og den enkelte arbeidstakers tilbøyelighet til å delta i høyere yrkesfaglig utdanning. Jeg finner også at ansatte i virksomheter med høy organisasjonsgrad får utbetalt høyere lønn underveis i utdanningen, men at dette går på bekostning av lavere lønnskompensasjon etter endt utdanning. I tillegg er gjennomtrekket av ansatte lavere i virksomheter med høy organisasjonsgrad. Samlet gir disse funnene støtte til hypotesen om at fagforeninger styrker bedrifters insentiver til å gi økonomisk støtte til ansatte under utdanning.

I den tredje artikkelen undersøker vi hvordan fagforeninger påvirker produktiviteten til bedrifter, og hvordan dette forholdet påvirkes av tilstedeværelsen av en tariffavtale. I fravær av en tariffavtale, finner vi at økt organisasjonsgrad påvirker produktiviteten negativt. Dersom man derimot innfører en tariffavtale, blir denne effekten redusert og i mange tilfeller positiv. Resultatene våre tyder derfor på at fagforeninger kan påvirke produktiviteten positivt dersom bedriften både har en tariffavtale og en tilstrekkelig høy organisasjonsgrad blant de ansatte.

Acknowledgements

I am indebted to many people who have supported and challenged me during the four years of my PhD. First and foremost, I would like to thank my supervisor, Ragnar Torvik, who has always taken the time to answer any questions or concerns I have had during every step of this journey. He has provided invaluable feedback on all my work in a very clear and efficient manner, which has made the process of my PhD much more comprehensible. I would also like to extend my gratitude to my co-supervisor, Halvor Holtskog, for encouraging me and giving me the confidence to reach my goals (and for literally demonstrating the difference between robots and automation). I would also like to thank Aristidis Kaloudis, Kåre Johansen, Terje Skjerpen, Ragnar Nymoen, Torberg Falch, Harald Dale-Olsen, and Colin Green for helpful discussions and comments on my drafts.

Doing research together with other scholars is much more fun than working alone. Thank you, Elin Svarstad, for all the collaboration and endless hours of Stata with shared screens in Teams. I look forward to the continuously growing list of future research projects.

I would like to thank all my colleagues in Gjøvik for embracing me as a teammate, and for all our informal conversations during lunches and coffee breaks which have made these four years more enjoyable.

A special thanks to Ottar Henriksen, who made this possible, and to Roger Bjørnstad for inspiring me to do a PhD on the Norwegian Model.

Last but not least, I would like to thank my family for always believing in me, especially Stine, for all your support and patience throughout this journey. Together with our children, Frida and Eilev, you have been a constant reminder of what really matters.

Contents

Introduction **1**

Chapter 1

Trade Unions and the Process of Technological Change **7**

Chapter 2

Do Unions Increase Participation in Further Education? **49**

Chapter 3

Unions, Collective Agreements and Productivity: A Firm-Level Analysis Using Norwegian Matched Employer-Employee Panel Data **83**

Introduction

This thesis is concerned with the question of how trade unions influence the productivity of firms in Norway. The Norwegian labor market is characterized by strong trade unions organized within a few major confederations who, together with a handful of umbrella organizations of employers' associations, have profound impacts on firms and workers through a hierarchy of collective agreements. While the main contents of collective agreements are negotiated at the central level, with sectoral adjustments, individual coverage is dependent of a workplace agreement, which is only established if the workplace union density reaches certain thresholds defined by the unions. In order to study the impact of trade unions in Norway, it is thus relevant to consider variations in unions density and collective agreement coverage rates across workplaces and within workplaces over time.

Collective agreements include central provisions on wage bargaining and working conditions. At the same time, the agreements establish and codify a system of collaboration, communication, and participation at the workplace, with the explicit purpose of enhancing productivity. The clear focus on co-operation in the collective agreements partly reflects and partly contributes to sustaining the long Nordic tradition of close co-operation between employers' associations and trade unions, as well as a high degree of co-determination and participation at the company level.

Internationally, what unions do to productivity has been the subject of extensive research for decades. According to the traditional neoclassical view, unions act as monopolies that distort the efficient allocation of resources in the labor market. By adding a union premium on market wages, wages will be set higher than the marginal productivity of labor and result in lower employment than what would be the case with perfectly competitive markets, thereby resulting in a social loss. Moreover, the presence of a union may limit a firm's flexibility in personnel decisions by introducing rules such as seniority in firing and hiring (Freeman & Medoff, 1984, p. 164). Any form of industrial unrest such as strikes or "work-to-rule" actions will also impede productivity by temporarily reducing the utilization of the firm's resources and causing uncertainty about output levels (Caves, 1980; Flaherty, 1987).

However, once we abstract from the perfectly competitive environment and allow for market imperfections, the impact of trade unions on productivity is no longer obvious. In the seminal works by Freeman and Medoff (1979; 1984), unions are portrayed with two "faces": the *monopoly face* and the *exit voice/institutional response face*. While the former refers to the monopoly power attained by unionizing workers, the latter covers various mechanisms through which unions may alter industrial relations. By providing workers with a means of expressing discontent through a collective voice, unions may reduce employee turnover and improve job satisfaction.

Simply put, the productivity of a firm is determined by the marginal products of the inputs in production, and how efficiently the inputs are combined to produce a certain amount of output. If we consider a simple production technology, where a final good is produced using some combination of capital and labor inputs, the question of how unions influence firm level productivity raises three fundamental research questions:

1. How do unions influence investments in capital?
2. How do unions influence investments in human capital?
3. How do unions influence total factor productivity, conditional on capital and labor inputs?

Theoretically, the impact of unions on capital formation is ambiguous (Freeman & Medoff, 1984, p. 170). On the one hand, unions may lower capital investments, as shareholder's expected return is reduced by the risk of ex-post rent-seeking by unions in the absence of binding contracts (Baldwin, 1983; Grout, 1984). By lowering investments, unions could thus potentially hamper innovation and adoption of new technologies (Connolly, et al., 1986). On the other hand, however, union wage premiums may strengthen firms' incentives to invest in capital as the relative price on capital to labor is lowered. Moreover, if unions compress the distribution of wages, this may provide firms with incentives to invest in new technology that substitutes for low-skilled labor and complements high-skilled labor, as the relative price of high-skilled labor over low-skilled labor is reduced. Unions may also influence investment by exploiting their bargaining power to influence strategical managerial decisions directly, effectively forcing employers off their demand curves (Freeman & Medoff, 1982; Maki & Meredith, 1987).

Regarding how unions influence investments in skills, the natural starting point is the theory of human capital. According to the standard theory, firms will never pay for investments in the general skills of their employees (Becker, 1964). As unions are known to compress the structure of wages, thereby reducing the individual's return to education, unions are likely to reduce workers' investments in skills (Mincer, 1981). Acemoglu & Pischke (1999), however, show how firms may find it optimal to invest in the general skills of their employees if the firm possesses monopsony power in the labor market, and that this effect is amplified by union wage compression. Hence, while wage-compression reduces workers' investments in skills, this reduction may be offset by increased incidence of firm-sponsored general training. In this case, the theoretical effect of unions on training is ambiguous. Booth & Chatterji (1998) further argue that reduced turnover in unionized firms will increase firms' incentives to invest in the skills of their workers, as the risk of losing the investment to competitors is lowered. Furthermore, unions may use their bargaining power to require firm-sponsoring of general training as part of their compensation package (Booth, et al., 2003).

This thesis is organized as three individual articles seeking to answer the three research questions above. The paper presented in Chapter 1, which is co-authored with Elin Svarstad, investigates how trade unions influence the process of technological change at the workplace level. Using matched employer-employee data, comprising all Norwegian workplaces and working individuals in the period 2000-2014, we exploit exogeneous changes in the tax rules for union members to identify how changes in unionization rates affect the structural composition of occupations within workplaces. That is, we rely on an indirect measure of technology based on how different technologies complement different types of labor. Making a distinction between routine and non-routine workers, based on their estimated probabilities of being replaced by automation technologies, we show how unions contribute to raising the relative wage of routine workers over non-routine workers. As routine workers on average have lower earnings than non-routine workers, unions thereby contribute to compress wages at the workplace level. The direct implication of this policy is shown to reduce the relative demand for routine workers over non-routine workers in unionized establishments. However, our results also suggest that unions influence the relative demand for routine workers, conditional on relative wages.

As such, the paper in Chapter 1 does not give a conclusive answer to how trade unions influence technological change. However, we provide a theoretical framework that highlights two important mechanisms that the impact of unions may work through, and we document the relevance of these mechanisms using empirical evidence. Within manufacturing industries, both effects are estimated to be positive. Heterogeneity across industries may reflect different union policies and experience with technological change, as well as different exposition to international competition.

The second research question of how unions influence investments in human capital is addressed in Chapter 2. In this article, which is authored by myself, I investigate the impact of trade unions on workers' participation in further education using Norwegian matched employer-employee panel data on full-time workers and a fixed-effects framework. The race between education and technology is a key issue for trade unions. Unions often include skill-upgrading and training in collective bargains, which might be an important tool to facilitate lifelong learning. In contrast to most existing studies, which rely on more or less representative surveys, my data comprise the entire working population over a period of 16 years, allowing me to control for unobserved individual heterogeneity. An increase in the workplace union density is estimated to raise the individual propensity to participate in tertiary vocational education. I also find that workers in unionized establishments enjoy higher salaries during further education, but at the expense of lower post-training wage premiums. In addition, employee turnover is found to be lower in more unionized establishments. Together, these findings give empirical support to the theoretical prediction of Acemoglu & Pischke (1999), where firms may optimally choose to sponsor investments in workers' skills in absence of perfect competition in the labor market.

The positive relationship found between workplace union density and participation in further education does not necessarily identify a causal effect of unions on training. An alternative interpretation is that firms with lower turnover of employees, for example due to monopsony power in the labor market, are more willing to invest in the skills of their workers, whereas the workers have larger incentives to unionize to reap a share of the monopsony rent. This alternative direction of causation should be further investigated.

In the article in Chapter 3, which is co-authored with Elin Svarstad, we address the research question of how unions influence total factor productivity, when we control for capital and labor inputs. Using matched employer-employee panel data for the Norwegian labor market, comprising almost 21 million individual-year observations in the period 2002-2018, we estimate production functions conditional on firm's stock of capital and use of four different types of labor defined by educational attainment. Furthermore, we ask how the effect of unions depends on whether the firm participates in a collective agreement. Without a collective agreement, higher union density is estimated to reduce productivity. However, if a collective agreement is implemented in the firm, not only is the estimated negative effect reduced – in some cases it becomes positive. This result remains significant, numerically and statistically, across several model specifications and different estimation methods. We provide a new source of exogenous variation in union memberships by utilizing information on intergenerational transmission of union preferences. Besides regulating terms and conditions for wage formation and working hours, collective agreements have a profound impact on how firms organize and formally recognize the voice of workers. In this regard, our finding supports the conclusion of Freeman and Medoff (1984) that the quality of institutional systems is crucial to understand what unions do to productivity.

Together, the three articles provide new empirical evidence of what unions do to productivity at the firm level, within the context of the Norwegian work life model. These contributions complement the results in Barth et al. (2020), who find a positive effect of union density on firm-level productivity in manufacturing firms in Norway. The first two articles illustrate how unions may influence the *inputs* to production, while the last article makes a more direct attempt on estimating total factor productivity *conditional* on the use of inputs. Does this mean that any positive results through investments in more productive technologies or upgrading of workers' skills come in addition to the productivity effect found in Chapter 3? Not necessarily. While we do control for worker's educational attainment in the production function, we do not capture further education at the tertiary vocational level, which is what I measure in Chapter 2. Furthermore, we only control for occupational shares at the 1-digit level, which does not fully account for the technological changes studied in Chapter 1. This means that investments in new technology and skill upgrading may contribute to the positive productivity effect found in Chapter 3.

All the analyses in this thesis suggest large heterogeneity across workers, establishments, and industries. While we investigate these heterogeneities to some extent in the papers, trade unions are treated as if they are all alike. This is obviously a simplification that should be addressed in future research. After all, local unions at the shop floor represent the interest of a wide range of workers across occupations, firms, industries and regions, which are not likely to be aligned. This naturally also applies to the generalization of results outside of Norway, where the recognition, organization and operation of trade unions are different.

References

Acemoglu, D. & Pischke, J. S., 1999. Beyond Becker: Training in Imperfect Labour Markets. *The Economic Journal*, 109(453), pp. 112-142.

Baldwin, C. Y., 1983. Productivity and Labor Unions: An Application of the Theory of Self-Enforcing Contracts. *The Journal of Business*, 56(2), pp. 155-185.

Barth, E., Bryson, A. and Dale-Olsen, H. (2020). 'Union Density Effects on Productivity and Wages'. *The Economic Journal*, 130(631): 1898–1936.

Becker, G., 1964. Human Capital. Chicago: The University of Chicago Press.

Booth, A. L. & Chatterji, M., 1998. Unions and Efficient Training. *The Economic Journal*, 108(447), pp. 328-343.

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

Caves, R. E., 1980. Productivity differences among industries. Britain's economic performance. Washington: Brookings Institution.

Connolly, R. A., Hirsch, B. T. & Hirschey, M., 1986. Union rent seeking, intangible capital, and market value of the firm. *The Review of Economics and Statistics*, 68(4), pp. 567-577.

Flaherty, S., 1987. Strike activity, worker militancy, and productivity change in manufacturing, 1961–1981. *ILR Review*, 40(4), pp. 585-600.

Freeman, R. B. & Medoff, J. L., 1979. The two faces of unionism. NBER Working Paper Series, Issue No. 364.

Freeman, R. B. & Medoff, J. L., 1982. Substitution Between Production Labor and Other Inputs in Unionzed and Nonunionized Manufacturing. *The Review of Economics and Statistics*, 64(2), pp. 220-233.

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

Maki, D. R. & Meredith, L. N., 1987. A note on unionization and the elasticity of substitution. *Canadian Journal of Economics*, 20(4), pp. 792-801.

Mincer, J., 1981. Union Effects: Wages, Turnover, and Job Training. *NBER Working Paper* (No. w0808).

Chapter 1

Trade Unions and the Process of Technological Change

Fredrik B. Kostøl and Elin Svarstad

The article was published in Labour Economics on May 11, 2023.

Reference:

Kostøl, F. B., & Svarstad, E. (2023). Trade Unions and the Process of Technological Change. Labour Economics, 84, 102386. *https://doi.org/10.1016/j.labeco.2023.102386*

Trade Unions and the Process of Technological Change

Fredrik B. Kostøl †
Norwegian University of Science and Technology
Elin Svarstad
Fafo Institute of Labor and Social Research

Abstract

We investigate how trade unions influence the process of technological change at the workplace level. Using matched employer-employee data, comprising all Norwegian workplaces and working individuals in the period 2000-2014, we exploit exogeneous changes in the tax rules for union members to identify how changes in unionization rates affect the structural composition of occupations within workplaces. Making a distinction between routine and non-routine workers, based on their estimated probabilities of being replaced by automation technologies, we show how labor unions contribute to raising the relative wage of routine workers over non-routine workers. As routine workers on average have lower earnings than non-routine workers, unions thereby contribute to compress wages at the workplace level. The direct implication of this policy is shown to reduce the relative demand for routine workers over non-routine workers in unionized establishments. However, our results also suggest that unions influence the relative demand for routine workers, conditional on relative wages. Our findings thus give some support to bargaining theories where unions force firms off their demand curves.

JEL Classification: C23, C26, J24, J31, J51, O33

Keywords: unions, technological change, automation, wage bargaining, wage differentials, panel data, instrumental variables

† Correspondence: Fredrik B. Kostøl, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, 2815 Gjøvik, Norway. E-mail: fredrik.b.kostol@ntnu.no

1 Introduction

Ever since Keynes' famously predicted that new technologies would bring the disease of '*technological unemployment'* (Keynes, 1931), the process of technological change and its implications for the labor market has been a source of extensive economic research. In the last decades, the concern of labor-replacing technologies has been fueled by the progress in the use of computers (Autor et al., 2003), industrial robots (Acemoglu & Restrepo, 2020; De Vries et al., 2020), and artificial intelligence and mobile robotics (Brynjolfsson & McAfee, 2012; Frey & Osborne, 2017). Recent studies document evidence of rising inequality following serious structural change in the composition of skills (Acemoglu, 2002; Autor & Dorn, 2013), as well as a decrease in the labor share of income as a result of a slowdown in the creation of new tasks and in the reinstatement of displaced labor (Acemoglu & Restrepo, 2019).

During the same period, most countries have also experienced a decline in unionization rates. While several authors have studied the erosion of unions in conjuncture with technological change, this work has mostly been concerned with answering how the two trends compete in explaining the surge in inequality and the fall of the labor share (Freeman, 1991; Card & DiNardo, 2002; Acemoglu et al., 2001; Piketty, 2014; Krueger, 2018; Guimarães & Gil, 2022). A few studies, however, investigate how technological change may explain variation in union density. Acemoglu et al. (2001) argue how skill-biased technological change (SBTC) could explain declining unionization rates, as larger wage gaps due to productivity differences undermine the coalition among skilled and unskilled workers in support of unions. Acikgoz & Kaymak (2014) demonstrate how SBTC may explain about 40 percent of the decline of unions in the US, both by reducing the incentives of skilled workers to unionize but also by weakening the firms' incentives to hire low-skilled union workers. Dinlersoz & Greenwood (2016) also show how the patterns of unionization in the US during the 20th century may be explained by SBTC. While the surge in unionization rates during the first half of the century is shown to coincide with the diffusion of mass production during the Second Industrial Revolution, the rise of automation and computerization may explain the fall of unions during the second half of the century.

Surprisingly, little effort has been put into understanding the reverse causation, that is how unions may influence the process of technological change. This is what we investigate in the current study. How are firms' incentives to invest in automation altered by the presence of a union and how are unions to respond to this threat of replacing technology? Assuming unions lower profitability,[1] the gains in profits from investing in replacing technology in unionized firms should be higher than in non-unionized firms, all else equal. However, if the firm remains unionized, the classical holdup problem (Baldwin, 1983; Grout, 1984), where union rent seeking lowers the return on investments in the absence of binding contracts, still applies. Moreover, by exploiting its bargaining power and by influencing internal relations, unions may have a direct impact on the decision on whether or not to automate tasks previously conducted by labor. It is therefore not obvious whether unionized firms will be more or less eager to invest in replacing technology than non-unionized firms. This is, to a large degree, an empirical question.

Using matched employer-employee panel data, comprising all Norwegian establishments and employees in the period 2000-2014, we exploit exogeneous changes in the tax rules for union members to identify how structural changes in the occupational composition within workplaces are affected by variation in union density. In order to evaluate the technological direction of structural changes, occupations are measured by their estimated risk of automation according to Frey and Osborne (2017). As a test of robustness, we also apply the more widely acknowledged measure of routine-task intensity (Autor et al., 2003). The share of workers in routine occupations is used as a proxy for the technological maturity of workplaces, where a reduction in the share is interpreted as a technological advance. Our approach is therefore to estimate how the presence of a union influences changes in the share of workers in routine occupations.

Our results suggest that unions contribute to raising the relative wage of routine workers over non-routine workers. As routine workers on average have lower earnings than non-routine workers, unions thereby contribute to compress wages at the workplace level. The direct implication of this policy is shown to reduce the relative demand for routine workers over non-routine workers. However, our results also suggest that unions influence the relative demand for routine workers, *conditional* on relative wages. In other words, our study identifies two potentially opposing channels through which unions influence the process of technological change.

[1] While unions may succeed in raising productivity through voice-effects and organizational change (Freeman & Medoff, 1984), this effect is assumed to be more than canceled by union wage premia. Indeed, this is also the finding in the comprehensive meta study of Doucouliagos et al. (2017).

While more empirical evidence on how unions alter technological change has been called for (Acemoglu & Autor, 2011, p. 1160), both of the two channels identified above are previously explored in the literature. On the one hand, there is a rich literature on how unions affect both the levels and distribution of wages. The monopoly bargaining power of unionized workers is widely recognized to add a union-premium on wages (Doucouliagos et al., 2017, p. 149). In isolation, a positive union wage premium implies stronger incentives to replace labor with new technology. Furthermore, unions are often believed to compress the distribution of wages, both within firms (Svarstad & Nymoen, 2022) and at the macro level in countries with a centralized or coordinated bargaining structure (Moene & Wallerstein, 1997; Haucap & Wey, 2004; Braun, 2011; Dale-Olsen, 2021). Wage compression contributes to making low-skilled labor relatively expensive and highly skilled labor relatively cheap. In line with theories of skilled-biased technological change, low-skilled labor is also more replaceable by automation technology, while high-skilled labor is more likely to complement this technology (Acemoglu, 2002).

However, if unions are able to capture a share of the quasi-rents of investments in new technology, this can be shown to reduce firms' optimal investments in absence of binding wage contracts (Baldwin, 1983; Grout, 1984). The risk of rent-seeking lowers the expected return and thus the level of investments.[2] This finding led Freeman and Medoff (1984, p. 170) to conclude that the effect of unionization on technological advance is theoretically ambiguous. In a recent study of the Norwegian manufacturing sector by Barth et al. (2020), higher union density is found to increase firm-level productivity, as measured by value added per worker. However, the authors also find that the union wage premium is increasing in value added per worker, which indicates rent-seeking behavior. In other words, while unionized firms may face stronger incentives to substitute labor for capital due to union wage premiums, union rent seeking may lower the returns on investments.

On the other hand, unions may also alter a firm's investment decision directly through their presence in the organization. Indeed, local union representatives often work in close relationship with the management.[3] By exploiting its bargaining power and by influencing internal relations, unions may acquire *de facto* influence in the managerial strategic operations. This mechanism is part of what Freeman and Medoff (1982) called the '*relative inelasticity*

---

[2] If the union can credibly commit its wage for a sufficiently long time, however, Tauman & Weiss (1987) illustrate how unionization, under certain conditions, may encourage the adoption of labor-saving technology.
[3] See e.g., Huzzard et al. (2004) for a discussion of strategic unionism and partnership.

hypothesis', which states that labor demand is less elastic in unionized firms.[4] In effect, unions '*force employers off their demand curves'* (Maki & Meredith, 1987). That is, not only may unions affect investments indirectly through their impact on labor costs. They may also have a direct impact on the investment decisions.

If unions influence firms' investment decisions, the effect of unions on technological change will depend on the local union's attitudes to technology. Carmichael & MacLeod (1993) develop a simple model that illustrates how multiskilled workers may benefit from the productivity gains of new technology, while specialized workers lose as they are more difficult to relocate within the organization. In a related paper, Dowrick & Spencer (1994) examine the conditions under which unions will embrace or oppose technological change within a framework of oligopolistic competition in the product market. In their model, unions may rationally take the role as 'Luddites' if labor demand is sufficiently inelastic and if union preferences are weighted in favor of jobs. Building on a similar framework, Lommerud et al. (2006) show how globalization tends to make technology opposition from unions more likely, and that technology opposition is stronger in more technologically advanced countries.

Based on a meta-regression of 20 different empirical studies, Doucouliagos et al. (2017, pp. 86-109) conclude that unionization seems to have a modest negative effect on physical capital formation. However, the survey documents a stronger negative association between unions and intangible capital investments,[5] which may be a better indicator of union resistance to technology investments. Cross-country differences are found to be largely driven by labor market regulations, where union resistance to technology seems to be lower in more regulated labor markets. This finding is important in the Norwegian context, where the Working Environment Act together with centralized collective bargaining and firm level agreements form an important regulatory framework for industrial relations (Svarstad & Kostøl, 2022).

Our study adds an important contribution to the literature on the interactions between trade unions and technological change. While most previous studies have been concerned with how unions are affected by technology, we identify two mechanisms through which unions may influence the process of technological change within a simple efficient bargaining model.

---

[4] Note, however, that this finding could also reflect a higher probability of unionization and survival of unions in firms or sectors where labor demand is more inelastic.

[5] Intangibles include R&D, patents, goodwill etc. The negative correlation between unionism and R&D is found to be larger than with innovations and patents.

Moreover, we provide causal evidence of these mechanisms using rich panel data covering all Norwegian workplaces and working individuals in the private sector.

The remainder of the paper is organized as follows. Section 2 develops a theoretical framework for analyzing how unions alter the occupational composition within workplaces. In Section 3, we present our empirical strategy and discuss issues of identification. We describe our data and present descriptive statistics in Section 4, while Section 5 documents our results. Section 6 concludes.

2 Theoretical framework

The purpose of this study is to investigate how unions influence the process of technological change at the workplace level, by altering the adoption of new technology. In this section, we outline a simple conceptual model to highlight two such mechanisms. While we will not attempt to estimate the structural parameters of the conceptual model, the model motivates our empirical specifications later in the paper. The model takes as a starting point the theory of routine-biased technological change (Autor et al., 2003; Autor et al., 2006; Goos & Manning, 2007; Autor & Dorn, 2013), and then extends this approach to include labor unions.

2.1 Technology

Let the output of an establishment be determined by the following generalized CES production function, where L_R and L_N denote the use of routine and non-routine labor input, respectively:

$$Y = [\alpha(A_R L_R)^\eta + (1-\alpha)(A_N L_N)^\eta]^{\frac{\upsilon}{\eta}}, \quad (1)$$

where η denotes the substitution parameter, with the elasticity of substitution between routine and non-routine labor defined by $\sigma = \frac{1}{1-\eta}$, α denotes the distribution parameter, while A_R and A_N represent factor-augmenting technology terms. υ measures the degree of homogeneity of the production function, where $\upsilon = 1$ corresponds to the standard CES production function with constant returns to scale.

In the case of competitive labor markets, the wage paid to each type of worker is given by the value of their marginal product. That is, the wage paid to routine workers is given by:

$$w_R = \frac{\partial Y}{\partial L_R} = \upsilon\alpha A_R^\eta L_R^{\eta-1} Y^{\frac{\upsilon-\eta}{\upsilon}}, \quad (2)$$

whereas the wage paid to non-routine workers is:

(3) $$w_N = \frac{\partial Y}{\partial L_N} = \upsilon(1-\alpha)A_N^{\eta}L_N^{\eta-1}Y^{\frac{\upsilon-\eta}{\upsilon}}$$

It then follows that the relative wage paid to routine workers over non-routine workers is:

(4) $$\omega \equiv \frac{w_R}{w_N} = \frac{\alpha}{1-\alpha}\left(\frac{A_R}{A_N}\right)^{\eta}\left(\frac{L_N}{L_R}\right)^{1-\eta}$$

If we keep the relative supply of routine and non-routine workers fixed, routine-biased technological change will affect the relative pay. We define technological change to be biased towards non-routine labor if it contributes to lowering the relative pay of routine workers. This amounts to an increase (decrease) in $\frac{A_R}{A_N}$ if the elasticity of substitution is smaller (larger) than unity.[6]

Under perfect competition, workplaces take wages as given and minimize costs conditional on some level of output. The workplace's relative conditional demand function is then given by the optimality condition in (4), which rearranged and in natural logarithms yields:

(5) $$\log\left(\frac{L_R}{L_N}\right) = -\sigma\log\left(\frac{1-\alpha}{\alpha}\right) + (\sigma-1)\log\left(\frac{A_R}{A_N}\right) - \sigma\log\left(\frac{w_R}{w_N}\right)$$

That is, the optimal demand for routine workers over non-routine workers is determined by relative wages, relative productivity, the elasticity of substitution, and the distribution parameter α. The optimal demand will change in response to changes in relative wages and routine-biased technological change.

2.2 Workers

Workers supply one unit of labor each and receive no disutility from work. They are randomly equipped with skills qualifying for a job as either routine or non-routine worker. Workers choose to organize in labor unions if the utility from doing so exceeds the utility from not being organized. We will denote the wage paid to worker of type i by w_i^u if unionized and w_i if not, where the non-union wage of each group equals its marginal product of labor. The price on union membership is equal to $c(1-\lambda)$, where λ denotes a government subsidy of union membership. Moreover, as in Barth et al. (2020), we allow heterogeneous political preferences

[6] This is found by differentiating (4) with respect to A_R/A_N.

regarding union membership, by discounting the cost of union membership with $1+\varepsilon$, where $E(\varepsilon)=0$. The participation constraint for joining a union is then given by:

$$w_i^u - \frac{c(1-\lambda)}{1+\varepsilon} \geq w_i, \qquad i = R, N \tag{6}$$

From (6) it is clear that union participation depends positively on the union wage premium, the government subsidy rate and union-friendly preferences, and negatively on the union membership fee.

2.3 Unions

Labor unions organize both routine and non-routine workers in the same local union at the workplace level. They face a constant unit cost per organized member equal to $\tilde{c}$, which is financed exclusively by the membership fee c per member. As a simplification, we impose a restriction that $c=\tilde{c}$, which implies that unions are not allowed to save or lend money. The local union is assumed to maximize an objective function equal to the expected utility of a representative union member. We use $\Omega = \Omega_R + \Omega_N$ to denote the pool of routine and non-routine union members available to the firm, while w_i^u and b_i denote the union wage rate and the reservation wage paid to workers of type $i=R,N$. With state-independent utility, the union's objective function is then given by:[7]

$$V = \frac{L_R}{\Omega}\left(u(w_R^u) - u(b_R)\right) + \frac{L_N}{\Omega}\left(u(w_N^u) - u(b_N)\right) + \bar{V}\ , \tag{7}$$

where $\bar{V} \equiv \frac{\Omega_R}{\Omega}u(b_R) + \frac{\Omega_N}{\Omega}u(b_N)$ represents the disagreement outcome, defined by the reservation wages of the two groups of workers multiplied by their respective shares in the available workforce. The reservation wage reflects the workers' outside option, which may differ between routine workers and non-routine workers. As we will see shortly, the possibility of different reservation wages has important implications for the predictions of the model.

The local union and the firm are assumed to simultaneously determine wages and employment of routine and non-routine workers in a bargaining process. The bargaining is efficient, in the

[7] To see this, note that the expected utility of a representative union member is given by the expected utility of a unionized routine worker times the fraction of routine workers, plus the expected utility of a unionized non-routine worker times the fraction of non-routine workers. The local union treats the pool of workers available to the firm as given and does not consider how the bargaining outcome may affect aggregate union memberships in the economy.

sense that the outcome Pareto dominates the outcome of a bargaining over wages only (McDonald & Solow, 1981). If we let $\pi = Y - w_R^u L_R - w_N^u L_N$ denote the profit of the firm, where the product price is set equal to unity, the outcome of the efficient bargaining is given by the solution of the following Nash problem:

$$\max_{\{w_i, L_i\}} (V - \bar{V})^{\mu} (\pi - \bar{\pi})^{1-\mu} \qquad i = R, L \qquad , \tag{8}$$

where $\bar{\pi}$ denotes the minimum profit requirement of the firm, and μ denotes the bargaining strength of the union.[8] The four first-order conditions from the maximization problem are given by:

$$\frac{\mu}{V - \bar{V}} \frac{L_R}{\Omega} u'(w_R^u) + \frac{1-\mu}{\pi - \bar{\pi}}(-L_R) = 0 \tag{9}$$

$$\frac{\mu}{V - \bar{V}} \frac{L_N}{\Omega} u'(w_N^u) + \frac{1-\mu}{\pi - \bar{\pi}}(-L_N) = 0 \tag{10}$$

$$\frac{\mu}{V - \bar{V}} \frac{u(w_R^u) - u(b_R)}{\Omega} + \frac{1-\mu}{\pi - \bar{\pi}} \left(\frac{\partial Y}{\partial L_R} - w_R^u\right) = 0 \tag{11}$$

$$\frac{\mu}{V - \bar{V}} \frac{u(w_N^u) - u(b_N)}{\Omega} + \frac{1-\mu}{\pi - \bar{\pi}} \left(\frac{\partial Y}{\partial L_N} - w_N^u\right) = 0 \tag{12}$$

If we combine (9) and (10), we immediately arrive at the result that the marginal utility of earning the routine wage should equal the marginal utility of the non-routine wage. As long as we assume smooth utility functions, this implies equal wage rates for the two types of workers, irrespective of their marginal products. This is due to the properties of the utilitarian objective function of the union, see e.g., Cahuc et al. (2014, pp. 441-443). In other words, the model predicts full wage compression.

By combining (9) with (11) and (10) with (12), we can derive the pairs of *contract curves:*

Contract curve

$$\frac{\partial Y}{\partial L_i} - w_i^u = -\frac{u(w_i^u) - u(b_i)}{u'(w_i^u)} \quad , \quad i = R, L \tag{13}$$

---

[8] The bargaining strength of unions could, in principle, reflect multiple factors like e.g., the size of strike funds, the business cycle or the legal position of unions in general. However, in the empirical analyses of how unions influence relative wages and relative demand for routine workers over non-routine workers, we will measure the union's bargaining strength by the union density among the workers at the workplace level.

The contract curves trace out all pairs of (w_i, L_i) where the union's indifference curves are tangent to the firm's isoprofit curves. Using the above result of full wage compression, $w_R^u = w_N^u = w^u$, the contract curves reduce to the following result:

$$\frac{\partial Y}{\partial L_R} - \frac{\partial Y}{\partial L_N} = \frac{u(b_N) - u(b_R)}{u'(w^u)} \tag{14}$$

That is, the contract curves implicitly define the firm's relative employment of routine and non-routine workers. Consider first the case where the reservation wages of the two groups of workers are equal, in which case (14) reduces to $\frac{\partial Y}{\partial L_R} = \frac{\partial Y}{\partial L_N}$. This is equivalent to the condition for optimal relative input demand in the case of equal wage rates. In other words, in this case *relative* employment will be consistent with the firm's optimal relative demand. However, if the reservation wage is higher for non-routine workers than for routine workers, relative demand for routine workers will be lower than in the competitive case. In the opposite case when the reservation wage for non-routine workers is lower than for routine workers, relative demand for routine workers will be higher. In other words, the contract curves illustrate how the union influence the relative employment of routine workers and non-routine workers, conditional on the relative wage, as a function of the relative reservation wages of the two types of workers.

We have now shown how unions are predicted to influence both the relative wage, *and* the relative employment conditional on the relative wage, using a simple model of efficient bargaining. To see the impact on the wage levels, which are equal, we may derive the pairs of *rent division curves* by combining the contract curves in (13) with (9) and letting $w_R = w_N = w^u$:

Rent division curve [9]

$$w^u = \mu \frac{(Y - \bar{\pi})}{L_R + L_N} + (1 - \mu) \frac{L_R \frac{\partial Y}{\partial L_R} + L_N \frac{\partial Y}{\partial L_N}}{L_R + L_N} \quad , \tag{15}$$

The rent division curves show how wages are determined as weighted averages of marginal and average productivity, where the weights are given by relative bargaining strength. As long

[9] To see this, insert for $V - \bar{V}$ and $\pi - \bar{\pi}$ in (9). Next, insert for $u(w_i^u) - u(b_i)$ using the contract curves in (13), and then use the result that $w_R = w_N = w^u$. See Booth (1995, pp. 128-134) for further details in the case of a single-input production function.

as the production technology exhibits decreasing returns to scale, corresponding to $\upsilon < 1$ in the production function in (1), average productivity will be greater than marginal productivity, and the union wage level will be higher than in the competitive case.[10]

While the conceptual model outlined in this section is highly stylized, it illustrates how unions may influence technological change through two key mechanisms. On the one hand, unions compress wages between routine and non-routine workers. If routine workers on average have lower earnings than non-routine workers, which we will indeed demonstrate in the following sections, this effect will contribute to increase the relative wage of routine workers over non-routine workers. In isolation, this "wage channel"-effect will accelerate the process of routine-biased technological change if relative employment is determined by the firm's relative demand curve. On the other hand, however, as unions and firms bargain over both wages and employment, unions may force firms off their relative demand curves. In other words, unions may prevent firms from choosing the optimal combination of routine and non-routine workers conditional on the relative wage. This effect could potentially either dampen or amplify the accelerating effect on technological change through the wage channel, depending on how the reservation wages of the two types of workers compare. This is ultimately an empirical question.

3 Methodology

In this section, we describe our empirical strategy for unveiling how unions influence the process of technological change. The theoretical framework developed in the last section illustrates how unions may influence technological change through two channels. On the one hand, unions are predicted to accelerate technological change by compressing wages between routine and non-routine workers. On the other hand, unions may also influence technological change by altering the firm's relative labor demand conditional on relative wages. While our empirical specifications use these theoretical predictions as guidance, we do not directly estimate the underlying structural parameters of the theoretical model.

The analysis is performed in two steps. In the first step, which is described in Section 3.1, we investigate how unions alter the relative wage paid to routine workers over non-routine

[10] Note that in the case of constant returns to scale ($\upsilon = 1$), in which case average productivity equals marginal productivity, the wage rate becomes independent of the union's bargaining strength under the zero-profit condition, see Agell & Lommerud (1992).

workers. Section 3.2 then describes the second step of the analysis, where we investigate how unions alter the pace of technological change in firms *conditional* on relative wages. To account for potentially endogenous selection into unions, we exploit exogeneous changes in the tax rules for union members. This identification strategy is described in Section 3.3.

3.1 How unions alter relative wages

The question of how unions alter the wage paid to routine and non-routine workers may be analyzed at the individual level by estimating a simple Mincer earnings equation (Mincer, 1974), controlling for unionization, whether or not the individual is occupied in a routine or non-routine occupation, as well as the interaction between these two effects. The interaction term will then inform us how the union's impact on wages differs between routine and non-routine workers.

In Norway, union wages are settled in a hierarchy of collective agreements, which are invoked by the labor union if the union density within the establishment reaches certain thresholds. Local agreements automatically extend to all workers in occupations covered by the agreement, irrespective of individual union membership.[11] While the gains from local bargaining may be higher for union members than for non-members, central provisions in the collective agreement heavily influence the wage paid to both union and non-union members. This implies that the effect of unions on wages is best reflected using workplace union density, instead of individual membership, as our measure of unionization. We therefore estimate the following equation:

$$(16) \qquad \log w_{it} = \beta_0 + \beta_1 R_{it} + \beta_2\, UD_{it} + \beta_3 R_{it} \times UD_{it} + \boldsymbol{X_{it}\gamma} + u_i + \delta_t + \epsilon_{it},$$

where w_{it} denotes the nominal wage of individual i in year t, measured as total payments per hour, including bonuses and supplementary pay for uncomfortable working hours. The vector $\boldsymbol{X_{it}}$ comprises individual workers' characteristics,[12] while u_i denotes fixed effects at the individual level, δ_t yearly dummies, and ϵ_{it} random shocks. R_{it} is a dummy variable taking the value 1 if the individual is occupied in a routine occupation and zero otherwise. UD_{it} denotes the union density at the individual's workplace if the individual is employed in a non-

[11] See Appendix A3 for a brief overview of the Norwegian institutional context, and Svarstad & Kostøl (2022) for a more detailed presentation of the Norwegian system of collective agreements.

[12] Individual workers' characteristics include education, age, sex, immigration status, and a distinction between part-time and full-time workers.

routine occupation, while $R_{it} \times UD_{it}$ measures the effect of workplace union density for individuals employed in routine occupations.

The theoretical model in Section 2.3 predicts that unions will compress wage levels. As we will document in the descriptive statistics in Section 4, the average wage paid to routine workers is lower than the wage paid to non-routine workers. Our theory thus predicts a positive interaction effect between workplace union density and having a routine occupation. That is, we expect a positive value of β_3, which is our primary parameter of interest.

3.2 How unions alter technological change

The theory of efficient bargaining presented in Section 2 implies that unions influence employment decisions and potentially force firms off their labor demand curves. This is in contrast to the monopoly theory of unions or the "right to manage" model, where the union dictates or bargain wages, respectively, while employment is determined by the firm's demand curve. A simple test of whether unions alter technological change by influencing the relative demand for routine labor over non-routine labor, is to estimate the relative labor demand function in (5) including a term capturing the presence of unions in the establishment. That is, we estimate

$$\text{(17)} \qquad \log\left(\frac{L_R}{L_N}\right)_{jt} = \alpha_0 + \alpha_1 \log\left(\frac{w_R}{w_N}\right)_{jt} + \alpha_3 UD_{jt} + \boldsymbol{Z_{jt}\gamma} + \delta_t + u_j + \varepsilon_{jt},$$

where $(L_R/L_N)_{jt}$ denotes the relative use of routine workers over non-routine workers in establishment j in year t, and $(w_R/w_N)_{jt}$ the corresponding relative wage. α_1 should thus be interpreted as the negative of the elasticity of substitution between routine and non-routine labor. δ_t captures any time-specific shocks common to all companies.[13] The vector $\boldsymbol{Z_{jt}}$ comprises workplace-level shares of individual workers' characteristics, while u_j and ε_{jt} denotes fixed effects at the workplace level and random shocks, respectively. Again, UD denotes workplace union density.

If unions only bargain over wages, we would expect to find $\alpha_3 = 0$ in (17). A rejection of the null hypothesis of $\alpha_3 = 0$ would thus indicate that unions also influence employment decisions, thereby forcing firms off their relative demand curves. Within the efficient

---

[13] Such shocks to relative demand may reflect nonneutral technological changes (Katz & Murhpy, 1992).

bargaining model presented in Section 2, the direction of how unions influence relative employment is determined by which group of workers has the largest reservation wage.[14] Going beyond the theoretical model, however, we may interpret α_3 as an expression of the union's attitude towards new technology. A positive value of α_3 implies that the relative demand for routine workers over non-routine workers increases with union density, conditional on how unions influence the relative wage. This could indicate union resistance towards new technology. On the contrary, a negative value of α_3 could indicate that unions embrace new technology.

One concern with the specification in (17) is the problem of unobserved productivity differences between workers, which are likely to be correlated with both wages and relative labor demand. More precisely, the wage paid to specific routine workers may reflect individual abilities not captured by the broad measure of routine workers, which is likely to comprise a very heterogeneous group of workers. While some of this heterogeneity may be controlled for by including various covariates reflecting individual characteristics, we cannot rule out the possibility that innate productivity differences will bias our estimator. To control for this, we replace firm-level wages with aggregate measures of market wages. Aggregate wages are constructed as average hourly wages within occupation by industry cells at the two-digit level, leaving us with a total of 2,993 market wage cells. As unions are likely to increase wage levels, we calculate separate sets of market wages for workers employed in unionized and non-unionized establishments, respectively.[15]

3.3 Identification

A serious concern relates to the causal interpretation of both equations (16) and (17). While union density may have an impact on relative labor demand, the structural composition of workers in a firm is also likely to have an impact on the union density, as the propensity to join a union may vary systematically across occupations. If routine workers are more likely to join a union than non-routine workers, a change in the relative demand for routine workers over non-routine workers is likely to affect union density. In order to say anything about causal

---

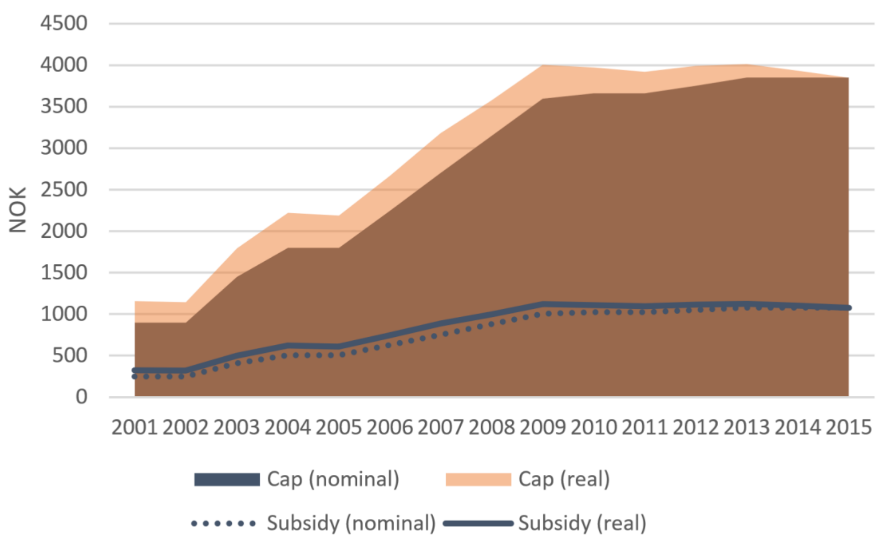
[14] If the reservation wage of routine workers is higher (lower) than for non-routine workers, we would expect α_3 to be positive (negative). In the case of equal reservation wages, the bargaining solution for relative employment will coincide with the firm's optimal relative demand conditional on relative wages.

[15] We use information on whether or not firms participate in collective agreements to distinguish unionized from non-unionized firms. To see whether our results are robust to the choice of wage measure, we try different specifications using either actual wages, market wages, or market wages controlling for unionized and non-unionized establishments.

effects, we are therefore dependent on some source of exogenous variation in unionization unrelated to the structural composition of occupations in the firm.

As indicated in Section 2, the propensity to join a union is a function of the union due. In Norway, as in many other countries, union dues are deductible in tax assessments. However, the deductible amount is limited by a cap, and this cap has changed several times during our period of analysis due to changes in political leadership (see Figure 1). Assuming union membership is an ordinary good, the demand for memberships will adapt when the price changes. It is therefore likely that changes in the rules for tax deduction of union dues will have some effect on the firm-level union density, which is also the finding of Barth et al. (2020), who were the first to exploit this source of exogenous variation. As changes in the government subsidy of union memberships are not correlated with the structural composition of occupations in a given firm, they may act as an instrument for union density.

Figure 1 Changes in the cap on tax deduction of union fees and the realized tax subsidy in NOK



Note: The figure illustrates both nominal and real changes in the cap on union due deductions on the tax schedule, measured in NOK (1000 NOK is approximately equal to €88). The subsidy is defined as the cap multiplied by the marginal income tax (28 percent).

In constructing our instrument, we utilize data on actual individual payments of union dues. As changes in tax rules for union members affect incentives to unionize also among individuals who are not union members, we follow the strategy of Barth et al. (2020) and construct hypothetical unions based on occupations (at the 3-digit level) within industries (at the 2-digit level). For each existing union member, we calculate the average membership fee within each hypothetical union each year, excluding the individual's own contribution to the mean. The tax subsidy is then calculated as the product of the income tax (28 percent) and the minimum of the imputed due and the cap on tax deductions. That is, $Subsidy = 0.28 \times \min(\overline{due}, cap)$.

One concern with our specification of the tax subsidy is that union dues may be affected by the cap on union due deductions. To control for this, as well as the less likely issue of endogenous occupational composition, we fix the imputed union due within workplaces at the first year of observation in the data. The average workplace due is then determined by the occupational composition the first year, only adjusted for price changes. In addition to the tax subsidy, we also include the workplace average imputed due, fixed at the first year of observation, net of the tax subsidy in our regressions. That is, we include $ND_j \equiv \overline{due}_{j0} - Subsidy_j$, where $\overline{due}_{j0}$ denotes the average imputed union due within workplace j fixed at the first year of observation of the workplace.

4 Data

The data cover the Norwegian private sector in the period 2000-2014 and consist of individual wage data, matched with several other sources of register data related to both firms and employees. The most important data sources are the State Register of Employers and Employees (the '*Aa-register'*) matched with the Register of End of the Year Certificate (the *'LTO register'*), as well as Statistics Norway's Wage Statistics. We have information on earnings, hours worked and occupation for each individual. Monthly earnings include agreed monthly earnings, irregular supplements, and bonuses. In order to compare part-time and full-time employees, we calculate hourly wages for each individual every year of observation, based on monthly earnings and reported working hours. Educational statistics are attached, as well as country of origin and other individual characteristics. Variables such as workplace industry and sector are obtained from the Register of Legal Entities and Statistics Norway's Business and Enterprise Register (VoF). Person-related identities are obtained from the Central Population Register (DSF). Individuals, workplaces, and firms have their own unique identifying number, enabling us to track the units across time.

The analysis of how unions alter relative wages relies on observations of individuals covered by the Wage Statistics of Statistics Norway. While the Wage Statistics is based on a sample of establishments – in contrast to the 'Aa-register', which cover all wage earners – the Wage Statistics is known to be a more reliable source of wage data, as it is specifically designed for this purpose.[16] This still leaves us with an individual level dataset containing 2,246,620 unique individuals across 98,263 private sector workplaces, amounting to 11,806,896 individual observations in total for the 15-year period. The analysis of how unions influence relative employment, however, is based on information on all wage earners aggregated to the establishment level, leaving us with 1,685,821 observations of 275,534 workplaces. Because workplaces are established and dissolved throughout the period of analysis, our panel is unbalanced.

Information on individual union membership is derived from data on union dues, which is reported to the tax authorities by the unions. Based on the membership payments, we calculate workplace level union density as the ratio of union members relative to the number of employees in the establishment. Whether a firm participates in a collective agreement or not is derived from membership data from the private sector collectively agreed pension scheme ('*Fellesordningen for AFP*'), in which all firms who are members are also part in a collective agreement.[17]

4.1 Measure of technological change

We rely on changes in the occupational composition within workplaces as our measure of technological change. Our primary measure is based on occupational risk of automation. Each individual in the data set is linked to a four-digit occupational code each year observed. The occupational classification is matched with the estimated risk of automation according to Frey & Osborne (2017). The estimated probabilities rely on a qualitative assessment made in a workshop with an expert team at the Engineering Sciences Department at the Oxford University. The team is asked whether 70 selected occupations in the SOC-classification can be performed by computer technology within 10-20 years. Combining the answers from this workshop with a standardized and measurable set of occupational characteristics from O*NET, the authors estimate automation probabilities for a total of 702 six-digit occupations in the

[16] The sampling applied by Statistics Norway is based on stratified random, systematic cluster selection, where the stratification is made by enterprise size (number of employees) in each industry, with complete counting in the largest companies, and cut-off in the smallest. However, all employees in the sampled establishments are included. See https://www.ssb.no/omssb/tjenester-og-verktoy/data-til-forskning/lonn/data_lonn.

[17] Some firms in the sample are covered by collective agreements, without being members in '*Fellesordningen*'. This mainly applies to establishments within shipping, the oil industry and privately run health and social services. The firms in question are manually coded as covered.

SOC-classification using a logistic regression.[18] When converted to the four-digit ISCO-08 classification standard used in Norway, this leaves us with automation probabilities for 374 occupations. Probabilities for the remaining 23 occupations in the Norwegian classification of occupations are calculated by averaging probabilities for higher level occupations in the nomenclature.

Using the estimated occupational risk of automation, workers are divided into two groups, based on whether their occupation is associated with a high or low risk of being automated within the next 10-20 years. Following the same probability threshold as in Frey & Osborne (2017), occupations with an estimated risk of automation exceeding 0.7 are defined as "high risk" occupations, while occupations with a lower probability of automation are defined as "low risk". With reference to the distinction between routine and non-routine workers in Sections 2 and 3, routine workers are employed in high-risk occupations, while non-routine workers are employed in low-risk occupations. Finally, technological change is defined as changes in the relative use of routine workers over non-routine workers.

As the probability threshold that defines high-risk occupations in Frey & Osborne (2017) seems somewhat arbitrary, we also test specifications using different thresholds, as well as a continuous measure of automation risk. Moreover, as the approach in their study has been subject to wide criticism (see e.g., Arntz et al. 2016), we also test the more widely applied measure of routine task intensity (RTI) as a robustness check. Exploiting datafiles on occupational abilities, skills, work activities and work content from O*NET, we extract relevant variables and convert occupational codes to the European ISCO classification using the code prepared by Hardy et al. (2018). Following Acemoglu & Autor (2011), we construct five composite task measures which are then used to calculate occupational RTI.[19] As in Autor

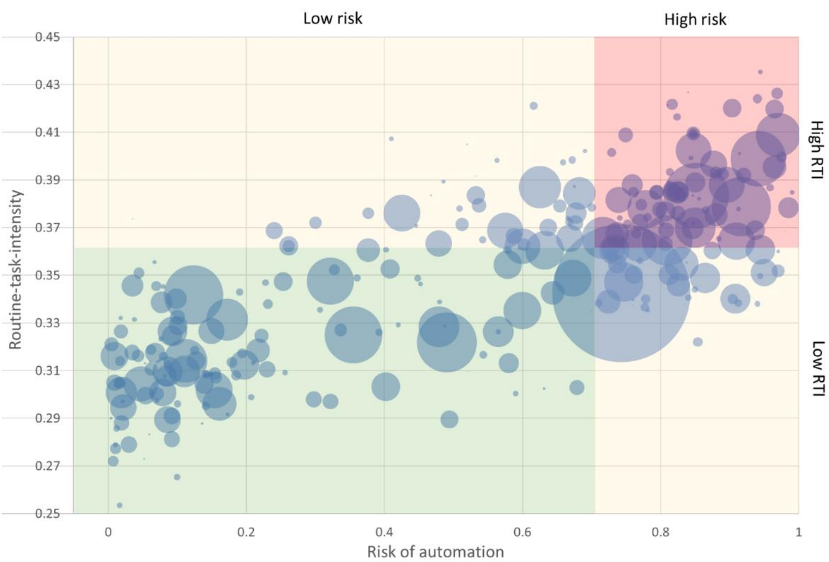
[18] For each of the 70 selected occupations in the 'training data', the team determines whether or not the occupations, based on their current composition of tasks, can be performed by automation technology within the next 10-20 years, assigning the occupations 1 if automatable, and 0 if not. The authors then identify nine variables in the O*NET database that describe the level of perception and manipulation, creativity, and social intelligence to perform the tasks of the occupation. They then use a logistic regression to estimate how each of these attributes contribute to the likelihood of automation using the training data. The estimated parameters of each attribute are finally used to predict the likelihood of automation using data on all occupations. Formally, they estimate the automation probability of occupation i as $P_{aut_i} = \frac{1}{1+e^{-\ell_i}}$, where $\ell_i = \boldsymbol{x}^T\boldsymbol{\beta}$ defines the log-likelihood function, $\boldsymbol{x}$ the vector of attributes, and $\boldsymbol{\beta}$ the corresponding parameters to be estimated.

[19] The five composite task measures are: non-routine analytical, non-routine interpersonal, non-routine manual, routine cognitive and routine manual. RTI is calculated as the sum of the routine measures divided by the sum of all measures.

& Dorn (2013, p. 1571), we then use RTI to identify routine workers as workers employed in occupations that are in the top employment-weighted third of routine task intensity.

The concepts of RTI and risk of automation are closely related, as routine tasks are more easily automated than non-routine tasks. Hence, RTI is often used as a proxy of automation risk (see e.g., Acemoglu & Restrepo, 2022). We have illustrated the correlation between the two measures in the bubble chart in Figure 2, where the bubbles represent occupations, the size of which determined by their relative frequencies in the data. The plot shows a clear positive correlation between automation risk and RTI, with a correlation coefficient equal to 0.73. Furthermore, the figure illustrates how the binary division of the two measures correspond to each other.[20] The green box in the bottom left corner of the figure contains occupations with both a low risk of automation and a low RTI. The red box in the upper right corner of the figure contains occupations with both a high risk of automation and high RTI. The yellow boxes in the top left and bottom right corner, however, contain occupations with non-corresponding binary measures.

Figure 2 Correlation between estimated risk of automation and a measure of routine task intensity



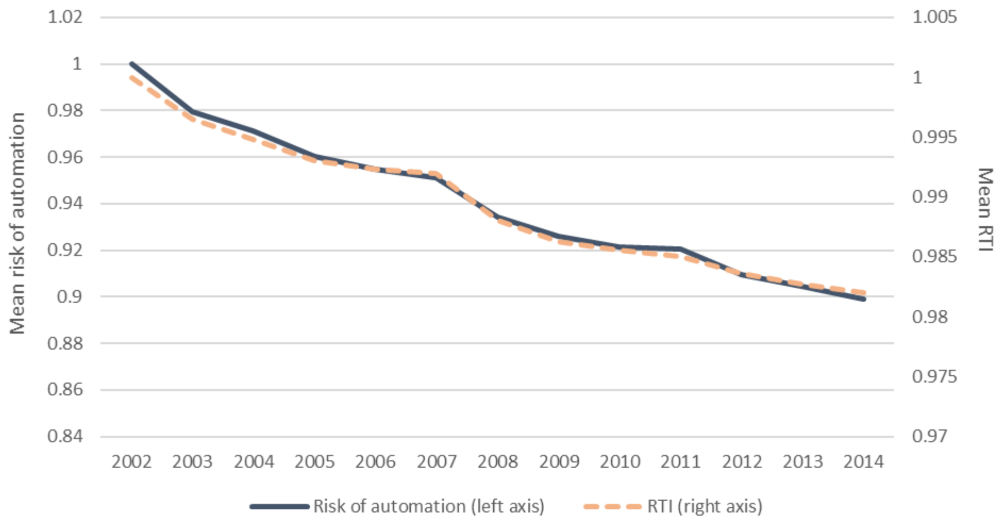
*Note: The bubbles represent occupations, the size of which determined by their relative frequencies in the data. Risk of automation refers to the estimated risks of computerization in Frey & Osborne (2017), where occupations are classified as 'High risk' if the risk exceeds 0.7. Routine-task-intensity (RTI) is constructed using occupational descriptions from O*NET as in Acemoglu & Autor (2011), where 'High RTI' refers to occupations in the top employment-weighted third of routine task intensity (see Autor & Dorn 2013).*

[20] Figure A1 in the Appendix illustrates how the two different measures to identify routine occupations compare in terms of the average composite task measures. Overall, the average scores are very similar between the two measures.

4.2 Descriptive statistics

We use structural changes in the composition of occupations, as measured by automation risk or routine task intensity (RTI), to proxy technological change. It is thus natural to ask how the measures change over the sample. While the occupational measures are kept constant all years, technological change is reflected by changes in the composition of workers employed in different occupations. In Figure 3, we illustrate how the average risk of automation (left axis) and the average RTI (right axis) among full-time employees change over time. Overall, the two measures of technological change show a very similar development.[21] Both the average risk of automation and the average RTI among full-time employees have been falling over time. This reflects that the share of workers employed in occupations with high risk of automation and high RTI is falling, possibly due to investments in new automation technologies. This trend could reflect changes both between and within establishments.

Figure 3 Average risk of automation and routine task intensity (RTI) among Norwegian full-time employees (2002=1)



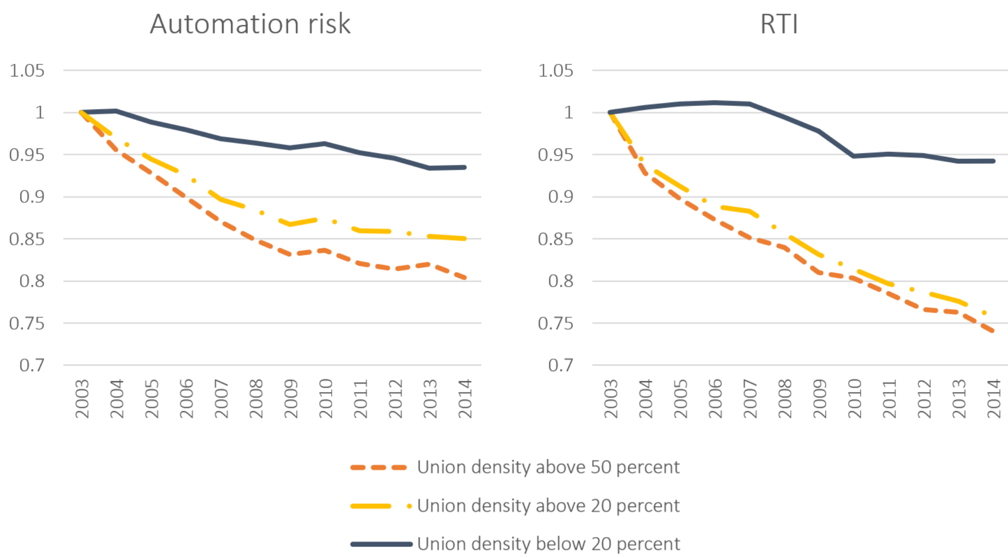
As in most other countries in the OECD, Norwegian unions have been on a steady decline during the years of our sample (see Figure A2 in the Appendix). However, the decline is modest and trade union density still amounted to 36 percent of all private sector employees in 2014,

---

[21] However, the percentage change in automation risk is larger than in RTI. This partly reflects the construction of the RTI index. The overall variation in the RTI index is 0.25-0.44, while automation risk varies continuously between 0 and 1. While the average risk of automation is reduced from 0.56 to 0.50 between 2002 and 2014, average RTI is reduced from 0.352 to 0.346.

which is high compared to most countries outside Scandinavia. To answer the question of how unions alter the process of technological change, we investigate how structural changes in the occupational composition are affected by changes in union density at the workplace level. In Figure 4, we illustrate how the share of routine workers has evolved within workplaces for different levels of union density, using both the measure of automation risk and RTI. It is apparent from both figures that the share of routine workers has been decreasing at a faster pace in establishments with a strong presence of unions. While the share is reduced by 5 percent from 2003 to 2014 in establishments where the union members make up less than 20 percent of the employees, it is reduced by 20-25 percent in establishments with a union density exceeding 50 percent, depending on which measure we use. The differences may of course be explained by compositional effects, as both union presence and the share of routine workers are higher in some industries than others.

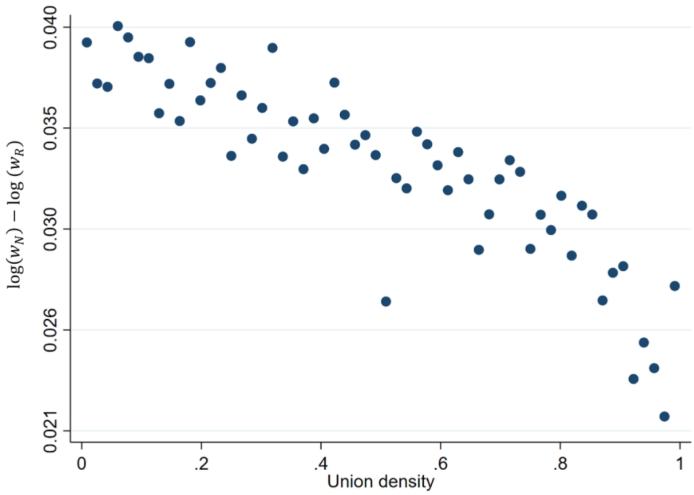
Figure 4 Mean share of routine workers in establishments with a minimum of 10 employees. Union density below 20 percent, above 20 percent and above 50 percent. 2003=1



Note: The figures illustrate the evolution of the mean share of routine workers in establishments with a minimum of 10 employees, using occupational risk of automation and RTI, respectively, for different levels of union density. The average measures are set equal to unity in 2003.

Another question of interest is how relative wages between non-routine and routine workers vary with union density. Figure 5 shows a binned scatter plot, illustrating the distribution of relative wages across union density within our sample of establishments. The figure shows that non-routine workers, on average, earn higher wages than routine workers for all levels of union density. However, the plot clearly shows a negative relationship between average relative wages and union density. The pattern thus indicates that the average wage gap between non-routine and routine workers is lower in workplaces with strong unions. Although one should be cautious in interpreting the underlying mechanisms that could explain the figures, union wage compression is a plausible explanation of the development illustrated in Figure 4, where the share of routine workers has been declining faster in more unionized establishments.

Figure 5 Binned scatter plot of (log) relative wages between non-routine and routine workers across union density



Note: The binned scatter plot illustrates the average relative wage (in logarithms) between non-routine and routine workers over establishments for different levels of union density. The sample includes all observations of establishments employing at least one worker from each group. N=684,721.

5 Results

In this section, we present the results of our empirical analysis. We begin by documenting the relationship between changes in the maximum deduction of union dues and the individual propensity to unionize. We then utilize this source of exogenous variation in two subsequent analyses: How unions affect the relative pay of routine workers over non-routine workers, and how unions alter technological change by influencing the relative demand for routine workers over non-routine workers, *conditional* on the corresponding relative wages.

5.1 Government subsidization of union membership

In Table 1, we document the results from estimating various linear probability models of the individual propensity to unionize as a function of the government tax subsidy of union dues. That is, we estimate variations of the following equation:

$$(18) \qquad U_{ikt} = \gamma_0 + \gamma_1 S_{kt} + \gamma_2 ND_{kt} + \boldsymbol{Z_{it}\xi} + \delta_t + u_i + v_k + \theta_{it},$$

where U_{ikt} is a binary variable equal to 1 if individual i in the hypothetical union k is a union member in year t, and 0 if not. S_{kt} and ND_{kt} denotes the subsidy and net due in NOK 1000 (approximately equal to €88), respectively, in the hypothetical union k in year t. The vector $\boldsymbol{Z_{it}}$ comprises individual workers' characteristics, including education, age, sex, immigration status, and a distinction between part-time and full-time workers. δ_t denotes yearly time dummies, while u_i and v_k denote fixed effects at the individual and union level, respectively. θ_{it} represents random shocks.

Model 1a shows a significant positive relationship between the subsidy and the propensity to join a union. The effect is significantly reduced but still substantial when we control for net union membership fee and various individual characteristics in *Model 1b.* Controlling for individual fixed effects in *Model 1c*, and both individual and union fixed effects in *Model 1d*, [22] further moderates the effect, but the estimated coefficient remains statistically significant. In *Model 1d*, an increase in the subsidy of 1000 NOK is estimated to increase the individual's probability of being a union member by approximately 2 percentage points.[23]

In *Model 1e,* we include a dummy variable measuring whether the individual is occupied in a routine or a non-routine occupation, defined by the associated risk of automation estimated in Frey & Osborne (2017), as well as interactions with the union subsidy and net due. First, we see that workers in routine occupations are associated with a lower probability of being unionized. Second, the positive interaction term indicates that workers in routine occupations are more likely to respond to increases in the tax subsidy compared to workers in non-routine occupations. The findings remain robust when restricting the sample to individuals employed

---

[22] In the construction of the subsidy, we have defined 8,248 hypothetical unions based on occupation by industry cells, see Section 3.3.

[23] When evaluating the marginal effects, we must take into consideration that an increase in the subsidy also reduces the net membership due.

in workplaces with at least ten employees. Overall, we conclude that the tax subsidy appears to be a highly relevant source of exogenous variation in unionization rates.

Table 1 Linear probability models of the impact of subsidizing union membership on individual propensity to join a union

	Model 1a	***Model 1b***	***Model 1c***	***Model 1d***	***Model 1e***	***Model 1f***
Subsidy (S)	0.360***	0.073***	0.047***	0.011***	0.009***	0.001
	(154.81)	(27.33)	(20.27)	(4.21)	(3.63)	(0.20)
Net due (ND)		0.050***	0.013***	-0.009***	-0.012***	-0.004***
		(177.37)	(40.19)	(-24.09)	(-26.39)	(-9.09)
Routine (R)					-0.029***	-0.029***
					(-13.90)	(-12.60)
R x S					0.017***	0.017***
					(16.39)	(15.99)
R x ND					0.004***	0.004***
					(7.40)	(7.02)
Year dummies	✓	✓	✓	✓	✓	✓
Controls		✓	✓	✓	✓	✓
Ind. FE			✓	✓	✓	✓
Union FE				✓	✓	✓
Min. empl.						10
N	11,874,008	11,866,919	11,866,919	10,988,908	10,284,019	9,121,160

*Note: The endogenous variable is a binary variable equal to 1 if the individual is unionized and 0 otherwise. The subsidy is measured in 1000 NOK (equal to approximately €88) as the marginal tax rate (28 per cent) multiplied with the minimum of actual membership payments and the maximum deductible amount. Controls contains various measures of individual workers' characteristics, including education, age, sex, immigration status, and a distinction between part-time and full-time workers. Sample:2000-2014. Robust standard errors. t statistics in parentheses. *** p<0.001.*

5.2 Union effect on wages

Results from individual wage regressions are reported in Table 2. *Model 2a* is a standard Mincer earnings equation estimated using ordinary least squares, where we use a second order polynomial in age to proxy experience, while skills are measured by the individual's highest level of education. We further control for sex, and whether or not the individual is an immigrant or works part-time, respectively (see Equation 16). The presence of unions is measured by union density at the workplace level, which is found to be positively correlated with individual earnings. In *Model 2b*, we include an indicator of whether the individual is employed in a routine occupation along with an interaction with union density. The results show that while routine workers on average are paid less than non-routine workers, an increase in workplace union density is estimated to have a larger positive effect on routine wages than non-routine wages. The results do not change much when we include individual fixed effects to control for unobserved heterogeneity in individual productivity in *Model 2c*.

Table 2 The effect of unionization on individual earnings

	Model 2a	***Model 2b***	***Model 2c***	***Model 2d***	***Model 2e***	***Model 2f***
Estimator	OLS	OLS	FE	2SLS	2SLS	2SLS
Union density (UD)	0.053***	0.037***	0.043***	0.172***	0.166***	0.215***
	(127.51)	(59.60)	(67.43)	(31.92)	(38.09)	(49.92)
Routine (R)		-0.120***	-0.056***	-0.099***	-0.091***	-0.048***
		(-252.79)	(-125.17)	(-50.84)	(-52.17)	(-28.44)
R x UD		0.044***	0.047***	0.165***	0.136***	0.052***
		(55.77)	(60.51)	(34.57)	(34.80)	(13.69)
Age	0.041***	0.038***	0.034***	0.031***	0.033***	0.035***
	(529.80)	(487.89)	(77.88)	(69.79)	(72.01)	(75.71)
Age^2	-0.0004***	-0.0004***	-0.0004***	-0.0004***	-0.0004***	-0.001***
	(-415.74)	(-382.54)	(-424.91)	(-391.87)	(-411.42)	(-414.69)
Medium-skilled	0.095***	0.088***	0.125***	0.122***	0.131***	0.132***
	(344.12)	(303.25)	(191.61)	(187.88)	(183.24)	(185.63)
High-skilled	0.289***	0.265***	0.137***	0.126***	0.133***	0.141***
	(750.35)	(652.98)	(159.13)	(144.99)	(142.23)	(148.54)
Top-skilled	0.484***	0.448***	0.303***	0.287***	0.291***	0.304***
	(861.30)	(748.61)	(219.48)	(205.58)	(201.78)	(205.73)
Part-time worker	-0.122***	-0.104***	0.004***	0.013***	0.017***	0.013***
	(-400.49)	(-329.81)	(12.25)	(37.26)	(49.11)	(36.43)
Immigrant	-0.112***	-0.114***	-	-	-	
	(-274.61)	(-274.75)				
Woman	-0.125***	-0.114***	-	-	-	
	(-499.33)	(-444.75)				
Year dummies	✓	✓	✓	✓	✓	✓
Individual FE.			✓	✓	✓	✓
Min. 10 empl. in establ.					✓	✓
Measure of automation	*Risk*	*Risk*	*Risk*	*Risk*	*Risk*	*RTI*
Subsidy				0.076***	0.082***	0.078***
				(49.85)	(54.37)	(51.23)
Net due				0.033***	0.045***	0.045***
				(121.28)	(157.00)	(159.85)
Cragg-Donald:				30,120.3	48,612.0	45,266.0
Kleibergen-Paap				8,187.7	12,123.6	10,975.1
N	11,873,636	10,873,793	10,873,793	10,398,830	9,226,478	9,226,347

*Note: The endogenous variable is log(wage), where wages are measured as total payments per hours, including bonuses and supplementary pay for uncomfortable working hours. Union density (UD) is measured as a rate between 0 and 1. Routine (R) is a dummy variable equal to 1 if the individual is occupied in an occupation with high automation risk and 0 if not. In Models 2a-2e, automation risk is measured according to the categorization in Frey & Osborne (2017). In Model 2f, we use the measure of routine task intensity (RTI) to identify the set of occupations that are in the top employment-weighted third of RTI in year 2000, which is used to proxy high-risk occupations. UD x R denotes the interaction between Routine (R) and Union density (UD). Cragg–Donald and Kleibergen–Paap refer to the Cragg-Donald Wald F statistic and the Kleibergen-Paap Wald rk F statistic of weak instruments, respectively. Sample:2000-2014. Robust standard errors. t statistics in parentheses *** p<0.001.*

We may suspect that the individual's propensity to join a union will depend on her wage, as well as her attitudes towards unions, which are possibly correlated with unobserved productivity and wages. We therefore instrument union density by exploiting exogenous variation in the government tax subsidy of union dues in *Models 2d.*[24] To control for other changes is the price on union membership, as proposed in Barth et al. (2020), we also include

[24] We use the interaction between the routine dummy and the subsidy to instrument R x UD. First-stage results of the interaction term is available upon request.

the actual membership fees paid by the individual net of the subsidy in the first-stage equation. We firmly reject the null hypothesis of weak instruments. A ten-percentage point increase in union density is estimated to increase the wage of non-routine workers by 1.7 percent, and the wage of routine workers by 3.4 percent. This result remains almost unchanged when restricting the sample to individuals employed in workplaces with at least ten employees in *Model 2e*. The result is also qualitatively robust to the choice of automation measure, although less pronounced when using routine task intensity to distinguish routine and non-routine workers in *Model 2f*. In Table A2 in the Appendix, we arrive at similar results using different thresholds of automation risk to define routine and non-routine occupations, as well as continuous measures of automation risk and RTI, showing that the results are not sensitive to the choice of thresholds. Overall, the results appear to be consistent with the hypothesis from the theoretical model – unions contribute to compress wages between routine and non-routine workers within workplaces.

5.3 Union effect on technological change

The results in the previous section indicate that unions contribute to compress wages between routine and non-routine workers, consistent with the prediction from the theory model in Section 2. We now ask whether unions have any impact on the relative labor demand *conditional* on the relative wage. We thereby shift the unit of analysis from the individual to the workplace. In Table 3, we report results from estimating Equation (17), a relative demand equation, using various estimators and specifications. As a reference point, *Model 3a* is estimated using OLS without any controls but year dummies. The elasticity of substitution between routine and non-routine labor is estimated to be around 2.[25] In other words, if unions raise the wage paid to routine workers by 1 percent relative to the wage of non-routine workers, firms will respond by reducing their relative demand for routine workers by 2 percent. Moreover, the result suggests a negative correlation between union density and the relative demand for routine workers, conditional on relative wages. However, this correlation turns positive when we control for individual workers' characteristics in *Model 3b*.[26] As the OLS-estimates not only reflect the effect of a change in union density *within* establishments, but also unobserved heterogeneity *between* establishments, possibly correlated with union density, the

---

[25] In comparison, the elasticity of substitution between low-skilled and high-skilled workers is usually estimated to be somewhere between 1.4 and 2 (Acemoglu & Autor, 2011, p. 1107).

[26] Characteristics include sex, age, education, and immigration status, all measured as shares at the workplace level.

OLS-estimator is likely to be inconsistent. In *Model 3c,* we therefore control for workplace fixed effects. This has the effect of significantly reducing the estimated elasticity of substitution from 2 to 0.5, while the effect of unions is estimated to zero.

While controlling for workplace fixed effects may eliminate the selection bias due to unobserved heterogeneity between workplaces, our estimator is likely to suffer from simultaneity bias as the individual propensity to unionize may be correlated with individuals' occupations. This correlation could be due to different traditions for trade unions in different professions, or the result of technological change (Acemoglu, et al., 2001) or offshoring (Dumont, et al., 2012) influencing unionization rates. To control for this issue of reverse causation, we exploit exogenous variation in the rules for tax deduction of union dues to instrument union density in *Model 3d,* while maintaining the assumption of fixed effects at the workplace level. An increase in workplace union density by one percentage point is now estimated to increase the relative demand for routine workers over non-routine workers by 2.2 percent. The result is statistically significant at the 5 percent level. While the instruments pass conventional tests for weak instruments, we notice that the variation is caused both by changes in the subsidy amount and by changes in the net membership fee.[27] As proposed in Barth et al. (2020), we measure the subsidy relative to the net fee in *Model 3e*. This does not affect the estimated coefficients in any significant way. A ten percent increase in the subsidy ratio is estimated to increase the workplace union density by 1.4 percentage points.

The estimated effect of a change in union density is significantly larger in *Models 3d* and *3e* than what was predicted by the OLS-models. This may indicate that the OLS-estimator is downward biased. However, it is important to emphasize that the IV estimator identifies the local average treatment effect (LATE) among compliers, which in general is not equal to the average treatment effect (ATE). In Section 5.1, we found that routine workers are more likely to unionize in response to changes in the rules for tax deduction of union dues than non-routine workers. All else equal, this implies that the expected variation in workplace union density following exogenous variation in the subsidization of union memberships would be higher in workplaces employing a high share of routine workers. The differences between the OLS and IV estimates could thus indicate that changes in tax deductions affect memberships where it matters most for technological change. As suggested in Barth et al. (2020), large effects of

[27] Recall that the net union membership fee is constructed by subtracting the government subsidy from the gross fee.

changes in union density may reflect threshold effects, as unions may require a collective agreement once the union density reaches certain thresholds.

The results prove robust when we restrict the estimation sample to workplaces present all years to control for firm entry and exit in *Model 3f*. In Table A3 in the Appendix, we also show that the results are robust to how the measure of relative wages is constructed. In *Model 3g*, we test how the results change when we use routine task intensity (RTI) to define routine and non-routine occupations. While both the estimated elasticity of substitution and the estimate of the subsidy ratio in the first-stage equation appear to be invariant to the choice of automation measure, the coefficient on union density is more than doubled when we use RTI to define occupations susceptible to automation. However, while the size of the coefficient is unstable, unions are still estimated to increase the relative demand for routine workers conditional on relative wages. In Table A3 in the Appendix, we also test two alternative thresholds of automation risk to define routine and non-routine occupations. If we increase the threshold value of automation risk that defines routine occupations to 0.8, the positive coefficient is further strengthened, while it turns negative (but not significant) if we lower the threshold to 0.6. This illustrates that the estimated coefficient is sensitive to the choice of threshold value.[28]

When we restrict the sample to workplaces with at least ten employees in *Model 3h*, leaving out almost 60 percent of the workplaces in our sample, the estimated coefficient on union density is no longer statistically significant. This could reflect that the estimated effect of unions on relative conditional labor demand mostly applies to small workplaces, or in industries dominated by small workplaces. Indeed, estimation of *Model 3e* within various industries reveals large heterogeneity in the estimated effects. In Table 4, we show the results within six selected main industries. First, the elasticity of substitution is estimated to 0.6-0.8 within manufacturing, transportation and storage, and commercial services, while it is twice as large within construction and not significantly different from zero within sales and retail and financial services. Second, while unions are estimated to have a positive and significant effect on the relative demand for routine labor within construction and commercial services, we find a negative and significant effect within manufacturing industries. In the other industries, the

[28] When we reduce the threshold of automation risk that defines routine occupations to 0.6, the share of routine workers in our sample is increased from 43 percent to 56 percent. When we increase the threshold to 0.8, the share is reduced to 23 percent. This means that even small changes in the threshold value have large consequences for composition of workers in each group. Moreover, the choice of threshold value also alters the composition of workplaces, as only workplaces that employ both routine and non-routine workers are included in the estimation.

estimated conditional effect of unions is not significantly different from zero. However, these estimates suffer from weak identification and should not be considered reliable.

Table 3 Union effect on relative demand for routine workers conditional on relative wages

	Model 3a	***Model 3b***	***Model 3c***	***Model 3d***	***Model 3e***	***Model 3f***	***Model 3g***	***Model 3h***
Estimator	*OLS*	*OLS*	*FE*	*2SLS*	*2SLS*	*2SLS*	*2SLS*	*2SLS*
$\log(w_R/w_N)$	-2.029***	-2.057***	-0.471***	-0.516***	-0.526***	-0.557***	-0.557***	-0.853***
	(-201.41)	(-192.81)	(-26.11)	(-22.19)	(-19.43)	(-13.35)	(-26.00)	(-21.80)
Union density (UD)	-0.290***	0.047***	0.003	2.181**	2.656**	3.258*	6.380***	1.740
	(-47.10)	(7.73)	(0.23)	(2.27)	(2.27)	(1.77)	(3.54)	(0.91)
Year dummies	✓	✓	✓	✓	✓	✓	✓	✓
Controls		✓	✓	✓	✓	✓	✓	✓
Workplace FE			✓	✓	✓	✓	✓	✓
Balanced panel						✓		
RTI							✓	
Min. 10 empl. in establ.								✓
First-stage:								
Subsidy				0.027**				
				(2.00)				
Net fee				-0.054***				
				(-4.74)				
Subsidy ratio					0.142***	0.158**	0.150***	0.150**
					(3.86)	(2.37)	(3.44)	(2.49)
Weak instruments test:								
Cragg–Donald:				25.06	19.12	8.88	15.30	10.38
Kleibergen–Paap:				19.67	14.78	6.69	11.09	8.34
No. of workplaces	118,338	118,338	118,338	96,801	96,801	54,862	77,995	39,923
Avg. obs. per workplace	5.8	5.8	5.8	6.8	6.8	8.9	6.8	7.1
Total observations	684,145	684,145	684,145	662,260	662,260	490,323	527,232	282,189

*Note: The endogenous variable is $log\ (L_R/L_N)$, where the demand for each labor input is measured in hours worked. Wages are measured as market averages of hourly wages within different job classes, determined by occupation and industry. For each individual, the individual's wage is excluded from the average within the job class. Information on whether or not firms participate in collective agreements is used to distinguish unionized from non-unionized firms in construction of the market wages. Controls include sex, age, education, and immigration status, all measured as shares at the workplace level. Union density is measured as a rate between 0 and 1. Models estimated using two-stage least squares (2SLS) use Subsidy and Net fee, or Subsidy ratio as excluded instruments for union density. The tax subsidy is measured in 1000 NOK (equal to approximately €88) as the marginal tax rate (28 per cent) multiplied with the minimum of actual membership payments and the maximum deductible amount). The subsidy ratio measures the subsidy as a share of the net membership fee. Cragg–Donald and Kleibergen–Paap refer to the Cragg-Donald Wald F statistic and the Kleibergen-Paap Wald rk F statistic of weak instruments, respectively. Sample:2003-2014. Robust standard errors. t statistics in parentheses. * p<0.1, ** p<0.05, *** p<0.01*

Table 4 Union effect on relative demand for routine workers conditional on relative wages within selected industries

	Model 4a	***Model 4b***	***Model 4c***	***Model 4d***	***Model 4e***	***Model 4f***
Industry	*Manufacturing*	*Construction*	*Wholesale & retail*	*Transportation & storage*	*Financial activities*	*Commercial services*
$\log(w_R/w_N)$	-0.617***	-1.759***	0.356	-0.780***	-0.235	-0.816***
	(-12.15)	(-30.40)	(0.71)	(-3.96)	(-1.18)	(-8.39)
Union density (UD)	-5.852**	4.065***	-20.880	-5.413	8.695	5.671**
	(-2.29)	(3.24)	(-1.48)	(-0.32)	(1.34)	(2.19)
First-stage:						
Subsidy ratio	0.371***	0.381***	0.144	0.092	0.252	0.294***
	(2.90)	(5.72)	(1.51)	(0.45)	(1.54)	(3.89)
Weak instruments test:						
Cragg–Donald:	16.87	48.72	3.26	0.27	3.15	19.65
Kleibergen–Paap:	8.42	32.67	2.29	0.21	2.37	15.16
No. of workplaces	9,530	12,460	35,932	4,033	1,098	4,366
Avg. obs. per workplace	7.7	6.4	7.2	6.4	5.9	5.3
Total observations	72,948	79,955	257,021	25,995	6,513	23,019

*Note: The endogenous variable is $log\ (L_R/L_N)$, where the demand for each labor input is measured in hours worked. Wages are measured as market averages of hourly wages within different job classes, determined by occupation and industry. For each individual, the individual's wage is excluded from the average within the job class. Information on whether or not firms participate in collective agreements is used to distinguish unionized from non-unionized firms in construction of the market wages. Union density is measured as a rate between 0 and 1. All models are estimated using 2SLS with workplace fixed effects, yearly time dummies and controls on workers' sex, age, education, and immigration status (measured as shares at the workplace level). The subsidy ratio is used as excluded instrument for union density. The subsidy is defined as the marginal tax rate (28 per cent) multiplied with the minimum of actual membership payments and the maximum deductible amount). The subsidy ratio measures the subsidy as a share of the net membership fee. Cragg–Donald and Kleibergen–Paap refer to the Cragg-Donald Wald F statistic and the Kleibergen-Paap Wald rk F statistic of weak instruments, respectively. Sample:2003-2014. Robust standard errors. t statistics in parentheses. * p<0.1, ** p<0.05, *** p<0.01*

6 Conclusion

In this paper, we have investigated how unions alter the process of technological change at the workplace level, as measured by the share of workers employed in routine occupations. We have used both occupational risk of automation and routine task intensity to define routine occupations and shown that the results of our study are robust to the choice of measure. The analysis has been concentrated around how unions alter relative wages between routine workers and non-routine workers, and how unions influence relative labor demand *conditional* on relative wages. In the first part of the analysis, we find that routine workers enjoy a larger union premium compared to non-routine workers, suggesting that unions contribute to increase the relative wage of routine workers over non-routine workers. This finding is consistent with policies of wage compressions followed by many labor unions, as routine workers on average are paid lower wages than non-routine workers.

In response to higher wages, firms reduce their relative demand for routine labor over non-routine labor, as documented in the second part of the analysis. In other words, by increasing the relative wage of workers in occupations with a high risk of being replaced by automation, unions contribute positively to technological change. This echoes the result in Moene & Wallerstein (1997), where wage compression at the national level as a result of centralized bargaining contributes to technological change. Our findings show that similar mechanisms are in place even at the establishment level.

Moreover, we show that unions – conditional on relative wages – influence the employment of routine workers over non-routine workers. This finding gives some support to theories of efficient bargaining, where firms and unions bargain over both wages and employment. An increase in the workplace union density is estimated to increase the relative demand for routine workers over non-routine workers. However, separate estimations for different industries reveal large heterogeneity. Within construction, unions are found to increase the conditional relative demand for routine workers. In other words, by influencing internal relations, unions are found to counteract the positive effect on technological change that we establish through the wage channel. Within manufacturing industries, however, unions are found to reduce the conditional relative demand for routine workers, thereby reinforcing the estimated positive influence of unions on technological change.

Heterogeneity across industries may reflect different union policies and experience with technological change. Indeed, both union density and collective bargaining coverage are significantly higher within manufacturing than in the construction industry. Norwegian manufacturing firms are also highly exposed to international competition and may thus be dependent of investments in new productive technology in order to stay is business. The construction industry, on the other hand, primarily serves the domestic market but has witnessed a decline in labor productivity due to massive labor migration following the expansions of the European Union in 2004 and 2007. Such differences in market conditions may influence how trade unions perceive investments in new technology.

We contribute to the literature on the interactions between trade unions and technological change by empirically identifying two mechanisms through which unions may influence automation decisions at the workplace level. However, our results rely on the use of observed structural changes in occupational compositions as a proxy for technological change. These changes could also reflect trends in offshoring or outsourcing of certain tasks, improvements in enabling technologies, organizational innovations, or supply side effects. Moreover, both measures used to evaluate occupations are constant over time. Future studies on unions and technological change should consider the use of time-varying classification of occupations to capture how unions may not only influence the composition of occupations, but also the composition of tasks within occupations.

Acknowledgements

We would like to thank Ragnar Torvik, Kåre Johansen, Harald Dale-Olsen, Terje Skjerpen, Joachim Thøgersen and Ragnar Nymoen, as well as two anonymous referees for valuable comments. A previous draft of this paper was presented at a seminar held by the Department of Economics at The Norwegian University of Science and Technology, November 18, 2021. The paper was also presented at the 34th EALE Conference in Padova, September 10, 2022. We thank the participants for useful feedback. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Declarations of interest: none.

Data Availability Statement

The data that support the findings of this study are available from Statistics Norway. Restrictions apply to the availability of these data, which were used under license for this study. Researchers affiliated with an approved research institution, or a public authority can apply to data from Statistics Norway (https://www.ssb.no/en/data-til-forskning/utlan-av-data-til-forskere).

References

Acemoglu, D., 2002. Technical change, inequality, and the labor market. *Journal of economic literature*, 40(1), pp. 7-72. https://doi.org/10.1257/0022051026976

Acemoglu, D., Aghion, P. & Violante, G. L., 2001. Deunionization, Technical Change and Inequality. *Carnegie-Rochester conference series on public policy*, 55(1), pp. 229-264. https://doi.org/10.1016/S0167-2231(01)00058-6

Acemoglu, D. & Autor, D., 2011. Skills, Tasks and Technologies: Implications for Employment and Earnings. In: D. Card & O. Ashenfelter, eds. *Handbook of Labor Economics.* Elsevier, pp. 1043-1171. https://doi.org/10.1016/S0169-7218(11)02410-5

Acemoglu, D. & Restrepo, P., 2019. Automation and New Tasks: How Technology Displaces and Reinstates Labor. *Journal of Economic Perspectives*, 33(2), pp. 3-30. https://doi.org/10.1257/jep.33.2.3

Acemoglu, D. & Restrepo, P., 2020. Robots and Jobs: Evidence from US Labor Markets. *Journal of Political Economy*, 128(6), pp. 2188-2244. https://doi.org/10.1086/705716

Acemoglu, D. & Restrepo, P., 2022. Tasks, Automation, and the Rise in U.S. Wage Inequality. *Econometrica*, 90(5), pp. 1973-2016. https://doi.org/10.3982/ECTA19815

Acikgoz, O. & Kaymak, B., 2014. The rising skill premium and deunionization. *Journal of Monetary Economics*, Volum 63, pp. 37-50. https://doi.org/10.1016/j.jmoneco.2014.01.002

Agell, J. & Lommerud, K. E., 1992. Union egalitarianism as income insurance. *Economica*, 59(235), pp. 295-310. https://doi.org/10.2307/2554603

Arntz, M., Gregory, T. & Zierahn, U. (2016), The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis (OECD Social, Employment and Migration Working Papers, No. 189). Paris: OECD Publishing. https://doi.org/10.1787/5jlz9h56dvq7-en

Autor, D. & Dorn, D., 2013. The growth of low-skill service jobs and the polarization of the US labor market. *American Economic Review*, 103(5), pp. 1553-97. https://doi.org/10.1257/aer.103.5.1553

Autor, D. H., Katz, L. F. & Kearney, M. S., 2006. The Polarization of the U.S. Labor Market. *American Economic Review*, 96(2), pp. 189-194. https://doi.org/10.3386/w11986

Autor, D. H., Levy, F. & Murnane, R. J., 2003. The Skill Content of Recent Technological Change: An empirical Exploration. *The Quarterly Journal of Economics*, 118(4), pp. 1279-1333. https://doi.org/10.1162/003355303322552801

Baldwin, C. Y., 1983. Productivity and Labor Unions: An Application of the Theory of Self-Enforcing Contracts. *The Journal of Business*, 56(2), pp. 155-185. https://www.jstor.org/stable/2352822

Barth, E., Bryson, A. & Dale-Olsen, H., 2020. Union Density Effects on Productivity and Wages. *The Economic Journal*, 130(631), p. 1898–1936. https://doi.org/10.1093/ej/ueaa048

Booth, A. L., 1995. *The economics of the trade union.* New York: Cambridge University Press.

Braun, S., 2011. Unionisation structures, productivity and firm performance: New insights from a heterogeneous firm model. *Labour Economics*, 18(1), pp. 120-129. https://doi.org/10.1016/j.labeco.2010.08.004

Brynjolfsson, E. & McAfee, A., 2012. *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment.* Lexington, MA: Digital Frontier Press.

Cahuc, P., Carcillo, S. & Zylberberg, A., 2014. *Labor economics.* Cambridge, MA: MIT press.

Card, D. & DiNardo, J. E., 2002. Skill-Biased Technological Change and Rising Wage Inequality: Some Problems and Puzzles. *Journal of Labor Economics*, 20(4), pp. 733-783. https://doi.org/10.1086/342055

Carmichael, L. & MacLeod, W. B., 1993. Multiskilling, Technical Change and the Japanese Firm. *The Economic Journal*, 103(416), pp. 142-160. https://doi.org/10.2307/2234341

Dale-Olsen, H., 2021. Do unions contribute to creative destruction? *PLoS ONE*, 16(12). https://doi.org/10.1371/journal.pone.0261212

De Vries, G. J., Gentile, E., Miroudot, S., & Wacker, K. M. (2020). The rise of robots and the fall of routine jobs. *Labour Economics*, 66 (101885) https://doi.org/10.1016/j.labeco.2020.101885

Dinlersoz, E. & Greenwood, J., 2016. The rise and fall of unions in the United States. *Journal of Monetary Economics*, Volum 83, pp. 129-146. https://doi.org/10.1016/j.jmoneco.2016.08.008

Doucouliagos, H., Freeman, R. B. & Laroche, P., 2017. *The economics of trade unions: A study of a research field and its findings.* Taylor & Francis.

Dowrick, S. & Spencer, B. J., 1994. Union Attitudes to Labor-saving Innovation: When Are Unions Luddites? *Journal of Labor Economics*, 12(2), pp. 316-344. https://doi.org/10.1086/298359

Dumont, M., Rayp, G. & Willemé, P., 2012. The bargaining position of low-skilled and high-skilled workers in a globalising world. *Labour Economics*, 19(3), pp. 312-319. https://doi.org/10.1016/j.labeco.2012.02.005

Freeman, R. B., 1991. How Much Has De-Unionization Contributed to the Rise in Male Earnings Inequality? *NBER working paper 3826.* http://doi.org/10.3386/w3826

Freeman, R. B. & Medoff, J. L., 1982. Substitution Between Production Labor and Other Inputs in Unionzed and Nonunionized Manufacturing. *The Review of Economics and Statistics*, 64(2), pp. 220-233. https://doi.org/10.2307/1924301

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

Frey, C. B. & Osborne, M. A., 2017. The future of employment: How susceptible are jobs to computerisation?. *Technological Forecasting and Social Change*, Volume 114, pp. 254-280. https://doi.org/10.1016/j.techfore.2016.08.019

Goos, M. & Manning, A., 2007. Lousy and lovely jobs: The rising polarization of work in Britain. *The Review of Economics and Statistics*, 89(1), pp. 118-133. https://doi.org/10.1162/rest.89.1.118

Grout, P., 1984. Investment and Wages in the Absence of Binding Contracts: A Nash Bargaining Approach. *Econometrica*, 52(2), pp. 449-460. https://doi.org/10.2307/1911498

Guimarães, L. & Gil, P. M., 2022. Explaining the Labor Share: Automation Vs Labor Market Institutions. *Labour Economics*, Volum 75, 102146. https://doi.org/10.1016/j.labeco.2022.102146

Hardy, W., Keister, R. & Lewandowski, P., 2018. Educational upgrading, structural change and the task composition of jobs in Europe. *Economics Of Transition*, 26(2), pp. 201-231. https://doi.org/10.1111/ecot.12145

Haucap, J. & Wey, C., 2004. Unionisation structures and innovation incentives. *The Economic Journal*, 114(494), pp. 149-165. https://doi.org/10.1111/j.0013-0133.2004.00203.x

Huzzard, T., Gregory, D. & Scott, R., 2004. *Strategic Unionism and Partnership: Boxing or Dancing?*. New York: Palgrave Macmillan.

Katz, L. & Murhpy, K. M., 1992. Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *The Quarterly Journal of Economics*, 107(1), pp. 35-78. https://doi.org/10.2307/2118323

Keynes, J. M., 1931. Economic Possibilities for our Grandchildren. In: *Essays in Persuasion.* London: Macmillan, pp. 358-373.

Krueger, A., 2018. Reflections on Dwindling Worker Bargaining Power and Monetary Policy. *Presentation at Jackson Hole Economic Policy Symposium*, Jackson Hole, WY, August 24, 2018.

Lommerud, K. E., Meland, F. & Straume, O. R., 2006. Globalisation and union opposition to technological change. *Journal of International Economics*, 68(1), pp. 1-23. https://doi.org/10.1016/j.jinteco.2005.03.002

Maki, D. R. & Meredith, L. N., 1987. A note on unionization and the elasticity of substitution. *Canadian Journal of Economics*, 20(4), pp. 792-801. https://doi.org/10.2307/135416

McDonald, I. M. & Solow, R. M., 1981. Wage Bargaining and Employment. *The American Economic Review*, 71(5), pp. 896-908. https://www.jstor.org/stable/1803472

Mincer, J., 1974. *Schooling, Experience and Earnings.* New York: National Bureau of Economic Research.

Moene, K. O. & Wallerstein, M., 1997. Pay Inequality. *Journal of Labor Economics*, 15(3), pp. 403-430. https://doi.org/10.1086/209866

Piketty, T., 2014. *Capital in the Twenty-first Century.* Cambridge (MA): The Belknap Press of Harvard University Press.

Svarstad, E. & Kostøl, F. B., 2022. Unions, Collective Agreements and Productivity: A Firm-Level Analysis Using Norwegian Matched Employer-Employee Panel Data. *British Journal of Industrial Relations*, 60(4), pp. 864-864. https://doi.org/10.1111/bjir.12662

Svarstad, E. & Nymoen, R., 2022. Wage inequality and union membership at the establishment level: An econometric study using Norwegian data. *Oxford Economic Papers*. https://doi.org/10.1093/oep/gpac018

Tauman, Y. & Weiss, Y., 1987. Labor Unions and the Adoption of New Technology. *Journal of Labor Economics*, 5(4), pp. 477-501. https://doi.org/10.1086/298158

Appendix

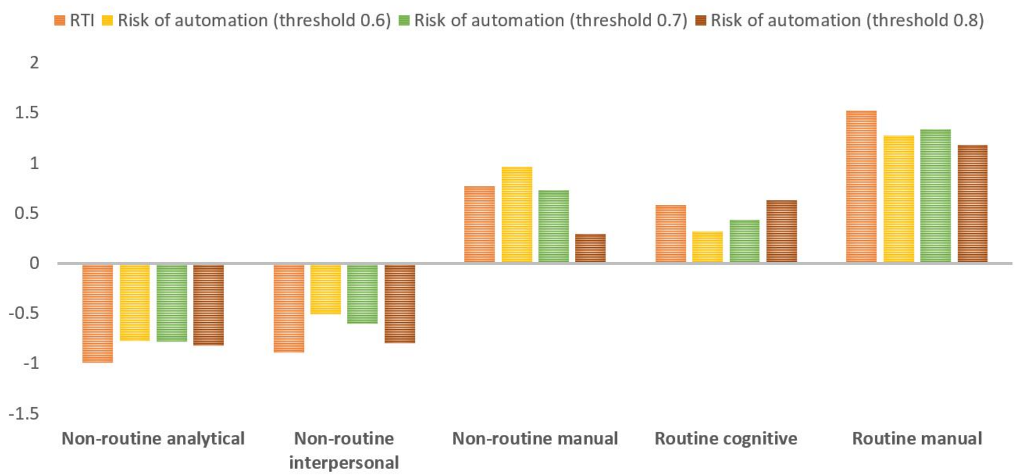
A1 Descriptive statistics

Table A1 Descriptive statistics at the workplace level. 2003-2014.

NACE A38	Industry	Union density	Collective agreement coverage	Mean risk of automation	Mean RTI	Share of high-risk workers	Share of high RTI workers	N
A	Primary	15 %	8 %	0.63	0.34	58 %	14 %	83 079
B	Mining and quarrying	33 %	35 %	0.56	0.35	40 %	28 %	9 493
C	Manufacturing	25 %	32 %	0.60	0.36	48 %	55 %	156 329
D-E	Technical infrastructure	55 %	26 %	0.51	0.35	25 %	36 %	18 037
F	Construction	13 %	13 %	0.59	0.34	38 %	21 %	238 660
G	Wholesale and retail	16 %	16 %	0.60	0.34	61 %	12 %	587 950
H	Transportation and storage	23 %	11 %	0.55	0.36	16 %	46 %	136 831
I	Hotel and restaurants	15 %	16 %	0.68	0.36	59 %	56 %	98 349
J	ICT	23 %	11 %	0.34	0.34	23 %	9 %	78 605
K	Finance	54 %	55 %	0.46	0.33	8 %	7 %	35 564
L-M	Professional services	21 %	7 %	0.48	0.34	31 %	35 %	255 349
N	Commercial services	17 %	13 %	0.53	0.35	28 %	32 %	79 148
O	Public adm. and defense	75 %	28 %	0.41	0.33	17 %	17 %	163
P-Q	Education and health care	36 %	8 %	0.29	0.33	9 %	19 %	168 916
R-S	Cultural activities	23 %	10 %	0.37	0.34	16 %	18 %	122 229
T-U	Other activities	25 %	7 %	0.63	0.36	9 %	74 %	3 201
	Missing	18 %	10 %	0.51	0.34	32 %	26 %	3 317
	Total	21 %	15 %	0.53	0.34	40 %	25 %	2 075 220

Note: All variables are measured at the workplace level (e.g., union density is measured as the mean union density across workplaces – not across workers).

Figure A1 Average composite task measure scores of routine occupations (demeaned)



Note: Average composite task measure scores of routine occupations, with sample mean subtracted, using different definitions of routine occupations. RTI identify routine workers as workers employed in occupations that are in the top employment-weighted third of routine task intensity. The other measures identify routine workers using three different threshold of automation risk.

A2 Supplementary estimation results

Table A2 Robustness checks of how unions influence relative wages in routine and non-routine occupations using different automation measures and threshold values

	Model A2a	***Model A2b***	***Model A2c***	***Model A2d***
Estimator	2SLS	2SLS	2SLS	2SLS
Union density (UD)	0.168***	0.224***	0.193***	0.192***
	(36.64)	(56.41)	(29.42)	(6.49)
Routine (R)	-0.096***	-0.050***	-0.119***	-0.756***
	(-50.46)	(-30.39)	(-35.20)	(-21.49)
R x UD	0.121***	0.070***	0.079***	0.183**
	(29.04)	(18.88)	(10.45)	(2.33)
Age	0.032***	0.034***	0.033***	0.034***
	(70.92)	(74.80)	(72.07)	(73.60)
Age^2	-0.0004***	-0.0005***	-0.0004***	-0.0004***
	(-403.66)	(-414.48)	(-407.05)	(-408.45)
Medium-skilled	0.130***	0.132***	0.132***	0.132***
	(182.93)	(184.58)	(185.72)	(185.62)
High-skilled	0.131***	0.140***	0.134***	0.138***
	(139.88)	(148.28)	(143.60)	(144.81)
Top-skilled	0.287***	0.303***	0.287***	0.295***
	(198.70)	(206.63)	(198.51)	(198.77)
Part-time worker	0.018***	0.013***	0.017***	0.015***
	(51.53)	(38.67)	(48.27)	(41.72)
Measure of automation	*Risk*	*Risk*	*Risk*	*RTI*
Threshold	*0.6*	*0.8*	*Continuous*	*Continuous*
Subsidy	0.089***	0.084***	0.093***	0.171***
	(58.62)	(55.61)	(58.70)	(45.95)
Net due	0.044***	0.049***	0.033***	-0.127***
	(146.35)	(176.93)	(88.45)	(-59.32)
Cragg-Donald:	54,328.6	48,938.4	47,103.5	42,208.9
Kleibergen-Paap	12,536.0	12,568.6	9,197.0	9,107.1
N	9,226,478	9,226,478	9,226,478	9,226,347

*Note: The endogenous variable is log(wage), where wages are measured as total payments per hours, including bonuses and supplementary pay for uncomfortable working hours. Union density (UD) is measured as a rate between 0 and 1. All models include year dummies and individual fixed effects. In Models A1a and A1b, Routine (R) is a dummy variable equal to 1 if the individual is occupied in an occupation with a risk of automation equal to or above the specified threshold. In Models A1c and A1d, Routine (R) is measured as a continuous variable using estimated risk of automation from Frey & Osborne (2017) and routine task intensity, respectively. Cragg–Donald and Kleibergen–Paap refer to the Cragg-Donald Wald F-statistic and the Kleibergen-Paap Wald rk F- statistic of weak instruments, respectively. UD x R denotes the interaction between Routine (R) and Union density (UD). Sample:2000-2014. Robust standard errors. t statistics in parentheses * p<0.1, ** p<0.05, *** p<0.01.*

Table A3 Robustness checks of how unions influence relative demand for routine over non-routine labor using different threshold values and wage measures

	Model 3e	***Model A3a***	***Model A3b***	***Model A3c***	***Model A3d***
Estimator	*2SLS*	*2SLS*	*2SLS*	*2SLS*	*2SLS*
$\log(w_R/w_N)$	-0.526***	-0.459***	-0.567***	-0.596***	-0.295***
	(-19.43)	(-33.17)	(-16.81)	(-22.41)	(-19.99)
Union density (UD)	2.656**	-1.376	7.484***	2.382**	4.259***
	(2.27)	(-1.63)	(3.08)	(2.09)	(3.26)
Risk threshold	0.7	0.6	0.8	0.7	0.7
Wage measure	Market wages controlling for collective agreements	Market wages controlling for collective agreements	Market wages controlling for collective agreements	Market wages	Actual wages
First-stage:					
Subsidy ratio	0.142***	0.197***	0.133***	0.143***	0.138***
	(3.86)	(5.13)	(2.82)	(3.89)	(3.84)
Weak instruments test:					
Cragg–Donald:	19.12	28.59	10.97	19.36	20.37
Kleibergen–Paap:	14.78	21.09	7.93	14.96	15.99
No. of workplaces	96,801	97,563	64,262	96,801	100,615
Avg. obs. per workplace	6.8	6.8	6.7	6.8	6.8
Total observations	662,260	666,813	430,048	662,260	681,114

*Note: The endogenous variable is $log\ (L_R/L_N)$, where the demand for each labor input is measured in hours worked. Wages are measured as market averages of hourly wages within different job classes, determined by occupation and industry. For each individual, the individual's wage is excluded from the average within the job class. Information on whether or not firms participate in collective agreements is used to distinguish unionized from non-unionized firms in construction of the market wages. All models include year dummies, workplace fixed effects and controls on sex, age, education, and immigration status (measured as shares at the workplace level). Union density is measured as a rate between 0 and 1. Models estimated using two-stage least squares (2SLS) use Subsidy and Net fee, or Subsidy ratio as excluded instruments for union density. The tax subsidy is measured in 1000 NOK (equal to approximately €88) as the marginal tax rate (28 per cent) multiplied with the minimum of actual membership payments and the maximum deductible amount). The subsidy ratio measures the government tax subsidy on union membership as a share of the net membership fee. Cragg–Donald and Kleibergen–Paap refer to the Cragg-Donald Wald F statistic and the Kleibergen-Paap Wald rk F statistic of weak instruments, respectively. Sample:2003-2014. Robust standard errors. t statistics in parentheses. * p<0.1, ** p<0.05, *** p<0.01*

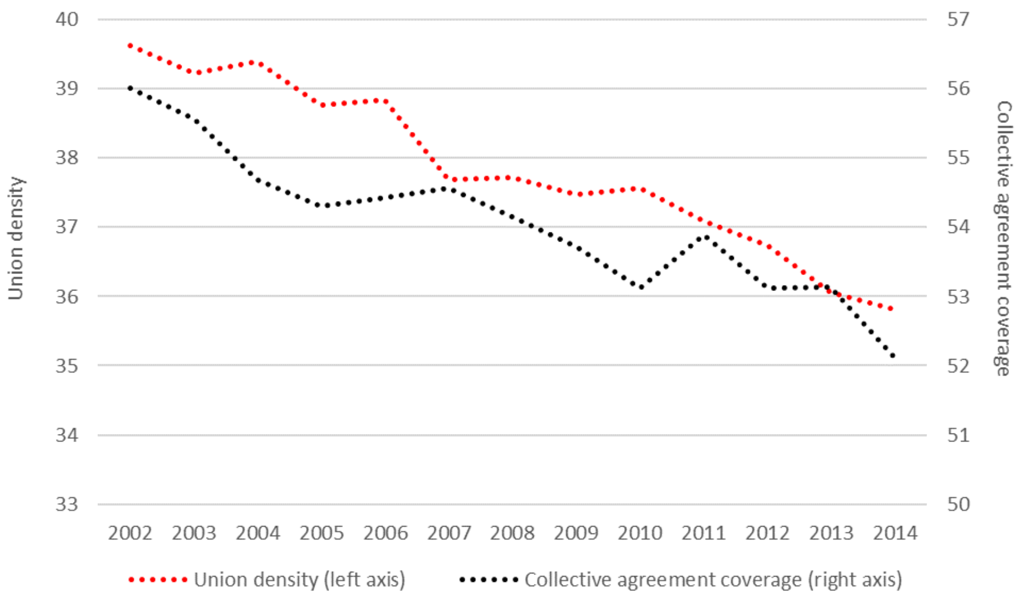
A3 Overview of the Norwegian Institutional Context

The relationship between employers and employees in Norway is organized through an interaction between legislation and collective agreements, where the importance of the latter is high compared to other countries. The labor market is characterized by strong trade unions and employer's associations. During our sample period, trade union density in the private sector has declined steadily but modestly from 40 percent in 2002 to 36 percent in 2014. However, union density and among Norwegian workers remain among the highest in the OECD.[29] The same applies to the coverage rate of collective bargaining, though the coverage rate is lower

[29] See the dataset on 'Trade Unions and Collective Bargaining' in the OECD statistical database.

than in many other Western European countries, where collective agreements at sectoral level may be required by law to extend to all firms and workers irrespective of union membership.[30]

Figure A2 Average union density (left axis) and collective agreement coverage rate (right axis)



In contrast to many other European countries, there is no general minimum wage in Norway. Instead, minimum wages are determined by collective agreements. Collective bargaining in Norway has a clear hierarchical structure. As in several other Western European countries, wages in the private sector may be negotiated at three levels: central, sectoral, and local. At the national level, a few major confederations determine the content of the basic agreements. The basic agreements form the basis for all lower-level agreements in specific industries. The second level in the hierarchy consists of agreements for specific industries, often referred to as business sector agreements. Local agreements between employers and employee representatives at company level, which are adapted to local conditions, make up the third level of the bargaining hierarchy. In contrast to sectoral agreements, local agreements automatically extend to all workers in occupations covered by the agreement, irrespective of union membership. Collective agreement coverage in Norway thus depends on the existence of local

[30] This is the case in Austria, Belgium, Finland, France, Germany, the Netherlands, and Portugal (García-Serrano 2009). A comprehensive overview of the prevalence and functioning of collective agreements in the OECD, including differences in the practice of *ergo omnes* clauses and extensions are found in the OECD report "Negotiating Our Way Up" (2019)

agreements. In general, if the union density among workers within the same bargaining area in a firm is above a certain threshold, the union will demand a collective agreement.[31] If the employer is organized in an employer's association, the agreement will be ratified more or less automatically. If the employer is not organized, the trade union will enter a direct agreement with the employer – if necessary, through the use of industrial action.

[31] The premise of a threshold in the union membership rate is institutionalized in the Basic Agreement between the Confederation of Norwegian Enterprise (NHO) and the Norwegian Confederation of Trade Unions (LO) (Hovedavtalen § 3-7, nr. 2). This states that employees cannot require that the enterprise become part of a collective agreement without at least 10 per cent of the employees being members of a union.

Chapter 2

Do Unions Increase Participation in Further Education?

Fredrik B. Kostøl

The manuscript was presented at the 13th annual meeting of the International Association of Economics of Education in Catanzaro, Italy, June 20, 2023, and at the 38th meeting of the European Economic Association, Barcelona, Spain, August 29, 2023.

The manuscript is under consideration in British Journal of Industrial Relations.

Reference:

Kostøl, F. B. (2023, August 29). Do Unions Increase Participation in Further Education? EEA-ESEM 2023, Barcelona, Spain.

Do unions increase participation in further education?

Fredrik B. Kostøl †

Department of Industrial Economics and Technology Management

Norwegian University of Science and Technology

Abstract

The race between education and technology is a key issue for trade unions. Unions often include skill-upgrading and training in collective bargains, which might be an important tool to facilitate lifelong learning. In this paper, I investigate how trade unions influence workers' participation in further education using Norwegian matched employer-employee panel data on full-time workers and a fixed-effects framework. In contrast to most existing studies, which rely on more or less representative surveys, our data comprise the entire working population over a period of 16 years, allowing us to control for unobserved individual heterogeneity. An increase in the workplace union density is estimated to raise the individual propensity to participate in tertiary vocational education. I also find that workers in unionized establishments enjoy higher salaries during further education, but at the expense of lower post-training wage premiums. In addition, unions are found to lower employee turnover. Together, these findings give empirical support to the theoretical prediction of Acemoglu & Pischke (1999), where firms may optimally choose to sponsor investments in workers' skills in absence of perfect competition in the labor market.

JEL Classification: I21, P36, J51, C23

Keywords: education; lifelong learning; trade unions; collective agreements, panel data

† Correspondence: Fredrik B. Kostøl, Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, 2815 Gjøvik, Norway. E-mail: fredrik.b.kostol@ntnu.no

1 Introduction

The process of technological change and its implications for the labor market has been a source of extensive debate since the first industrial revolution. In recent decades, the concern of labor-replacing technologies has been fueled by the progress in the use of computers (Autor et al., 2003), industrial robots (Acemoglu & Restrepo, 2020; De Vries et al., 2020), and artificial intelligence and mobile robotics (Frey & Osborne, 2017). Recent studies document evidence of rising inequality following serious structural change in the composition of skills (Acemoglu, 2002; Autor & Dorn, 2013), as well as a decrease in the labor share of income due to a slowdown in the creation of new tasks and in the reinstatement of displaced labor (Acemoglu & Restrepo, 2019). The bias in recent technological change in favor of highly skilled workers has put Tinbergen's classical race between education and technology back on the agenda (Tinbergen, 1974; Katz & Murhpy, 1992; Autor, et al., 2020). In order to keep track of the accelerating pace of technological developments, more investments in complementary education and skills are required to get the most out of the benefits made possible by new technology (Brynjolfsson & McAfee, 2012). In addition to formal education throughout childhood and youth, rapid technological advances also necessitates lifelong learning and contiuous skill-upgrading of workers (OECD, 2021).

The race between education and technology has been an important focus of trade unions. Faced with investments in labor-replacing technologies, unions may either oppose new technology and, under certain conditions, take the role as 'Luddites' (Dowrick & Spencer, 1994), or they may bargain for workers' skills to keep up with the technological progress (Heyes & Stuart, 1998). When unions include skill-upgrading and training in collective bargaining, this is an important tool to facilitate lifelong learning. In Norway, collective agreements include provisions on further educations which, to a large extent, place responsibility of funding educational leaves and associated costs on the employer. Moreover, by compressing the structure of wages, unions may increase the firms' willingness to sponsor general training in the case of oligopsonistic labor markets, as the post-training productivity will be increasing at a faster rate than wages (Booth et al., 2003).

In this paper, I investigate how trade unions influence workers' participation in further education, their wages during and after training, as well as their post-training likelihood of leaving their jobs. To measure further education, I concentrate on participation in tertiary vocational education among full-time employees with an educational attainment at the secondary level. Tertiary vocational schools were incorporated in the Norwegian legislation following the Competence Reform and they specialize in further education of craft workers. Participation in tertiary vocational education thus represent a well-suited measure of further education and lifelong learning. In a recent survey of the need for competence in Norwegian firms, more than half of the firms report a lack of workers with tertiary vocational education (Rørstad, et al., 2023).

There is a large literature on what unions do. In the seminal works by Freeman & Medoff (1979; 1984), unions are portrayed with two faces. On the one hand, the *monopoly face* represents the monopoly power attained by unionized workers through collective bargaining. On the other hand, the *exit voice/institutional response face* refers to various mechanisms through which unions may influence internal relations. While the monopoly bargaining power of unions is widely recognized to add a union-premium on wages (Blanchflower & Bryson, 2004), the question of how unions influence productivity has been more debated. The empirical evidence is mixed and found to vary across countries and different institutional contexts (Doucouliagos, et al., 2017). Recent studies of the Norwegian labor market document a positive causal effect of union density (Barth, et al., 2020) and collective agreements (Svarstad & Kostøl, 2022) on firm-level productivity. Both studies, as well as most other studies of what unions do, explain their results within the framework of the two-face methodology of Freeman and Medoff. However, when unions bargain not only for wages but also for the access to and funding of training and further education, both the wage premium of unionized workers *and* the positive effect of unions on productivity could reflect changes in individual worker productivity.

According to standard human capital theory, unions are likely to reduce workers' investments in training by reducing wage differentials (e.g. Mincer, 1981). Acemoglu & Pischke (1999), however, show how firms may invest in the general skills of their employees if labor markets are imperfect – in contrast to the case where labor markets are fully competitive, in which case firms never pay for investments in general training (Becker, 1964). In other words, if wage-compression reduces workers' investments in skills, this reduction may be offset by increased incidence of firm-sponsored general training. In this case, the theoretical effect of unions on training is ambiguous. Booth & Chatterji (1998), however, argue that reduced turnover in unionized firms will increase firms' incentives to invest in the skills of their workers, as the risk of losing the investment to competitors is lowered. Furthermore, unions may use their bargaining power to require firm-sponsoring of general training as part of their compensation package (Booth, et al., 2003).

The empirical evidence on how unions influence workers' participation in training is mixed. Different findings may be ascribed to different sources of data (e.g., cross-section surveys vs. panel data from administrative registers), different measures of training (e.g., job-specific training vs. formal general education), and different measures of unionization (e.g., individual union membership vs. workplace union density).[32] In the US, Duncan & Stafford (1980) and Mincer (1981) find negative effects of union membership on training, while Lynch (1992) and (1997) both report positive findings. Studies from the UK generally find a positive relationship between union coverage and training (Booth, 1991; Green, et al., 1999; Booth, et al., 2003). Hoque & Bacon (2008), however, find no consistent relationship between workplace union density and training. In Norway, the empirical evidence of how unions influence workers' participation in training is very limited. Stuart & Teige (2010) describe how Norwegian trade unions at the national level were deeply involved in the development of a competence reform designed to promote lifelong learning and skill-upgrading of adult workers during the 1990s. However, the authors note that weaker union structures at the local level constrained the implementation of the reform, which calls for an analysis of how unions influence participation in further education at the workplace level.

Using a panel of matched employer-employee data, comprising all Norwegian working individuals in the period 2004-2019, I find that participation rates in tertiary vocational education are positively related to workplace union density. To take account of possible endogenous selection into unions, I exclude the individual contribution to the workplace union density for all individuals. Furthermore, I include individual fixed effects to control for time-invariant unobserved heterogeneity, as well as industry trends to take account of idiosyncratic shocks at the industry level. A ten-percentage point increase in workplace union density is estimated to increase the individual propensity to participate in further education by 2-5 percent, depending on various model restrictions and specifications. In Norway, collective agreements are invoked once the workplace union density reaches certain thresholds. The findings may thus be explained by provisions in collective agreements to stimulate further education.

---

[32] See Table 2 in Waddoups (2014) for a systematic comparison of previous studies.

I also find evidence suggesting that unions compress the distribution of wages, thereby lowering the wage return of further education. While this will lower workers' incentives to invest in skills, it may increase firms' incentives to sponsor the education of their workers in absence of perfect competition in the labor market. Indeed, the results suggest that workers in unionized firms take lower wage cuts during education than workers in non-unionized firms. Furthermore, I find lower turnover amongst workers with a tertiary vocational degree in unionized firms compared to non-unionized firms. Together, these results suggest that higher participation rates in unionized firms could also be explained by firms optimally choosing to sponsor educational leaves.

The study adds an important contribution to the literature on unions and training by providing evidence using a comprehensive panel of matched employer-employee data from administrative registers. In contrast to most existing studies, which rely on more or less representative surveys, our data comprise the entire working population over a period of 16 years, allowing us to control for unobserved individual heterogeneity. Furthermore, the study contributes to the literature by utilizing data which allow us to concentrate on a particular type of formal *further* education offered to workers with upper secondary educational attainment. This complements existing studies relying on the more vaguely defined concepts of job-related training and general education.

The remainder of the paper is organized as follows. In Section 2, I present a simple conceptual framework to motivate some hypotheses for the empirical analysis. Section 3 then gives a short description of the Norwegian institutional context, before the data and descriptive statistics are presented in Section 4. In Section 5, I describe the methodological approach and discuss issues of identification. Section 6 documents the results, while Section 7 concludes.

2 Conceptual framework

Before presenting the data and empirical approach, this section outlines a simple conceptual framework in order to motivate a few hypotheses about how unions influence the incentives of individuals and firms to invest in further education. The framework consists of a one-period model, in which individuals supply one unit of labor inelastically to firms who produce a single good. Individuals either work in unionized or non-unionized firms. The individuals, who are otherwise equal, may choose to invest in further education, while firms may choose to sponsor a share $0 \leq \lambda \leq 1$ of the investment cost c.

The participation constraint of individuals employed in non-unionized establishments is described by the following condition:

$$\tilde{w} \equiv w^e - w \geq (1 - \lambda)c \quad (1)$$

where $\tilde{w}$ denotes the differential between the wage paid to trained and non-trained workers, respectively, and λ the share of the educational expenses sponsored by non-unionized firms. It is clear that the individual incentive for participating in further education is increasing in the wage differential $\tilde{w}$ and the share of costs that is sponsored by the firm.

Correspondingly, the participation constraint of individuals employed in unionized establishments is as follows:

$$\tilde{w}_u \equiv w_u^e - w_u \geq (1 - \lambda_u)c \quad (2)$$

where the wage rates and the share of investment costs sponsored by firms are allowed to vary between unionized and non-unionized establishments. Without modelling this explicitly, we will assume that unions contribute to compress the distribution of wages, such that the wage differential between trained and non-trained workers is lower in unionized establishments, that is $\tilde{w}_u < \tilde{w}$.[33] It follows from this that workers in unionized establishments have less incentives to invest in further education, which is also the result in standard human capital theory (Mincer, 1981).

Under perfect competition, equilibrium wages are set equal to the marginal productivities of the two types of labor. The marginal product of labor is assumed to be given by $1 + \mu$ for workers who have completed further education, where the parameter $\mu > 0$ reflects the increase in labor productivity from investing in further education. If the firm tries to pay a trained worker a wage below the equilibrium wage rate, the workers will immediately quit and receive the equilibrium wage elsewhere, in which case the trained workers are replaced with new non-trained workers. It thus follows that firms never will sponsor training if markets are perfectly competitive, which is a standard result in human capital theory (Becker, 1964).

However, if we allow firms to have some degree of monopsony power in the labor market, they may enjoy a quasi-rent from investing in skills. If the firm chooses to sponsor a share of each

---

[33] Indeed, this is a common characteristic of unions (see e.g., Acemoglu et al., 2001). This is also found in a recent empirical study of the Norwegian labor market (Kostøl & Svarstad, 2023).

workers' educational expenses equal to λ, it will earn an excess profit equal to $1 + \mu - w^e - \lambda c$ for each worker who remains in the firm. If a worker chooses to quit the firm, the firm will earn $1 - w - \lambda c$, where we assume that workers who quit are replaced by non-trained workers. If we let q denote the instantaneous quit rate, the firm's expected return from investing in education is:

(3) $$(1 - q)(1 + \mu - w^e) + q(1 - w) - \lambda c$$

If $q < 1$, the firm will be able to extract a quasi-rent by setting the wage paid to trained workers below the marginal product of trained labor. The firm will only choose to sponsor training if the expected return from doing so exceeds $(1 - w)$, that is if the following condition is satisfied:

(4) $$(1 - q)(1 + \mu - w^e) + q(1 - w) - \lambda c \geq 1 - w$$

Rearranging terms then yields the following participation constraint of the firm:

(5) $$\lambda \leq \frac{(1 - q)(\mu - \widetilde{w})}{c}$$

It is clear from the condition in (6) that the firm's willingness to sponsor further education is increasing in the productivity effect μ, while decreasing in the wage differential $\widetilde{w}$ and the quit rate q. This also illustrates two channels through which unions may influence firms' incentives for investing in the skills of their workers.

As previously noted, unions are known to compress the distribution of wages (Acemoglu, et al., 2001) *and* to reduce labor turnover (Freeman & Medoff, 1984; Booth & Chatterji, 1998). We may summarize these previous findings in the literature as two hypotheses:

- ***Hypothesis 1:*** *The wage differential between otherwise equal workers with and without further education is lower in unionized firms than in non-unionized firms*
- ***Hypothesis 2:*** *The turnover among trained workers is lower in unionized firms than in non-unionized firms*

If hypotheses 1 and 2 are true, and as long as the productivity gains from investing in education is the same in unionized and non-unionized firms, unionized firms are predicted to sponsor a larger share of educational expenses than non-unionized firms according to (5).

- ***Prediction:*** *Unionized firms will sponsor a larger share of educational expenses than non-unionized firms if hypotheses 1 and 2 are true.*

Whether participation in further education turns out to be larger in unionized or non-unionized firms remains theoretically ambiguous. If we combine the participation constraint of individuals in (2) with the firm's participation constraint in (5), we are left with the following condition:

$$1 - \frac{\tilde{w}}{c} \leq \lambda \leq \frac{(1-q)(\mu - \tilde{w})}{c} \qquad (6)$$

That is, unions are predicted to increase participation in further education if the firm has sufficiently strong monopsony power in the labor market, as measured by the quit rate q and the difference between the productivity and wage differentials of education $\mu - \tilde{w}$. This is ultimately an empirical question.

3 The Norwegian institutional context

An important characteristic of the Norwegian labor market, is the prominent role of social dialogue between collective organizations, ranging from the tripartite collaboration with trade union and enterprise confederations and the Government at the national level, down to deliberations between management and trade union representatives at the shop floor (Dølvik, 2022). Industrial relations are organized through an interaction between legislation and collective agreements, where the importance of the latter is high compared to other countries. While trade union density has declined during the last decades, unionized workers still amounted to 38 percent of all private sector workers in 2017 (Kjellberg & Nergaard, 2022), which is high compared to most countries outside Scandinavia.[34] The same applies to the coverage rate of collective bargaining, though the coverage rate is lower than in many other Western European countries, where collective agreements at sectoral level may be required by law to extend to all firms and workers irrespective of union membership.[35] Collective bargaining in Norway has a clear hierarchical structure (Svarstad & Kostøl, 2022). At the national level, a few major confederations determine the content of the basic agreements, which

[34] See the dataset on 'Trade Unions and Collective Bargaining' in the OECD statistical database.
[35] This is the case in Austria, Belgium, Finland, France, Germany, the Netherlands, and Portugal (García-Serrano 2009). A comprehensive overview of the prevalence and functioning of collective agreements in the OECD, including differences in the practice of *ergo omnes* clauses and extensions are found in the OECD report "Negotiating Our Way Up" (2019)

form the basis for all business sector agreements, which is then adapted to local conditions at the workplace level. In contrast to sectoral agreements, local agreements automatically extend to all workers in occupations covered by the agreement, irrespective of union membership. Collective bargaining coverage in Norway thus depends on the existence of local agreements. In general, if the workplace union density among workers within the same bargaining area is above a certain threshold, the union will demand a collective agreement. The required thresholds vary across different trade unions, usually in the range between 10 and 50 percent.[36]

There are long traditions for involving collective organizations in determining the design and content of the education system in Norway.[37] Indeed, The Norwegian Confederation of Trade Unions (LO) was the main driving force behind the development of what was to ultimately become the Norwegian Competence Reform in the late 1990s (Teige & Stuart, 2012). Concerned with declining membership and the risk of social exclusion and long-term unemployment of low-skilled members due to technological changes, there was an increasing awareness of the importance of lifelong access to skills development. Moreover, the tripartite social pact of wage restraint with the Government and the Confederation of Enterprise (NHO) in the period 1992-1997 caused LO to turn its attention to bargaining for training and skill-upgrading of existing workers (Payne, 2006).

The Competence Reform had several important implications for the access to education and training of adult workers. Among these were the introduction of a statutory right of all adults to complete basic education, as well as the right to educational leave from the workplace for up to three years to participate in relevant training and further education. Moreover, vocational schools providing craft workers with tertiary vocational education and training was formally legislated.[38] However, the reform did not resolve the issue of funding, which was an important requirement from the trade unions (Stuart & Teige, 2010). Up to the present date, the responsibility of funding further education of adult workers is not regulated in the legislation. However, in line with the Norwegian tradition of regulating industrial relations through an interaction between legislation and collective agreements, the responsibility of further education is incorporated into collective agreements. In the Basic Agreement between LO and

[36] As shown in Figure 3 in Svarstad & Kostøl (2022), the coverage rate of collective agreements is strictly increasing in workplace union density in the range between 10 and 50 percent.
[37] Se Appendix A1 for a description of the Norwegian education system.
[38] See Payne (2006, p. 483-484) for an overview of other elements of the reform.

NHO,[39] chapter 18 regulates development of workers' competence. Here it says that '*Both supplementary studies and further education will benefit the enterprise as well as the individual employee and therefore they must accept responsibility for developing such qualifications*' (§18-2). Regarding the question of funding, the agreement goes ever further: '*The costs of supplementary and further education must be borne by the enterprise. Responsibility for ensuring that any competence gap is covered satisfactorily rests with the enterprise and all its employees*' (§18-3).

In addition to the provisions in collective agreements, most trade unions offer some kind of financial support to members who want to participate in further education. For example, all members in 12 trade unions organized underneath the umbrella of LO have access to the confederation's educational fund. The perhaps most comprehensive financial support is offered to members of The Association for Management and Technology (FLT). Provided that the member is covered by a collective agreement at the workplace, the employer has agreed to pay NOK 1.20 per hour worked by the employee to a fund for further education. The union has also established its own company to facilitate education and training for its members in collaboration with education providers in Norway and Sweden (Undertun & Drange, 2018).

4 Data

The main data source is the register-based employment statistics produced by Statistics Norway, which is a combination of several administrative registers.[40] The population comprises all Norwegian individuals in the age 20-65 years who work at least one hour during the reference week in the period 2004-2019. In total, this amounts to 44,576,541 observations of 3,359,905 individuals. The reference week is the week containing the 16th of November, which is most often the third week of November. Individuals have their own unique identifying number, enabling us to track workers across time. As individuals enter and exit the labor market during the years of our sample, our panel is unbalanced. We use information on negotiated hours to define full-time workers as individuals who are working 30 hours or more during the reference week. Importantly, negotiated hours are not influenced by educational leaves. This implies that a full-time employee with a 50 percent educational leave still classifies as a full-

[39] For the latest version of the Basic Agreement in English (2018-2021), see https://www.lo.no/contentassets/2b75318eaad64229a5c5d135c81c4ecf/basic_agreement_lo-nho_2018-2021.pdf

[40] All data are provided by Statistics Norway through their web-application '*microdata.no*', which gives Norwegian researchers access to anonymized individual level data from administrative registers.

time employee. As we are interested in measuring further education of already established workers, we choose to leave out part-time workers. This restriction reduces our population to 28,088,775 observations.

Education is measured using two different variables. The first measures the individual's highest level of education at a given point in time, while the second measures ongoing participation in courses provided by tertiary vocational schools. As tertiary vocational education requires a degree from a secondary vocational school, we restrict the population to individuals who have finished a degree at the secondary vocational level. This reduces the number of observations to 9,622,713. We further reduce the population by leaving out individuals who have a degree from higher education, as the courses offered at tertiary vocational schools are less relevant for these individuals.[41] This leaves us with a total of 7,518,692 observations of 852,850 individuals.[42]

Information on individual union membership is derived from data on union dues, which is reported to the tax authorities by the unions. Furthermore, we have information about individuals' age, sex, and annual wage income. Each individual is linked to their current main employer each year, defined as the workplace where the individual works the most hours. By linking individuals and workplaces, we are able to identify workplace industry codes at the 5-digit level, as well as aggregate information at the workplace level derived from the composition of different individual workers' characteristics. Importantly, this allows us to calculate workplace union density as the ratio of union members relative to the number of employees in each establishment. Table A1 in the Appendix summarizes the main descriptive statistics.

4.1 Descriptive statistics

The data show a significant increase in the number of participants in tertiary vocational education during our sample period. As illustrated in Figure 1, the number of workers participating grew from less than 1,000 individuals in 2004 to about 9,000 in 2019. The figure also illustrates that a larger share of the participants are men. However, the growth has been largest among women, from almost no participants in 2004 to more than 3,000 participants in 2019. As shown in Figure 2, a large share of the participants works within construction,

[41] In Table A2 in the Appendix, I show that the results are robust but become somewhat weaker when we relax these restrictions on the estimation sample, as we would expect.
[42] Note that these sample restrictions imply that an individual may enter the sample when graduating from a secondary vocational school but then leave the sample if she finishes a degree within higher education.

manufacturing industries or oil and gas – industries dominated by male workers. The fast growth of female students can, to a large extent, be explained by the Government's funding of tertiary vocational education of health care workers as of 2009.[43]

Figure 1 Number of participants in tertiary vocational education

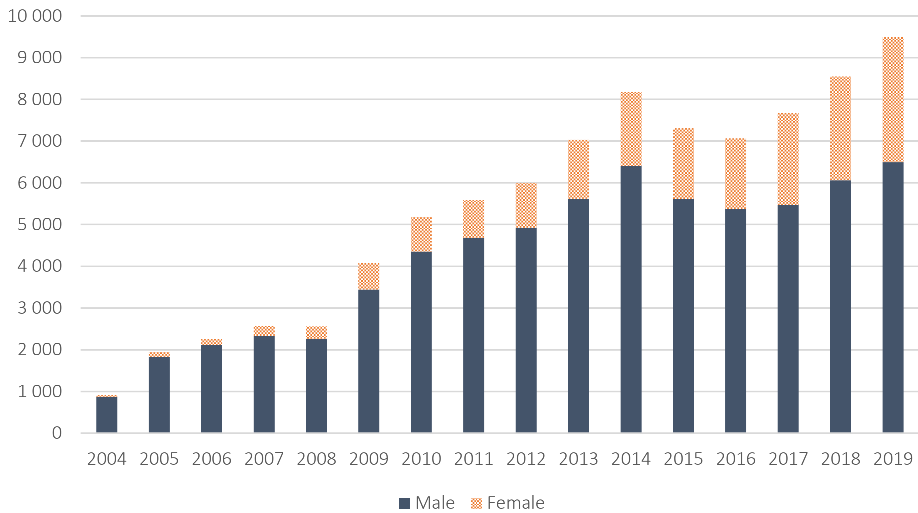
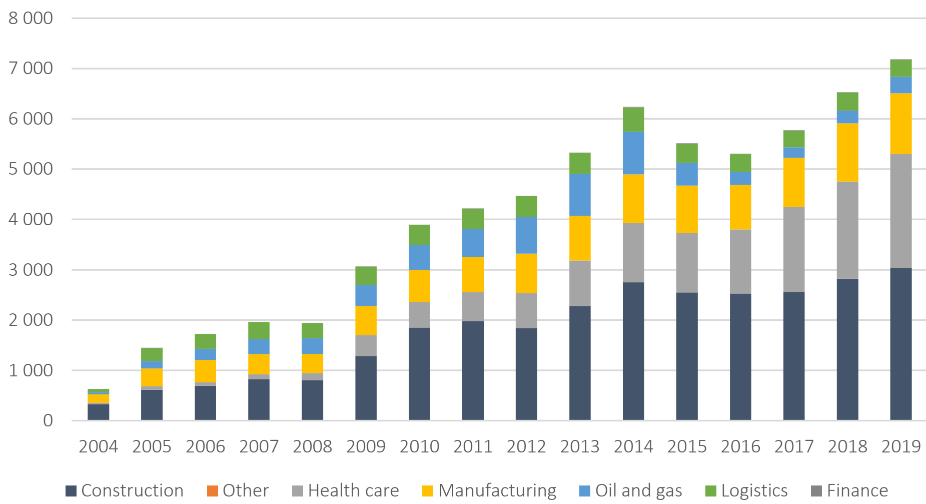


Figure 2 Participation in tertiary vocational education by industry



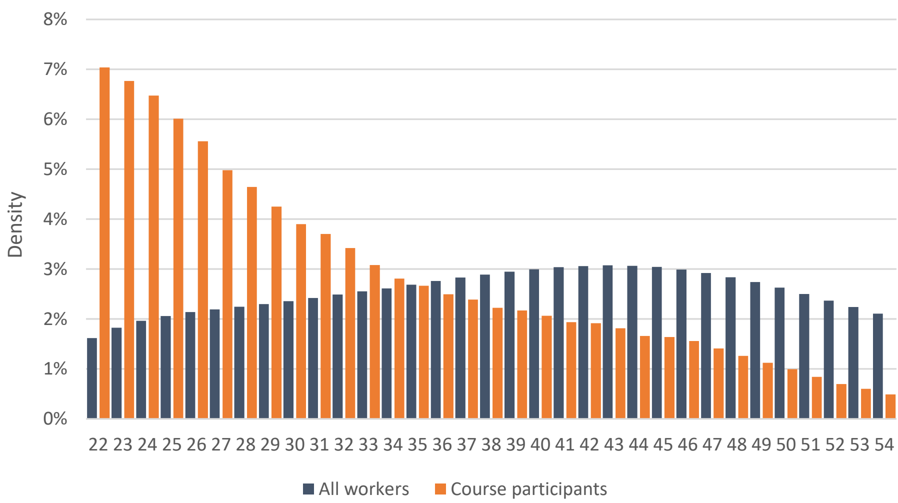
---

[43] See the Government's white paper '*St.meld nr. 44*' (2008-2009).

In Figure 3, I have illustrated the age profiles of workers who have participated in tertiary vocational education in the period 2004-2019, as well as for all vocational workers in our sample.[44] A large share of the participants is in the age between 20 and 30 years. However, while the participation rates fall as workers grow older, 46 percent of all full-time workers participating in tertiary vocational education are above 30 years. This illustrates the role of tertiary vocational education as a provider of lifelong learning to workers.

To get a picture of how participation in tertiary vocational education is influenced by unions, we have calculated participation rates for both union members and non-union members, as well as participation rates for full-time workers employed in a workplace where the union density exceeds 50 percent of the workers or not in Figure 4. The participation rates are simply defined as the number of participants in one or more courses in a given year, divided by the number of full-time workers in the corresponding group the same year. The participation rate is 20 percent higher for unionized workers than for non-union workers, and 34 percent higher for workers employed in workplaces where at least 50 percent of the workers are union members. While only suggestive, the raw data suggests a positive correlation between unionization and participation in tertiary vocational education.

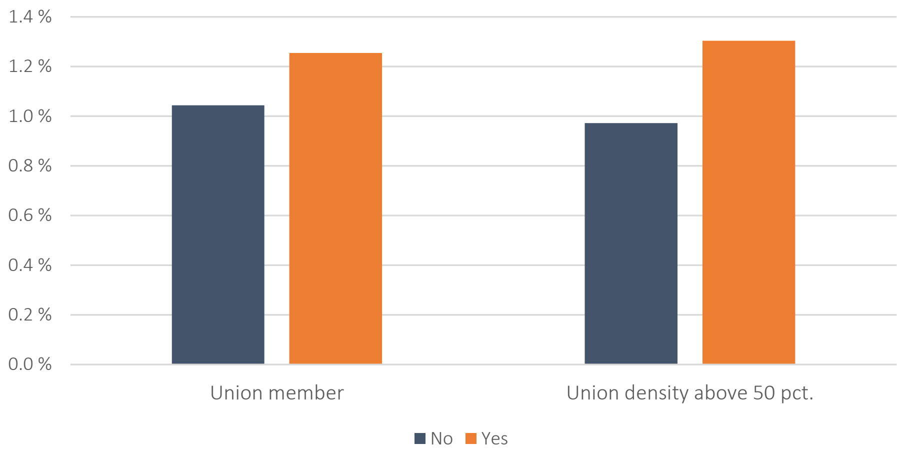
Figure 3 Age profiles of participants in tertiary vocational education



Note: The figure illustrates the age distribution of participants in tertiary vocational education compared to all vocational workers. The figure in censored in both directions.

[44] Note that individuals are counted each year they participate in one or more courses. In other words, an individual participating in two courses one year and three courses the next year, is counted two times in the figure.

Figure 4 Participation rates in tertiary vocational education by individual union membership and workplace union density



Note: The figure illustrates participation rates in tertiary vocational education among full-time employees and how participation varies with whether the individual is a union member or not and whether the union density at the workplace where the individual is employed is higher than 50 pct. of the workers or not.

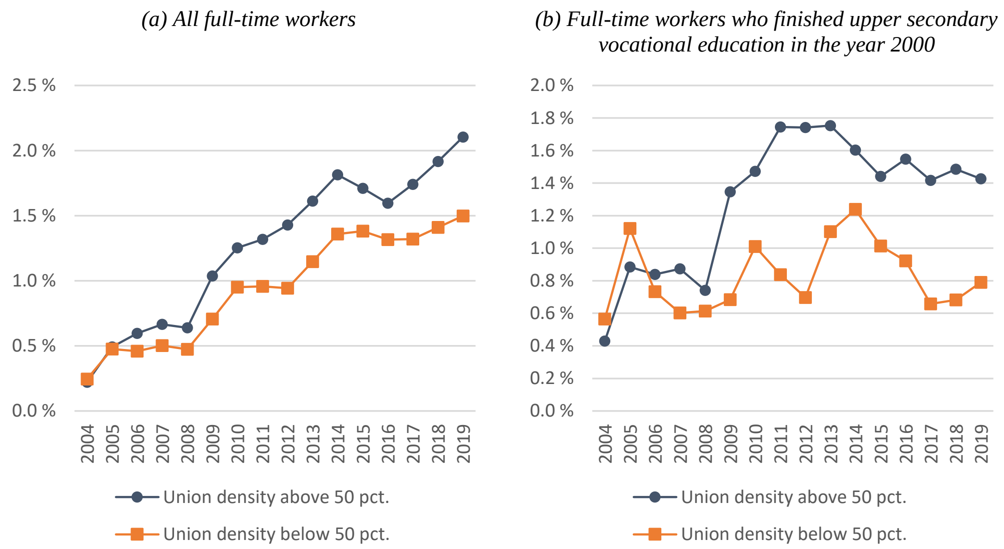
In Figure 5, we illustrate how the participation rates in tertiary vocational education by workplace union density vary over time. Panel (a) shows how participation rates have been increasing, both among workers employed in establishments where the union density is above and below 50 percent. However, the increase appears to be stronger for individuals employed in workplaces where the union density exceeds 50 percent. In Panel (b), we further restrict the sample to workers who finished their upper secondary *vocational* education in the year 2000. We do this for two reasons. First, requiring that workers have finished their upper secondary vocational education in the year 2000 allows us to study a more homogenous group of workers over a period of 16 years.[45] Second, by requiring workers to have graduated four years prior to the start of our period of analysis, we leave out any effect of onboarding of fresh graduates. The figure clearly suggests a higher participation rate among workers employed in establishments where the union density exceeds 50 percent of the workers.

Higher participation rates in further education in unionized firms could be explained by employers' incentives to sponsor further education. As shown in the conceptual model in Section 2, firms will sponsor the further education of their employees if unions contribute to a

[45] By the start of our period of analysis in 2004, the median full-time worker with upper secondary vocational education finished in the year 2000 is 26 years old, and 40 years old in 2019.

sufficiently large compression of the distribution of wages. The incentives to sponsor education would be further strengthened if unions also succeed in lowering turnover rates. Figure 6 shows estimated residuals from a regression of wages (in natural logarithms) on age, age squared, yearly dummies and industry fixed effects among workers in the years before and after finishing tertiary vocational education. The residuals are compared between workers employed in unionized and non-unionized firms. We see that the wage residuals are approximately equal to 0 for both groups of workers, before they make a significant drop in year -1, illustrating that the loss in wage income due to educational leaves make up an important cost of further education. The figure clearly indicates a lower drop in earnings for workers in unionized firms, which could indicate that their employers are sponsoring a share of their leaves. In line with the theory model, this could be explained by higher wage returns after finishing tertiary vocational education among workers in non-unionized firms, as indicated by Figure 6.

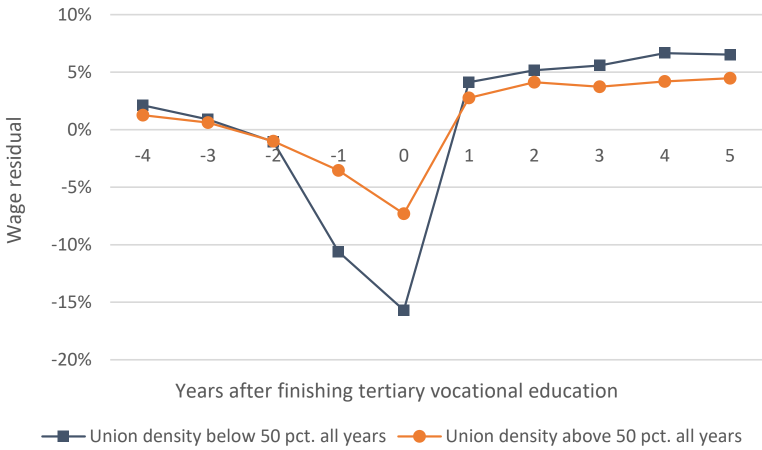
Figure 5 Participation rates in tertiary vocational education by workplace union density over time



Note: Both figures illustrate yearly participation rates in tertiary vocational education among full-time employees with upper secondary education as highest level of educational attainment (N=7,507,965). Panel (b) further restricts the sample to workers who finished their upper secondary vocational education in the year 2000 (N=223,923).

In Figure 7, I calculate cumulative turnover rates among workers in unionized and non-unionized firms in the years following tertiary vocational education. The figure suggests lower turnover rates among workers in unionized firms. After five years, 26 percent of workers employed in non-unionized establishments have left the firm they were employed in when they completed further education, as compared to 18 percent of workers in unionized establishments. Lower turnover rates in unionized firms will strengthen firms' incentives to sponsor the educational leaves of their employees if unions compress the distribution of wages.

Figure 6 Wage developments in the years before and after finishing tertiary vocational education



Note: The figure compares annual wages for full-time employees in establishments where the union density is below/above 50 percent all years

Figure 7 Employee turnover among workers finishing tertiary vocational education

Note: The figure compares cumulative turnover rates among full-time employees in establishments where the union density is below/above 50 percent all years

In summary, the raw data suggest a positive relationship between unionization and participation in further education, along with lower returns to education, lower wage declines during education, as well as lower turnover rates in in unionized establishments. These findings are consistent with the conceptual model outlined in Section 2. In the next section, I present the methodological framework for analyzing these relationships further.

5 Methodology

The descriptive statistics largely confirm the hypotheses that the return to further education and employee turnover are lower in unionized establishments. The data also show lower wage reductions during education among workers in unionized workplaces, which indicates that unionized establishments sponsor a larger share of the cost of absence from work. Ultimately, the descriptive statistics suggest that participation in further education is higher in more unionized establishments. In this section, I present empirical specifications for investigating these relationships more carefully using matched employer-employee panel data and a fixed-effects framework.

5.1 Participation in further education

In order to estimate the net effect of how unions influence workers' participation in further education, we estimate a linear probability model (LPM) conditional on workplace union density. As endogenous variable, we construct a binary variable taking the value 1 if the individual participates in one or more courses taught by a tertiary vocational school in a given year, and 0 if not. That is, if we let the discrete variable X_{it} denote the number of courses taught at tertiary vocational schools in which individual i participates in year t, we define the participation indicator P_{ijt} as:

$$P_{ijt} = \begin{cases} 1 \text{ if } X_{it} > 0 \\ 0 \text{ if } X_{it} = 0 \end{cases}$$

We then estimate the following model,

$$P_{ijt} = \beta_0 + \beta_1 UD_{it} + I_j + \delta_t + u_i + \varepsilon_{it} \qquad (7)$$

where UD_{it} is a continuous variable between 0 and 1 measuring the union density at the workplace where individual i is employed at time t. I_j denotes fixed effects at the industry level, while δ_t captures any time-specific shocks common to all individuals. u_i denotes fixed effects at the individual level, controlling for any time-invariant unobserved individual heterogeneity, while ϵ_{it} denotes random shocks. The parameter of interest is β_1.

5.2 Wage effects

In order to assess how unions influence the wage dispersion between workers with and without further education, we create a three-step categorical variable E_{it} which takes on one of the following values:

$$E_{it} = \begin{cases} 0 \text{ if individual } i \text{ has not participated in any courses by time } t \\ 1 \text{ if individual } i \text{ is currently participating in one or more courses at time } t \\ 2 \text{ if individual } i \text{ has completed further education by time } t \end{cases}$$

In order to simplify the analysis, the value of E_{it} is restricted to be increasing monotonically over time for each individual. The value of E_{it} shifts from 0 to 1 the first year an individual participates in one or more courses at the tertiary vocational level, and then shifts from 1 to 2 the last year of uninterrupted participation. E_{it} then remains equal to 2, regardless of whether the individual chooses to participate in more courses at the tertiary vocational level at a later point in time.[46] We then specify a simple Mincerian earnings equation, where we include our measure of further educational attainment along with a measure of workplace unionization, as well at their interactions:

$$\begin{aligned} w_{ijt} = \alpha_0 + \alpha_1 age + \alpha_2 age^2 + \alpha_3 E_{it}^{=1} + \alpha_4 E_{it}^{=2} + \alpha_5 U_{it} \\ + \alpha_6 E_{it}^{=1} \times U_{it} + \alpha_7 E_{it}^{=2} \times U_{it} + I_j + \delta_t + u_i + \epsilon_{it} \end{aligned} \tag{8}$$

where U_{it} is a binary variable equal to 1 if the number of union members amounts to at least 50 percent of the employees in the workplace.[47] This specification captures both the potential negative wage effect of educational leaves and the potential positive wage premium of further education, as captured by α_3 and α_4, respectively. Furthermore, the interaction coefficients α_6 and α_7 measures how these wage effects vary between unionized and non-unionized establishments. A positive value of α_4 together with a negative value of α_7 will give support to the assumption that unions contribute to reduce the wage premium of tertiary vocational education. A negative value of α_3, together with a positive value of α_6, will imply that workers in unionized firms face lower declines in annual earnings due to educational leaves compared

[46] Note, however, that this is not the case for individuals who advances to higher education, as these individuals leave the sample once graduated.

[47] Compared with the continuous measure of union density used in equation (8), this binary measure of unionization simplifies estimation and interpretation of the model. By choosing a cut-off at 50 percent, we require the majority of workers to be union members, which is also the requirement for implementing a collective agreement by one of the largest Norwegian trade unions ('Fellesforbundet'). See Section 3 for more details on the Norwegian institutional context.

to workers in non-unionized firms. This is consistent with the prediction of the theory model in Section 2, that unionized firms will sponsor a larger share of educational expenses. α_5 gives additional information on how wages, on average, are influenced by unionization. The included age polynomial is a proxy for individual experience,[48] while I_j, δ_t, u_i and ϵ_{it} are defined as in (7).

5.3 Turnover

While unions may reduce the wage returns to education, this only benefits the firm if it is able to prevent trained workers from quitting. In the conceptual framework outlined in Section 2, this can only be obtained if the firm exhibits some degree of monopsony power in the labor market. Going beyond the theory model, however, turnover could also be reduced by increasing employee satisfaction, for example by improving the quality of industrial relations, which may be achieved through unionization (Freeman & Medoff, 1984).

In order to estimate how unions influence employee turnover, we construct a binary variable τ_{ijty} equal to 0 if individual i working in industry j is employed at the workplace where she finished her tertiary vocational education in year y at time t. The variable is only defined for values of $t = [y, y+5]$. In other words, we follow workers from the year they finish their further education and the five preceding years. Moreover, we only include individuals who have been employed at their current workplace for at least one year at time $t = y$. We then estimate the following linear probability model:

$$\tau_{ijty} = \gamma_0 + \gamma_1 U_{it} + I_j + \delta_t + u_i + \xi_{it} \tag{9}$$

where the explanatory variables are defined as in (7) and (8). The parameter of interest is γ_1.

5.4 Identification

In the above estimations, we are interested in identifying how trade unions influence the wage return of education, employee turnover, the degree of firm sponsored training and ultimately participation in further education. However, the interpretation of the parameters of interest as causal effects rests on an identifying assumption of no endogenous selection into unions. This assumption could easily be violated if workers choose to unionize in response to low wages,

[48] When including individual fixed effects, however, the individual's age will be perfectly correlated with the time dummies and is thus excluded from the estimation.

high turnover or in order to get access to educational grants provided by trade unions.[49] However, as argued in Booth et al. (2003), the potential endogeneity problem induced by individual union member status is likely to be reduced when considering workplace union density, as we do in our analysis. In order to further mitigate the issue of endogenous unionization, we exclude the individual's contribution to the workplace union density for all workers, leaving us with a leave-out mean measure of union density invariant to changes in the individual's union status.

While we are mitigating the issue of endogenous selection into unions by using individual fixed effects and by measuring workplace union density as leave-out mean, we cannot rule out the possibility of idiosyncratic shocks influencing both participation in further education, wages or turnover, *and* union density at the workplace level. To reduce this potential issue, we include linear industry trends to absorb productivity shocks common to all workplaces within industries. Moreover, we include certified sickness absenteeism at the workplace level as a proxy for idiosyncratic productivity shocks.

6 Results

In this section, we present the results of the analyses of how unions influence participation in further education, the distribution of wages and employee turnover.

6.1 Participation in further education

The results from estimating a linear probability model (LPM) of how unions influence the individual's propensity to participate in tertiary vocational education are shown in *Table 1*. Using the OLS-estimator in *Models 1a-1d*, we find a positive relationship between workplace union density and the individual propensity to participate in tertiary vocational education. The correlation drops but remains statistically significant when we include individual fixed effects to control for unobserved heterogeneity in *Model 1e*. The estimated coefficient should be interpreted as percentage point change in individual participation in tertiary vocational education if the workplace union density increases from 0 to 1. If we compare the coefficient with the average participation rate in further education, which is equal to 1.2 percent, an

[49] As union memberships may be rather expensive, and as both the Norwegian Working Environment Act and collective agreements require some seniority in the firm before workers are entitled to educational leaves and grants, endogenous selection into unions of individuals seeking to participate in further education is not likely to represent a big problem.

increase in the workplace union density by ten percentage points is estimated to increase the participation rate by 2.2 percent.

In Table 2, we measure union density as leave-out mean in all models to mitigate the potential issue of time-varying endogenous selection into unions. When we compare the results in *Model 2a* and *Model 1e*, we see that the estimated coefficient on union density remains almost unchanged. In other words, the estimated effect does not appear to be a result of individual selection into union memberships.

Table 1 The effect of workplace union density on the individual propensity to participate in tertiary vocational education

	Model 1a	***Model 1b***	***Model 1c***	***Model 1d***	***Model 1e***
Estimator	OLS	OLS	OLS	OLS	FE
Union density	0.0054^{***}	0.0025^{***}	0.0048^{***}	0.0082^{***}	0.0025^{***}
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0004)
Year dummies		✓	✓	✓	✓
Industry fixed effects			✓	✓	✓
Sex and age				✓	
Individual fixed effects					✓
No. of individuals	851,881	851,881	851,881	851,881	847,025
Avg. obs. per individual	8.7	8.7	8.7	8.7	8.8
Total observations	7,445,676	7,445,676	7,445,676	7,445,676	7,445,649

*Note: Union density is a continuous variable ranging from 0 to 1 that measures the share of unionized workers at the workplace. Models 1a-1c are estimated using pooled ordinary least squares, exploiting variation across both time and between individuals. Models 1d-1e are estimated using the within estimator to control for individual unobserved heterogeneity. Industry fixed effects are included as dummy variables at the 2-digit NACE level. Robust standard errors in in parentheses. * p<0.05, ** p<0.01, *** p<0.001*

The rest of the models presented in Table 2 put various restrictions on the model to test the robustness of the coefficient on union density. To ease interpretation, we have calculated the estimated marginal effect of a ten-percentage point increase in union density when evaluated at the average participation rates under each restriction. In *Model 2b,* we restrict the sample to individuals employed in establishments with at least 10 employees. Next, to control for entry and exit from the labor market, we further restrict the sample to individuals who are employed in full-time positions throughout our period of analysis in *Model 2c*. In *Models 2d and 2e,* we then restrict our attention to males and individuals employed in private sector, respectively. In *Model 2f,* we only consider workers who received their diploma from secondary vocational education in the year 2000 or earlier, in order to exclude potential effects of onboarding of newly certified workers. To control for individuals who's education is related to entry or exit of a firm, we restrict the sample to workers who are currently employed in the same firm as they were both in the previous and in the consecutive year in *Model 2g*, labeled as 'stayers'. In *Model 2h*, we include the number of working days lost due to sickness absence per employee as a proxy for idiosyncratic productivity shocks at the workplace level. Finally, we include industry-by-time interactions in *Models 2h* to absorb productivity shocks common to all workplaces within the same industry.

Overall, the estimated effect of workplace union density on individual participation in further education proves to be robust to the various specifications and restrictions. A ten percentage points increase in union density is estimated to increase participation rates by 2-5 percent. Table A3 in the Appendix reports further results showing that the estimated coefficient is robust to the inclusion of individual union status to proxy individual productivity differences,[50] as well as an interaction term between union membership and workplace union density. Table A3 also includes two models where union density is entered as five splines (0-0.2, 0.2-0.4, etc.) to capture possible nonlinearities, but there are no clear signs of threshold effects.[51]

Table 2 The effect of union density, measured as leave-out mean, on the individual propensity to participate in tertiary vocational education under various restrictions

	Model 2a	***Model 2b***	***Model 2c***	***Model 2d***	***Model 2e***	***Model 2f***	***Model 2g***	***Model 2h***	***Model 2i***
Union density	0.0026*** (0.0004)	0.0030*** (0.0005)	0.0022*** (0.0007)	0.0024*** (0.0006)	0.0023** (0.0006)	0.0025*** (0.0004)	0.0030*** (0.0007)	0.0031*** (0.0007)	0.0042*** (0.0007)
Sick absenteeism								✓	
Industry trends									✓
Min. 10 empl.		✓	✓	✓	✓	✓	✓	✓	✓
Present all years			✓						
Male workers				✓					
Private sector					✓				
Certified pre-2000						✓			
Stayers							✓	✓	✓
Avg. part. Rate	1.2 %	1.3 %	0.5 %	1.3 %	1.3 %	0.5 %	1.0 %	1.0 %	1.0 %
Partial effect at avg.	2.2 %	2.4 %	4.2 %	1.8 %	1.8 %	5.4 %	3.1 %	3.1 %	4.3 %
No. of individuals	827,592	740,928	121,796	448,591	506,641	358,078	499,733	499,733	499,733
Avg. obs. per ind.	8.6	7.8	16	9.3	8.9	10.9	7.2	7.2	7.2
Total observations	7,129,995	5,751,520	1,948,731	4,162,764	4,521,542	3,889,178	3,596,081	3,596,081	3,596,081

*Note: All models are estimated using the fixed effects estimator and include year dummies, industry fixed effects (at the 2-digit NACE level) and individual fixed effects. Union density is a continuous variable ranging from 0 to 1 that measures the share of unionized workers at the workplace, measured as leave-out mean. 'Certified pre-2000' denotes workers who received their diploma from secondary vocational education in the year 2000 or earlier. 'Sick absenteeism' is a variable measuring the number of days of absenteeism due to sickness per employee at the workplace. 'Industry trends' comprises a set of industry-time-dummies. The table report average participation rates in tertiary vocational education for each sub-sample, as well as estimated partial effects of a ten percentage points increase in union density. Robust standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001*

6.2 Returns to further education

The above results suggest a positive effect of workplace unionization on the individual's propensity to attend further education at tertiary vocational schools. This effect may be explained by financial incentives included in collective agreements. As indicated by the

[50] For example, previous studies suggest a positive correlation between individual union membership and certified sickness absence (Mastekaasa, 2013).
[51] The results are also robust when measuring participation in further education as a continuous variable equal to the number of courses the individual participates in each year (results available upon request)

conceptual model in Section 2, however, higher participation rates in unionized firms could also be the result of firms optimally sponsoring the education of their workers. This hypothesis is investigated by estimating how workers' wages vary with further educational attainment and union density.

The results of estimating equation (9) are shown in Table, where all models are estimated using individual fixed effects, industry fixed effects, year dummies and controls for age and age squared. Participation in further education is captured by E_{it}, where the base level $E_{it} = 0$ means the individual has never participated in tertiary vocational education.

Table 3 The effect of unionization on the wage returns of further education

	Model 3a	***Model 3b***	***Model 3c***	***Model 3d***	***Model 3e***	***Model 3f***
$UD_{it} \geq 0.5$	0.0780 ***	0.0190 ***	0.0150 ***	0.0000	0.0000	0.0001
	(0.0008)	(0.0006)	(0.0008)	(0.0006)	(0.0006)	(0.0006)
$E_{it} = 1$	- 0.1794 ***	- 0.1755 ***	- 0.1409 ***	- 0.0592 ***	- 0.0592 ***	- 0.0598 ***
	(0.0056)	(0.0046)	(0.0092)	(0.0004)	(0.0004)	(0.0044)
$E_{it} = 2$	0.1551 ***	0.1361 ***	0.0932 ***	0.0820 ***	0.0819 ***	0.0798 ***
	(0.0045)	(0.0039)	(0.0065)	(0.0043)	(0.0043)	(0.0043)
$E_{it} = 1 \times UD_{it} \geq 0.5$	0.0875 ***	0.0696 ***	0.0669 ***	0.0285 ***	0.0286 ***	0.0264 ***
	(0.0056)	(0.0052)	(0.0100)	(0.0051)	(0.0051)	(0.0051)
$E_{it} = 2 \times UD_{it} \geq 0.5$	- 0.0080 *	- 0.0048	- 0.0197 ***	- 0.0148 ***	- 0.0146 ***	- 0.0139 ***
	(0.0047)	(0.0040)	(0.0066)	(0.0045)	(0.0045)	(0.0045)
Sick absenteeism					✓	✓
Industry trends						✓
Min. 10 employees		✓	✓	✓	✓	✓
Certified pre-2000			✓			
Stayers				✓	✓	✓
No. of individuals	838,656	740,191	408,470	584,536	584,536	584,536
Avg. obs. per ind.	8.7	7.8	9.5	6.2	6.2	6.2
Total observations	7,309,459	5,747,001	3,887,782	3,598,622	3,598,622	3,598,622

*Note: All models are estimated using the fixed effects estimator and controls for sex, age and age squared, year dummies, industry fixed effects (at the 2-digit NACE level) and individual fixed effects. Union density is a continuous variable ranging from 0 to 1 that measures the share of unionized workers at the workplace, measured as leave-out mean. E_{it} denotes a categorical variable equal to 0 if the individual has no further education, 1 if the individual is currently participating in further education, and 2 if the individual has finished further education. 'Sick absenteeism' is a variable measuring the number of days of absenteeism due to sickness per employee at the workplace. 'Industry trends' comprises a set of industry-time-dummies. Robust standard errors in parentheses. * p<0.1, ** p<0.05, *** p<0.01.*

In *Model 3a*, we see that workers employed in unionized firms, proxied by a union density amounting to at least 50 percent of the employees, on average are paid 7.8 percent higher annual wages. In non-unionized firms, participation in further education is estimated to lower annual earnings by 17.9 percent during the studies, while paying a wage premium of 15.5 percent when the education is completed. In unionized firms, the wage loss during studies is significantly lower, while the return to further education is somewhat smaller. Recall that all individuals included are full-time vocational workers. Absence during studies thus reflects educational leaves, and not that workers reduce their position in the firm. A smaller wage loss during education indicates that unionized firms sponsor further education to a larger extent than non-unionized firms. Importantly, this does not necessarily imply that this is the optimal choice of the firm. It could also be regulated in collective agreements. However, the results also indicate that unions compress the structure of wages, thereby reducing the returns to further education. Together, these findings are consistent with the prediction of the theory model that wage compression increases the firm's incentive to sponsor further education if labor markets are imperfect. The results in *Models 3b-3f* largely show that this story is robust to various restrictions on the estimation sample.

6.3 Turnover

Estimations of the relationship between employee turnover and unionization is shown in Table 4. The results show a significant negative correlation between cumulative turnover rates and workplace union density in the years following completion of tertiary vocational education. The negative correlation becomes stronger when we restrict the sample to workers employed in establishments with at least ten employees in *Model 4b* and does not change much when we add further restrictions. Combined with the finding in the previous section that unions seem to lower the return on further education, lower turnover rates may give unionized firms higher incentives to sponsor further education.

Table 4 The effect of unions on cumulative employee turnover rates in the years following completion of tertiary vocational education

	Model 4a	***Model 4b***	***Model 4c***	***Model 4d***	***Model 4e***
Union density	-0.0905*** (0.0168)	-0.1408*** (0.0223)	-0.1455*** (0.0408)	-0.1412*** (0.0223)	-0.1334*** (0.0223)
Sick absenteeism				✓	✓
Industry trends					✓
Min. 10 empl.		✓	✓	✓	✓
Certified pre-2000			✓		
No. of individuals	19,663	17,979	5,157	17,979	17,979
Avg. obs. per ind.	4.2	3.9	4.6	3.9	3.9
Total observations	81,852	70,792	23,559	70,792	70,792

*Note: The endogenous variable is cumulative turnover rate in the years following completion of further education at tertiary vocational schools. All models are estimated using the fixed effects estimator and include controls for sex, age and age squared, year dummies, industry fixed effects (at the 2-digit NACE level) and individual fixed effects. Union density is a continuous variable ranging from 0 to 1 that measures the share of unionized workers at the workplace, measured as leave-out mean. 'Certified pre-2000' denotes workers who received their diploma from secondary vocational education in the year 2000 or earlier. 'Sick absenteeism' is a variable measuring the number of days of absenteeism due to sickness per employee at the workplace. 'Industry trends' comprises a set of industry-time-dummies. Robust standard errors in parentheses. *** p<0.001*

7 Conclusion

In this paper, I have investigated how trade unions influence workers' participation in further education, as measured by participation in courses at tertiary vocational schools. Using a panel of matched employer-employee data comprising all Norwegian working individuals in the period 2004-2019, I have estimated how the individual propensity to participate in further education is influenced by workplace union density. Focusing on full-time employees with an educational attainment at the secondary level, I have found that a ten percentage points increase in workplace union density is estimated to increase the individual propensity to participate in further education by about 2-5 percent. The results prove robust to a wide range of specifications and sample restrictions. These results are also comparable to previous findings in other countries. For example, Booth et al. (2003) find that union covered workers in the UK are 5 percent more likely to receive training than non-covered.

In Norway, most trade unions provide grants and financial support to members who participate in further education. While employers are required by law to provide workers with educational leaves, unions may further promote lifelong learning through collective agreements, which states that both employers and employees are equally responsible for investments in required skills and training. To some extent, the agreements also place the responsibility of funding educational leaves and associated costs on the employer. As the coverage of collective agreement increases monotonically in union density, the estimated effect could reflect the implementation of collective agreements. I do not find evidence of threshold effects when testing for nonlinearities. This could indicate that it is the strength of the union that matters, and not merely the presence of a collective agreement.

The interpretation of the results as causal effects rests on an identifying assumption of no endogenous selection into unionized firms of workers who intent to participate in further education. I largely mitigate this issue by including fixed effects to control for unobserved individual heterogeneity, and by constructing a measure of workplace union density invariant to changes in individual union memberships. However, I cannot rule out the possibility that the estimator is biased by idiosyncratic shocks influencing both participation rates and workplace union density. Future studies should investigate this potential issue further.

As most education is free of charge in Norway, the largest cost of further education is the loss of income due to absence from work. I find that annual wages during education is reduced by less in unionized establishments than in non-unionized establishments. This may explain why participation rates are higher in unionized establishments. If firms possess monopsony power in the labor market, they may optimally choose to sponsor further education if union wage compression lowers the return on further education. I find evidence of slightly lower returns to further education and significantly lower turnover among employees in unionized establishments. These results are consistent with a causal interpretation that unions promote further education.

Acknowledgements

I would like to thank Ragnar Torvik, Torberg Falch and Harald Dale-Olsen for valuable help and comments, and Frank-Jørgen Vangen for helping me understand the system of tertiary vocational education and trade union involvement. The paper was presented at the 13th annual meeting of the International Association of Economics of Education in Catanzaro, Italy, June 20, 2023. I thank the conference participants for valuable remarks and helpful comments. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Availability Statement

The data that support the findings of this study are provided by Statistics Norway through the online application microdata.no, which is available to all researchers at approved research institutions in Norway free of charge. Scripts for reproduction are available upon request.

References

Acemoglu, D., 2002. Technical Change, Inequality, and the Labor Market. *Journal of Economic Literature*, 40(1), pp. 7-72.

Acemoglu, D. & Pischke, J. S., 1999. Beyond Becker: Training in Imperfect Labour Markets. *The Economic Journal*, 109(453), pp. 112-142.

Acemoglu, D. & Restrepo, P., 2020b. Robots and Jobs: Evidence from US Labor Markets. *Journal of Political Economy*, 128(6), pp. 2188-2244.

Autor, D. & Dorn, D., 2013. The growth of low-skill service jobs and the polarization of the US labor market. *American Economic Review*, 103(5), pp. 1553-97.

Autor, D., G., C. & Katz, L. F., 2020. Extending the race between education and technology. *AEA Papers and Proceedings*, Volume 110.

Autor, D. H., Levy, F. & Murnane, R. J., 2003. The Skill Content of Recent Technological Change: An empirical Exploration. *The Quarterly Journal of Economics*, 118(4), pp. 1279-1333.

Barron, J. M., Berger, M. C. & Black, D. A., 1997. *On-the-Job Training.* Kalamazoo: W.E. Upjohn Institute for Employment Research.

Barth, E., Bryson, A. & Dale-Olsen, H., 2020. Union Density Effects on Productivity and Wages. *The Economic Journal*, 130(631), p. 1898–1936.

Becker, G., 1964. *Human Capital.* Chicago: The University of Chicago Press.

Blanchflower, D. G. & Bryson, A., 2004. What Effect Do Unions Have on Wages Now and Would Freeman and Medoff Be Surprised?. *Journal of Labor Reserach*, Volume 25, p. 383–414.

Booth, A. L., 1991. Job-related formal training: Who receives it and what is it worth?. *Oxford Bulletin of Economics and Statistics*, Volume 53, pp. 281-294.

Booth, A. L. & Chatterji, M., 1998. Unions and Efficient Training. *The Economic Journal*, 108(447), pp. 328-343.

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

Brynjolfsson, E. & McAfee, A., 2012. *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment.* Lexington, MA: Digital Frontier Press.

De Vries, G. J., Gentile, E., Miroudot, S. & Wacker, K. M., 2020. The Rise of Robots and the Fall of Routine Jobs. *Labour Economics*, Volume 66.

Doucouliagos, H., Freeman, R. B. & Laroche, P., 2017. *The economics of trade unions: A study of a research field and its findings.* New York: Routledge.

Dowrick, S. & Spencer, B. J., 1994. Union Attitudes to Labor-saving Innovation: When Are Unions Luddites?. *Journal of Labor Economics*, 12(2), pp. 316-344.

Duncan, G. J. & Stafford, F. P., 1980. Do Union Members Receive Compensating Wage Differentials?. *The American Economic Review*, 70(3), pp. 355-371.

Dølvik, J. E., 2022. *Strengthening the Nordic working life model – a precondition for successful transition to the future of work. Background paper for Nordic Labour Minister meeting, 22 November 2022. Fafo-paper 2022:13*, s.l.: s.n.

Freeman, R. B. & Medoff, J. L., 1979. The two faces of unionism. *NBER Working Paper Series*, Issue No. 364.

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

Frey, C. B. & Osborne, M. A., 2017. The future of employment: How susceptible are jobs to computerisation?. *Technological Forecasting and Social Change*, Volume 114, pp. 254-280.

Goldin, C. & Katz, L., 2008. *The Race between Education and Technology*. Cambridge: Harvard University Press.

Green, F., Machin, S. & Wilkinson, D., 1999. Trade Unions and Training Practices in British Workplaces. *Industrial and Labor Relations Review*, 52(2), pp. 179-195.

Heyes, J. & Stuart, M., 1998. Bargaining for Skills: Trade Unions and Training at the Workplace. *British Journal of Industrial Relations*, 36(3), pp. 459-467.

Hoque, K. & Bacon, N., 2008. Trade Unions, Union Learning Representatives and Employer-Provided Training in Britain. *British Journal of Industrial Relations*, 46(4), pp. 702-731.

Katz, L. & Murhpy, K. M., 1992. Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *The Quarterly Journal of Economics*, 107(1), pp. 35-78.

Kjellberg, A. & Nergaard, K., 2022. Union Density in Norway and Sweden: Stability versus Decline. *Nordic journal of working life studies*, 12(S8).

Lynch, L. M., 1992. Private sector training and the earnings of young workers. *American Economic Review*, Volume 88, pp. 299-312.

Mastekaasa, A., 2013. Unionization and certified sickness absence: Norwegian evidence. *ILR Review*, 66(1), pp. 117-141.

Mincer, J., 1981. Union Effects: Wages, Turnover, and Job Training. *NBER Working Paper (No. w0808)*.

OECD, 2021. *OECD Skills Outlook 2021 : Learning for Life*, Paris: OECD Publishing.

Payne, J., 2006. The Norwegian competence reform and the limits of lifelong learning. *International Journal of Lifelong Education*, 25(5), pp. 477-505.

Rørstad, K., Børing, P. & Solberg, E., 2023. *NHOs kompetansebarometer 2022. En kartlegging av NHOs medlemsbedrifters kompetansebehov i 2022.*, Oslo: NIFU.

Stuart, M. & Teige, B., 2010. Trade Unions and the Norwegian Competence Reform. *Labour and Industry*, 21(2), pp. 513-528.

Svarstad, E. & Kostøl, F. B., 2022. Unions, Collective Agreements and Productivity: A Firm-Level Analysis Using Norwegian Matched Employer-Employee Panel Data. *British Journal of Industrial Relations*, 60(4), pp. 864-894.

Teige, B. K. & Stuart, M., 2012. Trade Union Involvment in Lifelong Learning in Norway. In: R. Cooney & M. Stuart, eds. *Trade Unions and Workplace Training: Issues and International Perspectives.* New York: Routledge, pp. 126-144.

Tinbergen, J., 1974. Substitution of Graduate by Other Labor. *Kyklos*, 27(2), pp. 217-26.

Undertun, A. & Drange, I., 2018. Bargaining for continuing education: A Norwegian case of 'lifelong learning unionism'. In: H. Hvid & E. Falkum, eds. *Work and Wellbeing in the Nordic Countries.* London: Routledge, pp. 178-193.

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

Appendix

A1 The Norwegian education system

As illustrated in Figure A1, the Norwegian school system consists of a primary, secondary, and tertiary level.[52] All children and youth have a statutory right and obligation to complete primary and lower-secondary education. Furthermore, everyone who completes the lower-secondary level are entitled to education at the upper-secondary level, but not required to participate. Starting from upper-secondary education, the schooling system is divided into two tracks – a general studies program qualifying for higher education at colleges or universities, and a vocational program leading to a craft certificate and qualification for tertiary vocational education. Students choosing the vocational track can also take an extra year of schooling to qualify for higher education. Higher education at colleges and universities is divided into courses at the bachelor, master, and PhD level, while tertiary vocational education mostly comprises vocationally oriented courses of varying length. The Government is the main provider of education at all levels, which is offered free of charge. Private schools mostly operate at the tertiary level.

In Figure A2, we have illustrated the development of educational attainment of the Norwegian population. Children begin at primary school the year they turn 6 and finish lower secondary school the year they turn 16. Upper secondary school has a length of 3-4 years, while bachelor's and master's degrees have expected lengths of 3 and 5 years, respectively. In other words, regular students finish their initial educational track when aged 19-25 years. However, educational breaks are common due to military service, stays at boarding schools or breaks to attain work experience, implying that many students may be several years older when finishing their final education. In order to concentrate on working individuals finished with their initial education, we thus restrict the sample in the figure to individuals aged 30-66 years. The figure clearly illustrates a trend of massive investments in skills. In 1980, the share of working individuals holding a bachelor's or master's degree or a PhD was 13 percent, whereas the same share amounted to 43 percent in 2020. The share of workers with primary or lower secondary education as highest attainment level has consequently been steadily declining. While the share

---

[52] For more information, see the Norwegian Agency for Quality Assurance in Education for more details on the Norwegian education system https://www.nokut.no/en/norwegian-education/general-information-about-education-in-norway/

of workers with educational attainment at the upper secondary level has also been declining, this trend is less pronounced. However, these numbers camouflage a growing trend of workers participating in tertiary vocational education. During the last decade, the number of students in tertiary vocational education has doubled (Statistics Norway, 2021).

Figure A1 The Norwegian school system

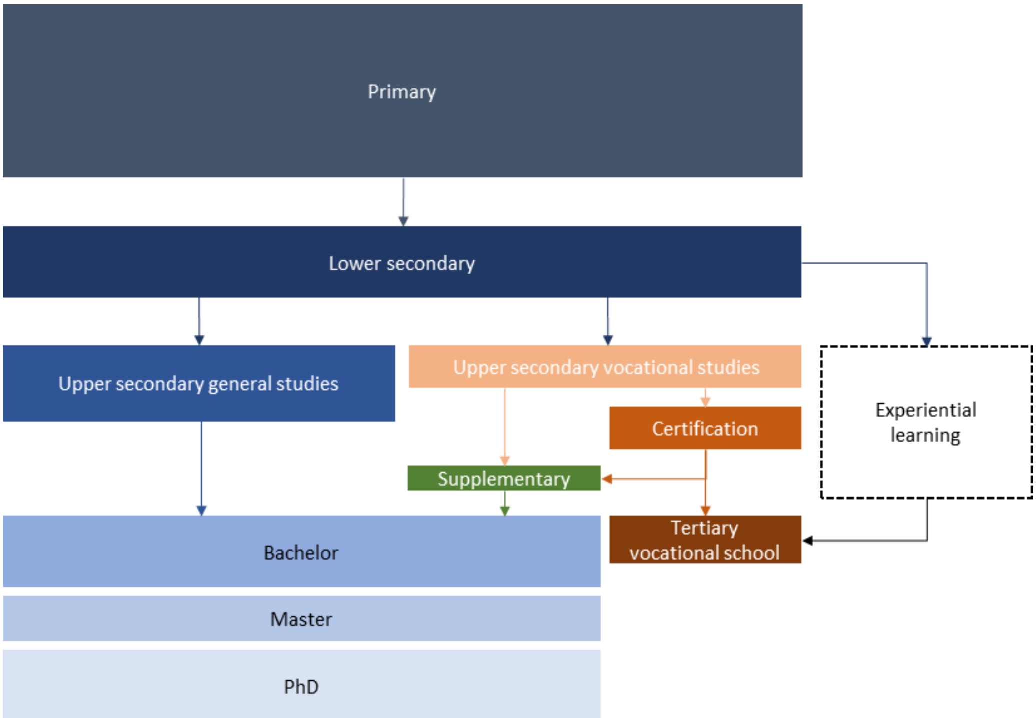
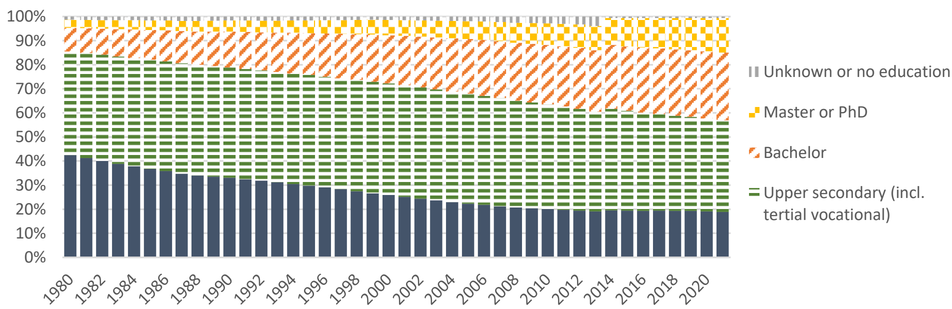


Figure A2 Educational attainment among Norwegian males and females. 30-66 years.1980-2020.



Note: Upper secondary education includes tertiary vocational education. Attainment levels for immigrants with unknown educational background are estimated values from 2014 and onwards, causing a statistical break in 2014. Source: Statistics Norway, Educational attainment of the population, Table 08921.

A2 Descriptive statistics

Table A1 Descriptive statistics

Variable	Mean	Std. dev.	N	1 %	25 %	50 %	75 %	99 %
Male	72 %	0.45	7,507,939	0	0	1	1	1
Age	41	11	7,507,939	21	33	41	50	64
Annual wage	478,970	209,156	7,309,753	35,400	349,000	445,000	571,000	1,250,000
Union member	50.6 %	0.500	7,507,939	0	0	1	1	1
Union density	47.5 %	0.344	7,445,646	0	0.111	0.525	0.798	1
Participation rate	1.2 %	0.107	7,507,939	0	0	0	0	1
Length of studies	2.8	1.4	86,370	1	2	3	4	7
Number of courses	3.0	1.7	86,370	1	2	3	4	8
Courses per year	1.1	0.2	86,370	1	1	1	1	2

Note: 'Participation rate' measures the share of workers participating in one or more courses taught at a tertiary vocational school in a given year. 'Length of studies' denotes the number of years under further education. 'Number of courses' measures the total number of courses the individual participates in, while 'Courses per year' measures the number of courses the individual participates in each year during the education. The last three variables are only defined for individuals while participating in further education.

A3 Supplementary estimation results

Table A2 The effect of union density on the individual propensity to participate in tertiary vocational education estimated on various samples

	Model 2a	***Model 2b***	***Model A2a***	***Model A2b***	***Model A2c***	***Model A2d***
Union density	0.0026^{***}	0.0030^{***}	0.0020^{***}	0.0024^{***}	0.0013^{***}	0.0016^{***}
	(0.0004)	(0.0005)	(0.0003)	(0.0004)	(0.0001)	(0.0002)
Min. 10 empl.		✓		✓		✓
Sample	Preferred	Preferred	Extended	Extended	Full	Full
No. of individuals	827,592	740,928	1,009,826	916,313	3,172,324	2,856,585
Avg. obs. per ind.	8.6	7.8	9.1	8.2	8.4	7.7
Total observations	7,129,995	5,751,520	9,160,112	7,517,330	26,529,884	21,961,613

*Note: All models are estimated using the fixed effects estimator and include year dummies, industry fixed effects (at the 2-digit NACE level) and individual fixed effects. Union density is a continuous variable ranging from 0 to 1 that measures the share of unionized workers at the workplace, measured as leave-out mean. Models 2a and 2b are estimated using our preferred sample, as in Table 2. In Models A2a and A2b, the sample includes vocational workers who also hold an academic degree. Models A2c and A2d are estimated using the full sample including workers without vocational training. Robust standard errors in parentheses. * p<0.05, ** p<0.01, *** p<0.001*

Table A3 The effect of union density, measured as leave-out mean, on the propensity of full-time workers to participate in tertiary vocational education under various restrictions

	Model A3a	***Model A3b***	***Model A3c***	***Model A3d***
Union density (UD)	0.0026***	0.0025***		
	(0.0007)	(0.0010)		
- $0.2 \leq UD < 0.4$			0.0003	0.0002
			(0.0003)	(0.0003)
- $0.4 \leq UD < 0.6$			0.0010***	0.0008**
			(0.0003)	(0.0004)
- $0.6 \leq UD < 0.8$			0.0015**	0.0012***
			(0.0004)	(0.0004)
- $0.8 \leq UD \leq 1$			0.0019***	0.0015***
			(0.0005)	(0.0005)
Union member (U)	0.0009**	0.0008		0.0009**
	(0.0004)	(0.0006)		(0.0004)
UD x U		0.0001		
		(0.0011)		
No. of individuals	584,752	584,752	584,752	584,752
Avg. obs. per ind.	6.2	6.2	6.2	6.2
Total observations	3,600,013	3,600,013	3,600,013	3,600,013

*Note: All models are estimated using the fixed effects estimator and include year dummies, industry fixed effects and individual fixed effects. The sample includes certified workers employed in establishments with at least ten employees, who are currently employed in the same firm as they were both in the previous and in the consecutive year. Union density is a continuous variable ranging from 0 to 1 that measures the share of unionized workers at the workplace, measured as leave-out mean. Robust standard errors in parentheses. * p<0.10, ** p<0.05, *** p<0.01.*

Chapter 3

Unions, Collective Agreements and Productivity: A Firm-Level Analysis Using Norwegian Matched Employer-Employee Panel Data

Elin Svarstad and Fredrik B. Kostøl

The article was published in British Journal of Industrial Relations on January 14, 2022.

Reference:

Svarstad, E., & Kostøl, F. B. (2022). Unions, collective agreements and productivity: A firm-level analysis using Norwegian matched employer–employee panel data. British Journal of Industrial Relations, 60(4), 864-894. https://doi.org/10.1111/bjir.12662

This article is also included in the dissertation of Elin Svarstad.

Unions, Collective Agreements and Productivity: A Firm-Level Analysis Using Norwegian Matched Employer-Employee Panel Data

Elin Svarstad †

Fafo Institute of Labor and Social Research

Fredrik B. Kostøl

Norwegian University of Science and Technology

Abstract

What is the role of collective agreements in explaining how unions affect firm-level productivity? Using matched employer-employee panel data for the Norwegian labor market, comprising almost 21 million individual-year observations in the period 2002-2018, we find that the presence of a collective agreement in a firm is associated with higher productivity. Without a collective agreement, higher union density is estimated to reduce productivity. However, if a collective agreement is implemented in the firm, not only is the estimated negative effect reduced – in some cases it becomes positive. This result remains significant, numerically and statistically, across several model specifications and different estimation methods. In particular, we provide a new source of exogenous variation in union memberships by utilizing information on intergenerational transmission of union preferences. Besides regulating terms and conditions for wage formation and working hours, collective agreements have a profound impact on how firms organize and formally recognize the voice of workers. In this regard, our finding supports the conclusion of Freeman and Medoff (1984) that the quality of institutional systems is crucial to understand what unions do to productivity.

JEL Classification: C23, C26, D24, J50, J51, J53

Keywords: unions, collective agreements, productivity, industrial relations, linked panel data, instrumental variables

† Correspondence: Elin Svarstad, Fafo Institute of Labor and Social Research, P.O. Box 2947, Tøyen, NO-0608, Oslo, Norway. E-mail: elin.svarstad@fafo.no

1 Introduction

What unions do to productivity, as well as for other aspects of corporate performance, has been the subject of extensive research for decades. In the seminal works by Freeman and Medoff (1979; 1984), unions are portrayed with two faces: the *monopoly face* and the *exit voice/institutional response face*. While the former refers to the monopoly power attained by unionized workers through collective bargaining, the latter covers the various mechanisms through which unions may alter industrial relations. As these effects generally work in opposite directions, the effect of unions on productivity is theoretically ambiguous. The question of how unions affect productivity is therefore a question that must be answered empirically. However, despite the vast body of empirical literature, the evidence is mixed and inconclusive, reflecting various strengths of the two faces of unionism in different contexts (Doucouliagos *et al.* 2017).

The mixed evidence on what unions do to productivity calls for the scope of union research to extend to more countries, sectors, time periods, and institutional contexts (Laroche 2020). Unions operate in very diverse environments with respect to how institutions and legislation regulate and facilitate their activities and organization. More fundamentally, the impact of unions on firms' performance is likely to vary with the extent of unionization. Union presence may be measured along at least two important dimensions – the first being the union density at the workplace, the second the union's formal impact on the firm's organization, as measured by the presence of a collective agreement. The former dimension has been utilized in many studies, recently also in Norway (Barth *et al.* 2020), but less attention has been devoted to the study of collective agreements.

In countries characterized by decentralized bargaining, the introduction of a firm-level collective agreement often requires that the union wins a majority vote. In other words, collective agreements are only implemented in firms with a strong local union. In many European countries, however, there is an important distinction between having unionized workers at the plant and being covered by a collective agreement, as firms may be covered by sectoral agreements without having unionized employees in the firm (OECD, 2019). The rules for implementing a collective agreement in Norway are somewhere in between. In general, collective agreements are invoked by labor unions, but only if the union density is above the threshold determined in higher level agreements, which is usually 10 percent of the workers in the particular bargaining area. Moreover, participation in the agreements is in principle voluntary for both parties. Both the voluntary engagement and the low threshold for invoking collective agreements, make the distinction between union density and collective agreement coverage important in the Norwegian context.

In this paper, we argue that collective agreements act as a formal recognition of the unions' right to express their views on working conditions and the organization of firms. A collective agreement thus constitutes an important organizational institution through which unions may alter industrial relations at the firm level. By not taking this dimension of unionization into account, empirical analyses of unions' impact on productivity could be biased, or at best imprecise. We contribute to the discourse on what unions do to productivity by explicitly exploring how the union-productivity relationship is altered by the presence of collective agreements. More generally, our contribution adds to the growing literature on what unions do to productivity in different contexts by providing evidence from the Norwegian labor market. Norway represents an interesting case because voluntary collective agreements are relatively more important than legislation compared to many other countries. Also, the availability of high-quality register data on all individuals enables more accurate inference. Finally, our paper is an important contribution to the limited number of studies providing causal evidence on what unions do to productivity. While we are not able to fully control for the possible correlation between productivity shocks and the presence of a collective agreement, endogenous unionization is handled by instrumenting union density among workers with the union density among the workers' parents.

The remainder of the paper is organized as follows. Section 2 reviews previous literature on how unions alter productivity. The section also discusses the few studies that emphasize the role of collective agreements and related labor market institutions. Section 3 then gives a brief introduction to the system and organization of unions and collective agreements in Norway. We present the data in Section 4, while Section 5 describes our methodological approach. Section 6 contains a presentation and discussion of our results. Section 7 provides a conclusion.

2 Related literature

Theoretically, the influence of unions on productivity is ambiguous. In the traditional neoclassical view, unions act as monopolies that distort labor market efficiency by adding a union premium to the competitive market wage. Union presence may also limit management's flexibility in personnel decisions by introducing rules such as seniority in hiring and firing (Freeman and Medoff 1984: 164). Furthermore, any form of industrial unrest will affect productivity adversely by temporarily reducing the utilization of the firm's resources and causing uncertainty about output levels (Caves 1980; Flaherty 1987). However, the direction of causation is not obvious, as poor labor productivity could reflect poor management, which also causes more industrial action (Addison and Schnabel 2003: 123). Unions may also harm productivity by lowering investment, as shareholders' expected return is reduced by the risk of ex post rent-seeking by unions in the absence of binding contracts (Grout 1984). Union rent-seeking could thus be considered a tax on the return on investments, potentially hampering innovation and technological development (Connolly *et al.* 1986). Finally, militant unions may disrupt industrial relations. If both employers and employees are only concerned with promoting their own interests, both may be worse off in terms of productivity and earnings than if they cooperated. In this regard, Freeman and Medoff (1984) argued that unions would only raise productivity if *'industrial relations are good, with management and unions working together to produce a bigger "pie"'* (p. 165).

However, many authors have argued that unions may promote productivity through institutional channels. Freeman (1976) and Freeman and Medoff (1984) claim that by providing workers with a means of expressing discontent through a collective voice, unions can reduce turnover and improve morale, motivation, job satisfaction and cooperation, thereby enhancing productivity. The additional information provided by a collective voice can moreover enable firms to choose a better mix of working conditions, workplace rules and wage levels (Laroche 2020). In Norway, for example, the management and the union in firms participating in collective agreements can agree on more flexible working time arrangements than are otherwise permitted by law. A potential means of offsetting efficiency losses may thus arise if unions are able to induce managers to alter methods of production and adopt policies that improve efficiency. Unions may also give workers an increased experience of fairness because their presence reduces the potentially arbitrary nature of decisions about promotions and layoffs. That is, the union may act as '*the employees' auditor of management, checking that the employer is fulfilling his part of the labour contract.'* (Pencavel 1977: 141). Moreover, unions may contribute to higher productivity through the wage channel. By using their monopoly power to raise wages, unionized firms may attract more productive employees (Lazear 2000). It is also plausible that the wage differentials between unionized and non-unionized firms may reduce turnover in unionized firms, thereby saving them potential firing and hiring costs, as well as conserving firm-specific human capital. Higher wages may give employers incentives to replace some labor by capital, which, although not socially efficient, will increase labor productivity at the firm level (Freeman and Medoff 1984: 164).

Many attempts have been made to estimate empirically how unions influence productivity. The pioneering study of Brown and Medoff (1978) is one of the few studies that finds a large and positive effect of unions on productivity in the U.S. manufacturing industry. However, these estimates were later attributed to serious data limitations (Hirsch and Addison 1986). Other studies from the U.S. have found both positive and negative union effects on productivity, with large variations across sectors and industries (Clark 1980; Allen 1988). A recent meta-analysis by Doucouliagos *et al.* (2017) reviews a large number of studies published over the last thirty years that address the impact of unions on productivity. The overall association between unions and productivity is shown to be near zero, but the relationship varies significantly across countries and industries. The authors indicate that the wide diversity of findings makes it hard to adopt a definitive position on what unions do to productivity: it depends on the period of analysis, the industry, the nature of the social climate in both the specific country and the firm, methods of data collection, the productivity indicator used, and the econometric frameworks adopted.

It is apparent that the question of what unions do to productivity is far from resolved. To better understand the empirical ambiguity, the literature has considered various mechanisms that might be at play. There is an extensive literature examining the relationship between unionization, job satisfaction and productivity. In a meta-analysis of 235 estimates from 59 studies published between 1975 and 2015, Laroche (2016) finds an overall small negative association between unionization and job satisfaction. However, the study shows that the industrial relations climate has a positive and significant impact on the union-satisfaction effect. Moreover, when taking account of the possibility that unions often organize in firms with poor working conditions, Blanchflower and Bryson (2020) find a positive relationship between unions and several measures of worker well-being, including job satisfaction. Others have investigated how organizational commitment can be a channel through which unions affect productivity. Several studies show a positive correlation between measures of job performance and workers' organizational commitment (Mathieu and Zajac 1990; Jaramillo *et al.* 2005), which has been found to be positively related to unionization in the United States and Norway (Kalleberg and Mastekaasa 1994).

Another strand of literature has looked at how the institutional context in which unions operate affect the way they function (Blanchflower and Freeman 1992). The focus in these studies is the institutions that enable and constrain union efforts to improve working conditions. In the UK, Bryson *et al.* (2006) find that employee perception of managerial responsiveness to worker voice leads to superior productivity. In France, Coutrot (1996) shows that firms with at least one union delegate in the workplace are more productive than other firms. This finding is partly confirmed by Laroche (2004). In general, several studies have shown that measures of the industrial relations climate are positively associated with better economic performance (Belman 1992; Whitman *et al.* 2010). As suggested by Freeman and Medoff (1984), unions can improve the quality of labor relations by cultivating voice rather than exit.

A particular feature of the institutional context that has received less attention is the role of collective agreements. Notable exceptions are García-Serrano (2009) and Bryson *et al.* (2010), who separate the roles of union membership and firm-level collective agreements in their assessment of how unions affect job satisfaction in Spain and the UK. In a recent study from Belgium, Garnero *et al.* (2020) investigate how firm-level collective agreements affect firm performance in a multi-level bargaining system. They find that firm agreements increase both wage costs and labor productivity. However, this result must be interpreted within the context of the Belgian national bargaining system, where firm-level agreements act as supplements to agreements at sectoral level, which cover practically the entire Belgian workforce (p. 945). In another recent study, Barth *et al.* (2020) identify a large positive impact of union density on productivity in Norway. By exploiting exogenous variation in the rules for the tax deductibility of union membership fees, the study is one of a limited number that handle the possibly endogenous behavior of unionization. The authors interpret the large coefficient as a threshold effect, where the union forces the employer to implement a collective agreement once the union density reaches a particular threshold. However, they do not have information in their data to further investigate this hypothesis.

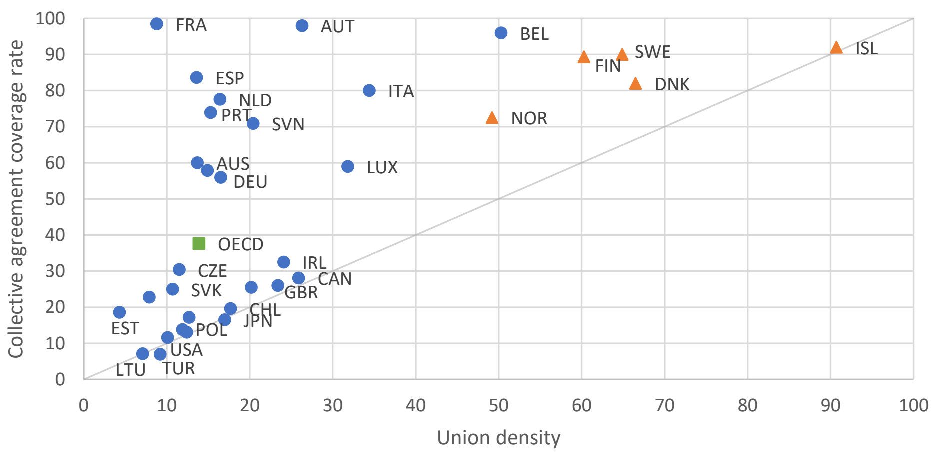
Our contribution expands the current knowledge of what unions do to productivity in general, and in particular how this relationship is affected by the quality of industrial relations as measured by the presence of a collective agreement. Moreover, our paper adds an important contribution to the very limited number of studies providing causal evidence of what unions do to productivity. Although we do not fully control for the possible correlation between productivity shocks and a decision to enter or exit a collective agreement, we provide a new source of exogenous variation in union memberships by utilizing information on intergenerational transmission of union preferences.

3 Unionization and collective agreements in Norway

The relationship between employers and employees in Norway is organized through an interaction between legislation and collective agreements, where the importance of the latter is relatively high compared to other countries. The labor market is characterized by strong trade unions and employer's associations. During the last decade, union density has been stable at around 50 percent, or 38 percent if we consider the private sector only. In the same period, the organization rate among private sector employers has been steadily increasing and amounted to approximately 71 percent in 2019 (Alsos *et al.* 2021).

As shown in Figure 1, union density in Norway is high compared to most other countries in the OECD, and so is the prevalence of collective agreements.[53] About ten percent of Norwegian private sector firms participate in collective agreements, which accounted for 46 percent of all private sector workers in 2018. If we include the public sector, almost 73 percent of all workers were covered by collective agreements in 2018. However, the coverage rate is lower than in many other Western European countries, where collective agreements at sectoral level may be required by law to extend to all firms and workers irrespective of union membership.[54]

Figure 1 Union density and collective agreement coverage in OECD countries. 2018 or last observation. Nordic countries and OECD average are highlighted by orange triangles and a green square, respectively. Source: OECD databases on 'Trade union density' and 'Collective bargaining coverage'.



[53] However, union density is low compared to the other Nordic countries, where trade unions have traditionally administered the unemployment benefit funds, and thus have had better recruitment opportunities.

[54] This is the case in Austria, Belgium, Finland, France, Germany, the Netherlands, and Portugal (García-Serrano 2009). A comprehensive overview of the prevalence and functioning of collective agreements in the OECD, including differences in the practice of *ergo omnes* clauses and extensions are found in the OECD report "Negotiating Our Way Up" (2019).

Collective bargaining in Norway has a clear hierarchical structure. As in several other Western European countries, wages in the private sector may be negotiated at three levels: central, sectoral, and local. At the national level, a few major confederations determine the content of the basic agreements. The basic agreements form the basis for all lower-level agreements in specific industries, set the framework for bargaining, and regulate issues such as rights to information and consultation and rules for taking industrial action (most importantly strike and lock-out). Moreover, the basic agreements include procedures for electing employee representatives, which are important for facilitating the firm-level relationship between employees and employers. The second level in the hierarchy consists of agreements for specific industries, often referred to as business sector agreements. Most of these agreements include the text of the corresponding basic agreement as their first section. The second part typically contains provisions regarding minimum wage and entitlements regarding working hours, overtime payment and welfare leave. Business sector agreements normally apply for two years at a time.

Local agreements between employers and employee representatives at company level, which are adapted to local conditions, make up the third level of the bargaining hierarchy. In contrast to sectoral agreements, local agreements automatically extend to all workers in occupations covered by the agreement, irrespective of union membership.[55] Collective agreement coverage in Norway thus depends on the existence of local agreements. In general, if the union density among workers within the same bargaining area in a firm is above a certain threshold, the union will demand a collective agreement. If the employer is organized in an employer's association, the agreement will be ratified more or less automatically. If the employer is not organized, the trade union will enter a direct agreement with the employer – if necessary, through the use of industrial action.

A particular feature of the Norwegian system of collective agreements is that the basic agreements include extensive provisions on co-determination. Specifically, the agreements introduce regulations designed to strengthen and further develop the collaboration between employees, their representatives, and the management. Furthermore, they formalize the mutual

---

[55] There is an important exception. In industries where inflows of migrant workers have led to 'social dumping', general application of collective agreements is practiced. However, such extensions are 'narrow' in the sense that they only include minimum wage rates and some basic supplements. The provisions in the basic agreements about co-determination (including the election of employee representatives), do not extend to all firms in an industry unless they have a local agreement in place.

responsibility of employer and employees for productivity growth and business development (Bergh 2010). The presence of a collective agreement thus constitutes an important institutional feature when evaluating what unions do to productivity and other aspects of corporate performance.

In short, collective agreements in Norway are not only a means of regulating observable working conditions such as wages and hours; they also establish and codify a system of collaboration, communication, and participation, with the explicit purpose of enhancing productivity. The clear focus on co-operation in the collective agreements partly reflects and partly contributes to sustaining the long Nordic tradition of close co-operation between employers' associations and trade unions, as well as a high degree of co-determination and participation at company level. A better understanding of the interplay between unions, collective agreements and firm performance is thus paramount when investigating how unions affect productivity in Norwegian firms.

4 Data

The empirical analysis utilizes a matched employer-employee data set, obtained from Statistics Norway (see Table A1 in the appendix for descriptive statistics). The data cover the Norwegian private sector in the period 2002-2018 and consist of individual data collected by the Norwegian Tax Authorities and Social Services, matched with several other sources of register data related to both firms and employees. The most important data source for the period 2002-2014 is the State Register of Employers and Employees (the '*Aa-register'*), which provides information on income, earnings, hours worked and occupation for each individual. For the remaining years, 2015-2018, our data are collected from the '*a-ordning'*, a coordinated service used by employers to report information about income and employees to the Norwegian Labor and Welfare Administration, Statistics Norway, and the Norwegian Tax Administration. Educational statistics are attached, as well as firm-level financial data and several other characteristics. Every individual, workplace and firm has its own unique identifying number, enabling us to track the units across time.

Whether a firm participates in a collective agreement or not is obtained from membership data from the private sector collectively agreed pension scheme ('*Fellesordningen for AFP*'- the

AFP scheme), whereby all firms that are members are also parties to a collective agreement.[56] In a model with firm fixed effects, identifying the effect of a collective agreement requires sufficient time variation in this variable. While most firms do not change their status during the period in question, Tables 1 and 2 document substantial variation in collective agreement coverage within firms. On average, 448 firms enter a collective agreement each year, while 275 firms exit. In total, this amounts to 112 138 observations of, in total, 10 520 firms changing their coverage status at least once.

Table 1 Observations by collective agreement coverage

	Observations	Firms
Never collective agreement	969 614	158 630
Always collective agreement	88 918	9 228
Firms changing status	112 138	10 520
Total	1 170 670	178 438

Table 2 Observations of entries and exits from collective agreements

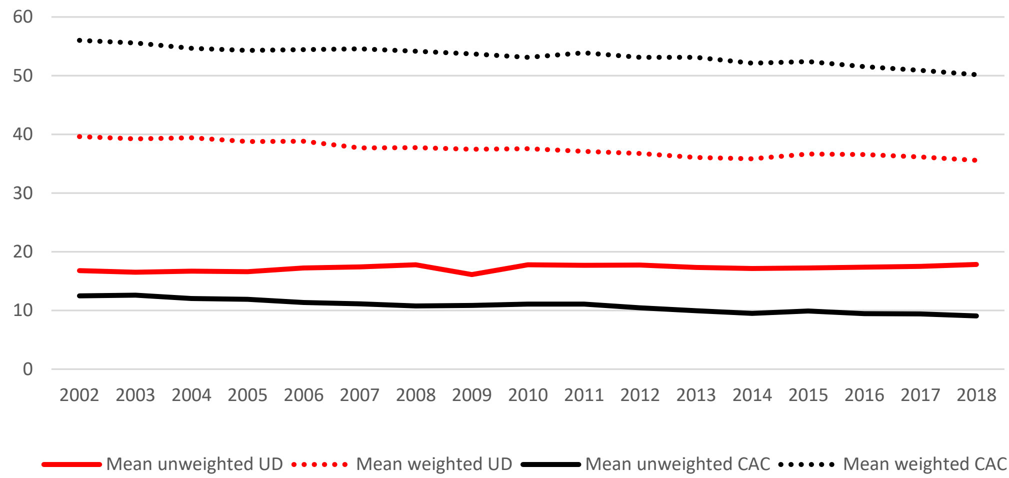
	Entry	**Exit**
2002	578	552
2003	466	169
2004	409	507
2005	460	182
2006	474	388
2007	412	165
2008	453	400
2009	409	165
2010	893	363
2011	439	165
2012	413	318
2013	388	167
2014	353	307
2015	349	157
2016	335	270
2017	383	115
2018	407	286
Total	7 621	4 676

Individual union membership is obtained from data on union membership fees, which are reported to the tax authorities by the unions. From the membership payments, we calculate firm-level union density as the ratio of union members to the number of employees in each firm. Figure 2 shows how the two variables union density (UD) and collective agreement

[56] Some firms in the sample are covered by collective agreements, without being members of the AFP scheme'. This mainly applies to enterprises in shipping and the oil industry and privately run health and social services. The firms in question are manually coded as covered if union density exceeds 50 percent and the number of employees is at least 25.

coverage (CAC) evolve through our period of analysis. While the solid lines show unweighted firm averages, the dashed lines are weighted averages, where the number of employees in each firm are used as weights. They thus illustrate union density and collective agreement coverage across firms and individuals, respectively. The differences between the weighted and unweighted means reflect the fact that union density and the prevalence of collective agreements are higher among large firms (see Figure A1 in the Appendix).

Figure 2 Mean union density (UD) and collective agreement coverage (CAC) unweighted and weighted by the number of employees in the firm, in our sample.



Our initial individual level dataset contains around 1.5 million yearly private sector jobs, amounting to 25.2 million observations in total for the whole period. The number of yearly jobs is not equal to the number of individuals, as one individual may have multiple jobs within the same year. The total number of firms present in the initial sample is 334 511. However, we have placed some restrictions on the sample. Firms not required by law to provide financial statements, or which for other reasons do not have financial information, are excluded. This restriction leaves us with 20.9 million observations, amounting to just under 80 percent of all private sector jobs.[57] The individual-level data are then aggregated to firm level using firm-based averages of job and worker information. The final estimation sample consists of 189 900 firms (corresponding to 58 percent of all private sector firms, employing 75 percent of all wage earners), with a total of 1 170 670 firm-year observations. Because firms are established and

[57] There are only small differences between firms in the initial and the final sample in union density, collective agreement coverage, average age and distribution across sex, education levels, occupations and industries. Overall, the final sample appears to be representative of the population of private sector employees.

dissolved throughout the period of analysis, our panel is unbalanced. Around 10 percent of the firms are present in all 17 years, while the median number of observations per firm is 5 years. Firms with less than two observations are excluded from most estimations.

Figure 3 The distribution of collective agreements across union density in our sample. Firms with at least 10 employees. Binscatter, 88 bins. N=383,297.

The interaction between union density and the presence of a collective agreement is of primary concern in our study. In order to qualify for a collective agreement, the union density among the firm's workers must exceed a certain threshold. In the largest basic agreement in Norway, this threshold is specified as ten percent of the workers.[58] Figure 3 illustrates the distribution of collective agreements as a function of firm-level union density in firms with at least 10 employees. The figure clearly shows a positive relation between unionization and the presence

[58] The premise of a threshold in the union membership rate is institutionalized in the Basic Agreement between the Confederation of Norwegian Enterprise (NHO) and the Norwegian Confederation of Trade Unions (LO) (Hovedavtalen § 3-7, nr. 2). This states that employees cannot require that the enterprise become part of a collective agreement without at least 10 per cent of the employees within the particular bargaining area being members of a union.

of collective agreements. The lines at 10 and 50 percent represent two common thresholds where the union may demand a collective agreement. The relationship appears to have a steeper slope when union density passes 10 percent, indicating an acceleration in the accumulation of collective agreements. When the firm unionization rate exceeds 50-60 percent, most firms have implemented an agreement.

5 Methodology

Productivity can be measured in many ways, with the various methods being confounded by a range of issues (Syverson 2011). In the following, we use total factor productivity as our measure, in line with Barth *et al.* (2020). As demonstrated in the Appendix, however, our main conclusions are robust to the choice of productivity measure. As a change in total factor productivity reflects variations in output that cannot be ascribed to observable variation in factor inputs, we use a production function to estimate output conditional on the use of labor and capital. Our theoretical reference point is a skill-augmented production function specified as Cobb-Douglas, which in log-transformed notation is represented by:

$$(1) \qquad y_{it} = \alpha + \beta_j k_{it} + \boldsymbol{l_{it}}\phi_j + \gamma_1 UD_{it} + \gamma_2 CA_{it} + \gamma_3 (UD \times CA)_{it} + \boldsymbol{X_{it}}\delta + u_i + \lambda_t + \omega_{it} + \varepsilon_{it},$$

where y_{it} and k_{it} denote the value added and capital stock, respectively, of firm *i* in year *t*, both measured by their natural logarithms. Labor is divided into four skills groups determined by educational attainment, denoted by the row vector $\boldsymbol{l_{it}}$, and is measured by the log aggregated weekly number of hours worked within each group.[59] The stock of capital and the number of hours worked both represent a measure of firm size, which is strongly correlated with the presence of a collective agreement (see Figure A1 in the Appendix).

The partial elasticities of output with respect to capital and labor are allowed to vary across industries *j*, as represented by the coefficient β_j and the labor coefficient vector ϕ_j. u_i denotes firm fixed effects, while λ_t represents time-specific effects reflecting both nominal and real trends common to all firms. ω_{it} represents unobservable idiosyncratic productivity shocks

[59] Low-skilled labor comprises workers who do not complete upper secondary school, while medium-skilled corresponds to workers who have completed upper secondary school. High-skilled labor includes workers with a degree from up to 4 years of higher education and workers with at least 120 credits without a degree. Finally, top-skilled labor includes workers who have completed more than 4 years of tertiary education.

known to the firm, while ε_{it} represents measurement errors or random productivity shocks truly unknown to both firms and researchers, assumed to be normally distributed and i.i.d. The model equation is further augmented with our primary variables of interest, which are added successively to the estimated equation: workplace union density (UD_{it}), a dummy variable capturing the presence of a collective agreement (CA_{it}) and a term interacting union density with the presence of a collective agreement. Finally, the model is saturated with a vector of control variables ($\boldsymbol{X_{it}}$) reflecting demographic, occupational and industry-by-year interactions.

We estimate equation (1) to identify the impact of union presence on firm-level productivity. Our main parameters of interest are γ_1, γ_2 and γ_3. The marginal effect of an increase in union density is $\gamma_1$for firms without a collective agreement ($CA = 0$) and $\gamma_1 + \gamma_3$ in firms with an agreement ($CA = 1$). The effect of implementing a collective agreement is given by $\gamma_2 + \gamma_3 \times UD$, which may be evaluated for different values of UD.

Our strategy to identify the productivity effect of unionization is not without challenges. Any unobserved heterogeneity across firms will make the ordinary least squares (OLS) estimator inconsistent. We therefore estimate the model using the within estimator which allows for firm fixed effects. However, a key identifying assumption in the fixed effects model is the absence of any idiosyncratic productivity shocks correlated with union density or the presence of a collective agreement. This assumption is violated if, for example, the decision to implement or abolish a collective agreement is taken systematically at a specific stage of the firm's life, and if the firm is moving along a productivity path that would imply higher or lower productivity after this stage irrespective of the presence of the agreement. As the presence of a collective agreement is measured by a dummy variable, which takes on the value 0 for all years before the implementation and 1 as long as the firm participates in the agreement, any such systematic covariation will bias $\hat{\gamma}_2$.

Moreover, as first noted by Marschak and Andrews (1944), the firm's demand for factor inputs is likely to depend on idiosyncratic productivity shocks known to the firm, but unobservable to the econometrician. This is represented by the ω_{it} term in (1) and may, for example, represent the quality of machines and equipment not reflected in the book value of fixed assets. Such (to the firm) observables, and the omission of these by the econometrician, will in general make both the OLS estimator and the within estimator biased and inconsistent, as factor inputs are endogenously determined together with production. However, as proposed by Olley and Pakes (1996) and further developed by Levinsohn and Petrin (2003) and Wooldridge (2009), the issue of idiosyncratic productivity shocks may be handled by forming a control function where a polynomial in investments and/or intermediate inputs is used to proxy such unobserved productivity differences between individual firms.

A more serious problem of selection bias, however, relates to the potential endogenous determination of union density. The presence of a union is likely to not only *affect* but also *reflect* a firm's performance. The individual workers' decisions on whether or not to unionize may depend on the firm's performance in several ways (DiNardo and Lee 2004; Barth *et al.* 2020). On the one hand, the scope for rent sharing is larger in highly profitable firms than in less profitable ones. On the other hand, as unions are usually considered to improve the protection of workers and workers' rights, workers may seek unionization as a matter of job security if productivity is declining.

To identify the impact of union presence on firm-level productivity, as we discuss in more detail below, we instrument union density among the workers in a workplace by the union density among their parents. As we show Section 6.4, parental unionization behavior has a strong impact on an individual's propensity to join a union. Intergenerational transmission of union membership thus provides a source of exogenous variation in analyses relating unionization to the performance of firms. It is highly unlikely for parents to unionize as a result of changes in performance at their children's workplace, and the variation in parents' union memberships could thus be considered a valid instrument for the individual's decision of whether or not to join a union. One important exception, however, is the case where parents work in the same firm as their children. In such a case, changes in the firm's performance will alter the unionization incentives of both the workers and the workers' parents in a similar manner. This situation may be of particular relevance in sparsely populated areas with one or a few major employers.

Our identification strategy rests on the assumption that any selection bias in the implementation or abolishment of a collective agreement is effectively controlled for by handling the potentially endogenous nature of unionization. In general, this assumption is not likely to hold. Although a collective agreement will often come into place following a recruitment process that results in increasing union density, this is not always the case. In some firms, the union density may be above the threshold required for the union to enter an agreement, without the workers wanting to do so. Furthermore, the decision to enter or exit a collective agreement ultimately depends on the signature of the manager, who is not obliged by law to sign the agreement. As argued in the introduction, the presence of a collective agreement must therefore be treated as a separate and independent dimension of the union's presence in the firm, as must any endogenous decision on whether or not to enter or exit an agreement. The possible selection bias arising from not fully controlling for this problem thus represents a caveat in our study.

6 Results

Table 3 summarizes the results of estimating equation (1) by means of different estimators. In *Model 1a*, we employ the within transformation of equation (1) to allow for firm fixed effects, which effectively controls for any unobserved time-invariant heterogeneity across firms. In this model, we assume (for the moment) homogeneous input elasticities across industries, and union presence is measured by union density alone. As union density is measured as a rate between 0 and 1, the corresponding estimated coefficient implies a 0.11 percent increase in productivity from a ten percentage point increase in union density. The effect is only significant at the ten percent level.[60]

In *Model 1b,* we include a dummy variable that captures whether the firm is engaged in a collective agreement or not, and in *Model 1c* we add a term for the interaction between workplace union density and the existence of an agreement. This completely alters the interpretation of how productivity is affected by the presence of a union. To facilitate interpretation, we have included the derived effects of implementing a collective agreement evaluated on average union density, as well as the marginal effects of an increase in union density with and without a collective agreement. When both variables are included in *Model 1c*, a ten percentage point increase in union density is estimated to *reduce* productivity by 0.3 percent in the absence of a collective agreement. If the firm is covered by a collective agreement, however, a similar increase in union density is estimated to *increase* productivity by 0.8 percent. Furthermore, the implementation of a collective agreement in a firm with an average union density is estimated to increase firm productivity by 13.5 percent. However, this estimate is likely to be biased upwards, a point we will return to below.

[60] Input elasticities are omitted from Table 3 for the sake of readability and reported in Table A2 in the Appendix. The drop in the estimated coefficients of capital and labor inputs when moving from the OLS estimator to the FE estimator reflects the common issue of estimating panel data production functions using microdata (Griliches and Mairesse 1999).

Table 3 Estimated effects of union density and collective agreements on total factor productivity

	Model 1a FE	***Model 1b*** FE	***Model 1c*** FE	***Model 1d*** FE	***Model 1e*** LPW-GMM	***Model 1f*** LPW-GMM	***Model 1g*** LPW-GMM
Union density (UD)	0.011	-0.013*	-0.026***	-0.025***	-0.098***	-0.130***	-0.138***
	(1.83)	(-2.29)	(-4.19)	(-4.02)	(-14.30)	(-12.87)	(-8.56)
Collective agreement (CA)		0.157***	0.117***	0.117***	0.002	-0.019*	-0.016
		(25.79)	(14.46)	(14.47)	(0.18)	(-2.22)	(-1.53)
UD x CA			0.102***	0.099***	0.159***	0.206***	0.197***
			(7.05)	(6.83)	(10.20)	(12.26)	(8.95)
Marginal effects of:							
$UD\ for\ CA = 0$			-0.026***	-0.025***	-0.098***	-0.130***	-0.138***
			(-4.20)	(-4.02)	(-14.30)	(-12.87)	(-8.56)
$UD\ for\ CA = 1$			0.076***	0.074***	0.061***	0.076***	0.059**
			(5.59)	(5.44)	(4.17)	(5.19)	(3.28)
$CA\ for\ \overline{UD}$			0.135***	0.134***	0.028***	0.024***	0.035***
			(20.14)	(20.08)	(4.07)	(3.53)	(4.52)
Test (p-value): $\hat{\gamma}_1 + \hat{\gamma}_3 = 0^{\dagger}$			0.000	0.000	0.000	0.000	0.000
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Occupation and demographics				Yes	Yes	Yes	Yes
Min. number of employees						5	10
R^2 (within)	0.260	0.261	0.261	0.266	0.075	0.098	0.085
R^2 (between)	0.610	0.613	0.613	0.589	0.048	0.129	0.132
R^2 (overall)	0.654	0.657	0.657	0.640	0.059	0.124	0.122
N	1 109 883	1 109 883	1 109 883	1 109 842	942 084	525 791	282 417
Firms	173 257	173 257	173 257	173 247	152 683	83 536	45 168
Avg. obs. per firm	6.4	6.4	6.4	6.4	6.2	6.3	6.3

Note: Union density measured as a rate between 0 and 1. Collective agreement measured as a dummy variable. All estimations include year dummies. Demographics include age intervals, sex, and country of origin. *t* statistics in parentheses. Models *1e* - *1f* use as regressand the residuals from an LPW-GMM estimation of value added on capital and labor inputs only. Input elasticities reported in Table A2 in the Appendix. † The reported test refers to the p-value of an F-test of the sum of the coefficients on UD and UD x CA. Robust standard errors clustered at firm level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

6.1 Unobserved idiosyncratic productivity shocks

In *Model 1d*, we control for heterogeneity in workers' skills (other than educational attainment level) by including occupational shares at the 1-digit (ISCO 08) level, as well as demographic characteristics such as age, sex, and immigration status. However, this enlargement of the specification has no significant effect on the estimated coefficients, which remain robust. In Table A3 in the Appendix, we demonstrate how using labor productivity as our endogenous variable produces similar results.[61] In *Model 1e*, however, we consider how factor inputs may be endogenously determined in the production function by allowing time-varying idiosyncratic productivity shocks, represented by ω_{it} in (1). Applying the GMM estimator proposed in Wooldridge (2009),[62] we first estimate the production function, including capital and labor inputs only, where unobserved productivity is proxied by a third-order polynomial in intermediate inputs. We then use the residuals from this regression, which acts as a measure of total factor productivity, as regressand in the fixed-effects model. When this approach is employed, the effect of implementing a collective agreement drops sharply, suggesting that the estimated effect above is partly caused by idiosyncratic productivity shocks correlated with the decision to implement or abolish a collective agreement. However, the presence of a collective agreement still constitutes an important factor in understanding how unionization alters productivity. The implementation of a collective agreement, evaluated on average union density, is estimated to increase productivity by 2.8 percent. Moreover, while a ten percentage point increase in union density is estimated to *decrease* productivity by almost one percent in the absence of an agreement, a similar increase in union density in the presence of an agreement is estimated to *increase* productivity by 0.6 percent.

The influence of collective agreements may be limited in small organizations. In *Models 1f* and *1g* we therefore constrain our sample to firms with at least five and ten employees, respectively, to make sure our results are not driven by variation generated by small firms. The restriction is not trivial, as the models then exclude 43 and 69 percent of the firms in our sample. Nevertheless, the results remain robust and somewhat strengthened.

6.2 Industry heterogeneity

To control for industry heterogeneity, we start by including industry-by-year interactions to capture potential heterogeneity in technological trends across industries.[63] The results are presented in *Model 2a* of Table 4. In *Model 2b*, we expand the scope for industry heterogeneity

---

[61] Table A3 in the Appendix shows the results of estimating various models using labor productivity, measured as value added per hours worked, as endogenous variable. All models are estimated with firm fixed effects, year dummy variables, and controls on individual worker characteristics. Note that the hours worked by employees with different skill levels are now included as shares among the controls, in contrast to the models presented in Tables 1, 2 and 4. The model is estimated with and without controls for hours worked and capital intensity. Theoretically, the model should include the total number of hours worked, as the assumption of constant returns to scale is rejected in our models. Overall, we find that our results are robust to the choice of productivity measure.
[62] The estimator is implemented using the -prodest- command in Stata with the Wooldridge (wrdg) estimator and the gmm option specified (Rovigatti and Mollisi 2018). The estimator proposed by Levinsohn & Petrin (2003) produces almost identical results (not reported).
[63] Specifically, we add interactions between yearly time dummies and 19 main groups of industries.

by relaxing our previous assumption of homogeneous input elasticities. Specifically, we use the residuals from industry-specific GMM estimations as left-hand side variables in the fixed effects model, thereby recognizing heterogeneous capital and labor elasticities while assuming the impact of unions on productivity to be homogeneous. This more flexible specification changes the results slightly, but the overall pattern remains quite robust.

Finally, in *Models 2c-2i*, we present the results of separate GMM estimations for selected groups of industries.[64] Most noteworthy is how robust the interaction term is estimated across most industries. Whereas higher union density is estimated to lower productivity in the absence of a collective agreement, this effect is moderated, and in many cases becomes positive, in the presence of an agreement. Moreover, the implementation of a collective agreement is estimated to increase productivity in all industries but professional services (evaluated at average union density), with an estimated elasticity ranging from 1 to 10 percent.

We estimate that the implementation of a collective agreement, also in manufacturing industries, has a positive and significant effect on productivity. As firms operating in manufacturing industries are generally exposed to international competition – especially in a small, open economy like that of Norway, their market power is limited. This suggests that our findings are not merely price effects caused by firms passing on the union wage premium to consumers, which is a general concern in studies using value measures of output (Freeman and Medoff 1984: 167).

[64] Results for all 19 main groups of industries are available upon request.

Table 4 LPW-GMM estimates of union density and collective agreements on total factor productivity allowing for various forms of industry heterogeneity.

	Model 2a	***Model 2b***	***Model 2c***	***Model 2d***	***Model 2e***	***Model 2f***	***Model 2g***	***Model 2h***	***Model 2i***
Union density (UD)	-0.099***	-0.103***	-0.139***	-0.149***	-0.130***	-0.127***	-0.129**	-0.032	-0.135***
	(-14.43)	(-15.44)	(-5.52)	(-8.97)	(-10.17)	(-4.88)	(-3.15)	(-1.37)	(-3.78)
Collective agreement (CA)	0.002	0.018*	0.024	0.022	0.026	0.080**	-0.048	-0.037	-0.036
	(0.23)	(2.25)	(1.19)	(1.28)	(1.92)	(3.08)	(-0.84)	(-0.77)	(-0.81)
UD x CA	0.148***	0.130***	0.118**	0.199***	0.109***	0.136*	0.335**	0.0944	0.288**
	(9.60)	(8.70)	(3.05)	(5.97)	(3.92)	(2.18)	(3.17)	(1.23)	(3.29)
Marginal effects of:									
$UD\ for\ CA = 0$	-0.099***	-0.103***	-0.139***	-0.149***	-0.130***	-0.127***	-0.129**	-0.032	-0.135***
	(-14.43)	(-15.44)	(-5.52)	(-8.97)	(-10.17)	(-4.88)	(-3.15)	(-1.37)	(-3.78)
$UD\ for\ CA = 1$	0.050***	0.027	-0.021	0.050	-0.021	0.010	0.207*	0.063	0.153
	(3.44)	(1.91)	(-0.66)	(1.66)	(-0.82)	(0.17)	(2.04)	(0.83)	(1.87)
$CA\ for\ \overline{UD}$	0.030***	0.040***	0.051**	0.048**	0.040***	0.097***	0.026	-0.014	0.006
	(3.90)	(6.02)	(3.17)	(3.16)	(3.35)	(4.16)	(0.61)	(-0.41)	(0.16)
Test (p-value): $\hat{\gamma}_1 + \hat{\gamma}_3 = 0^{\dagger}$	0.001	0.056	0.507	0.097	0.414	0.864	0.041	0.404	0.062
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Occupation and demographics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry by year dummies	Yes	Yes							
Heterogen. input elasticities		Yes							
Industry	All	All	Manufacturing	Construction	Sales & Retail	Hotel & Restaurants	ICT	Professional service	Industrial service
N	941 995	941 969	101 571	187 111	291 121	59 801	33 950	65 923	34 472
Firms	152 658	152 651	133 63	30 272	42 934	11 327	6 643	14 287	7 225
Average obs. per firm	6.2	6.2	7.6	6.2	6.8	5.3	5.1	4.6	4.8

Note: Union density measured as a rate between 0 and 1. Collective agreement measured as a dummy variable. Industries are divided into 19 groups. Demographics include age intervals, sex, and country of origin. All models use as regressand the residuals from LPW-GMM estimation of value added on capital and labor inputs only. Standard errors of marginal effects are calculated using the delta method. †The reported test refers to the p-value of an F-test of the sum of the coefficients on UD and UD x CA. *t* statistics in parentheses. Robust standard errors clustered at firm level. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

6.3 Further investigation of robustness

Our estimations rely on an unbalanced panel of observations, with new firms entering and others exiting the sample along the period of analysis. On the one hand, an unbalanced panel eliminates the potential bias caused by low-productivity firms going into bankruptcy. On the other hand, the productivity effect of collective agreements and unionized workers may differ systematically between new entrants and existing firms in the market. It is therefore interesting to investigate how our results are influenced by imposing various restrictions on the sample of included firms.

Table A4 in the Appendix shows the results of estimating *Model 2b* with only firms present all years, only entrant firms, and only entrants that remain in our sample, respectively. The effect of implementing a collective agreement evaluated at average union density is estimated to be close to zero when only firms that are present all years are considered. The estimated positive impact of collective agreements on productivity thus seems to be driven mainly by new market entrants during our sample period. However, our main result that collective agreements act as an important moderator of what unions do to productivity, remains robust across all the mentioned restrictions.

We also investigate how our results are affected by only including firms with or without changes in their collective agreement coverage throughout the sample. In Table A4, we first restrict the sample to firms that always or never, respectively, are covered by a collective agreement. While the effect of collective agreements naturally cannot be identified under these restrictions, we note that an increase in union density is estimated to *reduce* productivity in firms never covered by an agreement but to increase productivity in firms that are always covered. Although the latter estimate is not significantly different from zero, the results are consistent with our prior findings. We further restrict our sample to firms that do not change coverage status and firms that do change coverage status, respectively, during our sample period. Once again, our results prove to be robust to these restrictions. Compared to the results in *Model 2b*, the estimated effect of implementing a collective agreement, when evaluated at average union density, is stronger when only firms that do change status are considered. This is consistent with the above finding that this effect mainly seems to be driven by new entrants to the market, as the propensity to change coverage is higher among entrant firms.

Finally, we explore the importance of the linearity assumption implicitly imposed in our estimations. In general, there is no reason why an increase in union density from 10 to 20 percent should have the same effect on productivity as an increase from 80-90 percent. In Table A5 in the Appendix, we show the results of estimating *Model 2b* with union density measured as a categorical variable split into five equal intervals. Each union density interval is included in the estimation, as well as the interaction between each interval and the presence of a collective agreement. This exercise reveals that union density has a non-linear effect on productivity. The estimated effects of going from a union density below 20 percent to a union density between 20 and 40 percent, between 40 and 60 percent, or between 60 and 80 percent is in fact very similar. In other words, the negative productivity effect of unionization is estimated to be the same whether the union density goes from 0 to 20-40 percent or from 0 to 60-80 percent. The linearity assumption seems more reasonable when we consider the evaluated effect of implementing a collective agreement conditional on different levels of union density, which is also illustrated in Figure A2 in the Appendix. Overall, taking non-linearity into consideration does not alter our prior findings in any significant way. If anything, our results are strengthened.

6.4 Endogenous unionization

We may worry that our above estimates are confounded by selection bias, as unionization may be endogenously determined by the performance of the firm. In order to overcome this issue, we instrument union density at the workplace with the union density among the workers' parents. In the next section, we explore this instrument further, before we continue with the firm-level analysis in Section 6.3.2. Importantly, however, and as discussed in Section 5, the possible correlation between productivity shocks and the decision to enter or exit a collective agreement, remains a caveat in our study, even after controlling for fixed effects and union density.

6.4.1 Parental influence on individual propensity to join a union

It is widely recognized that the choices of the individual are affected by intergenerational transmission of preferences regarding political orientation (Jennings *et al.* 2009), education (Holmund *et al.* 2011) and receipt of welfare insurance (Dahl *et al.* 2014), to mention some. This is also the case for union membership. As demonstrated in Bryson and Davies (2018), the decision of young workers in Britain of whether or not to join a union is influenced by their parents' union membership. In particular, their study reveals that young workers are 29 per cent more likely to join a union if one of their parents is a union member, and 87 per cent more likely to join a union if both are union members, compared to individuals with no unionized parents (pp. 12-13).

In our sample, the probability that a given individual was a union member in 2018 was 26 per cent higher if at least one of their parents were union members, compared to an individual with no unionized parents.[65] Note that our sample of individuals with information on parents' union memberships averages approximately 500,000 individuals per year, compared to approximately 1.6 million individuals in our full sample. This mainly reflects the fact that parents are excluded from our data when they leave the labor force. In addition, individuals working with their parents are excluded from the analysis.

In order to gain a better understanding of how the unionization behavior of individuals is influenced by their parents' union memberships, we estimate a simple linear probability model, where union membership is estimated as a function of parents' union membership. We then add a list of controls, including sex, age, occupation, the industry of their current occupation, education, and immigration status, as well as year dummies. We also exclude individuals co-working with any of their parents.[66] The estimated partial effect of parental union memberships on an individual's unionization behavior is reported in *Model 3* of Table.[67] The result shows that the probability of being unionized is 6.7 percentage points higher for individuals with at least one unionized parent, compared to an individual with no unionized parents. Evaluated at union density among individuals with no unionized parents in 2018, this amounts to a 22.3 per cent increase in the probability of being unionized, which is same order of size as found among young British workers (Bryson and Davies 2018).

While a rigorous analysis of intergenerational transmission of union membership should be implemented using a more sophisticated identification strategy, our aim here is limited to documenting its relevance in the Norwegian labor market. The simple analysis presented shows a strongly significant and sizeable intergenerational relationship for unionization behavior. Admittedly, we cannot rule out the possibility that this relationship works in the reverse direction, that is, that the unionization behavior of children affects the parents' decision on

---

[65] Figure A3 in the Appendix compares the sample's union density among workers with and without unionized parents in a given year during our sample period.
[66] This restriction barely changes the result.
[67] Full estimation results are available upon request.

whether or not to join a union. However, our result fits into a series of studies of how the decision of parents influence the preferences and choices made by their children.

Table 5 Linear probability model estimates of union density as a function of parents' union memberships.

	Model 3
At least one parent unionized	0.068*** (197.26)
N	7 969 901
R^2	0.134

Endogenous variable: binary variable taking the value 1 if the individual is a union member and 0 if not. Included controls: sex, age, immigration status, occupation (1-digit ISCO-08), industry of current occupation (2-digit NACE), educational attainment level (1-digit ISCED 2011) and year dummies. Individuals working together with their parents are excluded. t statistic in parentheses. Robust standard errors clustered at the firm level. *** p < 0.001.

6.4.2 Union density among parents as an instrument for workplace union density

Table 6 documents the estimation results when instrumenting workplace union density with the contemporary union density among the workers' parents. Although the effect of intergenerational transmission of union memberships naturally becomes weaker when moving from individual unionization decisions to union density at the firm level, it remains highly statistically significant and passes conventional tests for weak instruments by a good margin. In *Model 4a*, we re-estimate *Model 1e* from Table 1 using two-stage least squares (2SLS). *Model 4b* then adds linear industry trends and allows for heterogeneous input elasticities, using the residuals from industry-specific production function GMM estimations as values for the endogenous variable (referred to as GMM-IV). Finally, *Models 4c* and *4d* restrict the sample to firms with at least five and ten employees, respectively.

Overall, the IV estimates confirm our main result: the presence of a collective agreement significantly alters what unions do to productivity. However, although the presence of an agreement moderates the negative effect of an increase in union density, the effect remains negative (though not statistically significant). Moreover, the effect of implementing a collective agreement, evaluated at average union density, is only significant (at the 10 percent level) when we restrict the sample to firms with at least ten employees in *Model 4d*. However, the estimated coefficient values in *Models 4b, 4c* and *4d* are comparable to the above GMM estimates. It is also important to emphasize that the IV estimator identifies the productivity effect of unionization among *compliers* (LATE), which in general is not equal to the average treatment effect (ATE). The results in Tables 6 and 4 are thus not directly comparable, as differences may be ascribed to either selection bias or treatment heterogeneity, or a combination of the two.

Table 6 IV estimates of the effects of union density and collective agreements on total factor productivity

	Model 4a 2SLS	***Model 4b*** GMM-IV	***Model 4c*** GMM-IV	***Model 4d*** GMM-IV
Union density (UD)	0.0985	-0.764***	-0.695***	-0.982**
	(0.69)	(-5.16)	(-3.45)	(-2.72)
Collective agreement (CA)	-0.131	-0.079	-0.090	-0.159
	(-1.68)	(-0.99)	(-1.09)	(-1.69)
UD x CA	0.559**	0.661**	0.658**	0.928**
	(2.67)	(3.10)	(2.84)	(3.11)
Marginal effects:				
$UD\ for\ CA = 0$	0.0985	-0.764***	-0.695***	-0.982**
	(0.69)	(-5.16)	(-3.45)	(-2.72)
$UD\ for\ CA = 1$	0.657	-0.103	-0.037	-0.054
	(3.23)	(-0.50)	(-0.17)	(-0.19)
$CA\ for\ \overline{UD}$	-0.029	0.041	0.048	0.084
	(-0.67)	(0.92)	(1.13)	(1.73)
Test (p-value): $\hat{\gamma}_1 + \hat{\gamma}_3 = 0^{\dagger}$	0.001	0.620	0.869	0.851
Year dummies	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes
Occupation and demographics	Yes	Yes	Yes	Yes
Industry trends		Yes	Yes	Yes
Heterogen. input elasticities		Yes	Yes	Yes
Minimum number of employees			5	10
N	704 314	704 314	490 776	275 139
Firms	118 441	118 441	78 740	43 840
Average obs. per firm	5.9	5.9	6.2	6.3
Test for weak instruments (F-statistics):				
Kleibergen-Paap Wald	268.2	277.9	170.9	70.6
Cragg-Donald Wald	669.4	698.0	387.6	157.8

Note: Union density measured as a rate between 0 and 1. Collective agreement measured as a dummy variable. Union density is instrumented by the contemporary union density among the workers' parents. The interaction term is instrumented with the interaction between the collective agreement dummy and the instrument. Industries are divided into 19 groups. Demographics include age intervals, sex, and country of origin. Union density instrumented by union density among parents in IV estimation. †The reported test refers to the p-value of an F-test of the sum of the coefficients on UD and UD x CA. *t* statistics in parentheses. Robust standard errors clustered at firm level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

7 Discussion and conclusions

Overall, our results show that the qualitative interpretation of what unions do to total factor productivity depends on whether or not the firm is covered by a collective agreement. In the absence of an agreement, increases in union density among the workers in a firm are estimated to reduce productivity. However, the implementation of a collective agreement is estimated to moderate this negative impact. Moreover, when evaluated at average union density, the implementation of a collective agreement is estimated to increase productivity in most model specifications. Our findings thus give some support to the conclusions in Barth *et al.* (2020), but demonstrate the importance of taking account of the industrial relations climate when evaluating the impact of unionization on firm performance.

In general, there are good reasons to believe that the institutional framework encompassed in the collective agreements contributes to improving industrial relations in a firm. In the Norwegian context in particular, the agreements formally acknowledge the importance of the workers' voice and their contributions to productivity growth by establishing a system of collaboration, communication, and participation. Furthermore, they regulate issues such as the right to information and consultation, procedures for electing employee representatives, and rules for taking industrial action. Collective agreements thus represent an institutionalization of a particular way of managing industrial relations. In the absence of this institution, union activity may be more poorly organized and less predictable. Similarly, it may be difficult to utilize the productivity-enhancing potential of collective agreements in the absence of union activity. Based on our findings, union density and the presence of a collective agreement represent two necessary but insufficient conditions *per se* for releasing the productivity-enhancing effects of unionization. However, our results indicate that a sufficiently high union density and a collective agreement combined have a positive impact on firm-level productivity.

Despite the vast body of empirical literature investigating whether unions promote or impede productivity, the evidence is mixed and inconclusive. In this paper we have demonstrated the importance of recognizing institutional contexts when answering this question. In particular, we have argued that the presence of unions can be measured along two dimensions: the density of union members among employees, and the presence of a collective agreement. Such agreements act as a formal recognition of the policy put forward by the union and constitute an important organizational institution through which unions may alter industrial relations.

However, little attention has been devoted to the study of collective agreements and their influence on what unions do to productivity.

Using matched employer-employee panel data, comprising almost 21 million individual-year and almost 1.2 million firm-year observations in the period 2002-2018, we have estimated how unions alter productivity at the firm level and how this effect is influenced by the presence of a collective agreement. Our main finding, which is robust across model specifications, is that the presence of a collective agreement significantly and positively alters what unions do to productivity. In most specifications, collective agreements are estimated to increase productivity. Moreover, across all specifications, collective agreements moderate the negative impact on productivity of increases in union density found in the absence of such agreements. However, care should be taken in interpreting our results, as the possible endogenous decision to enter or exit a collective agreement may bias our findings, even when controlling for firm fixed effects and endogenous unionization.

Our findings may reflect an interdependence between union density and collective agreements with respect to how they affect productivity. While they may have a negative or insignificant impact on productivity in isolation, our results indicate that the combination of a sufficiently high union density and a collective agreement has a positive impact on firm-level productivity. Future research should investigate this interdependence further. In particular, it would be interesting to see an explicit attempt to model this complex relationship, especially within a dynamic framework.

Acknowledgements

We thank Kåre Johansen, Ragnar Torvik, Ragnar Nymoen, Terje Skjerpen, Colin Green, Arnt Ove Hopland, Erling Barth, Harald Dale-Olsen, Kristine Nergaard, Sissel Trygstad, Kristin Alsos and Inger Marie Hagen for helpful comments. A previous version of this paper was presented at a seminar on the Department of Economics at The Norwegian University of Technology and Science. We thank the seminar participants for useful feedback.

Data Availability Statement

The data that support the findings of this study are provided by Statistics Norway through the online application microdata.no, which is available to all researchers at approved research institutions in Norway free of charge. Scripts for reproduction are available upon request.

References

Addison, J. T. and Schnabel, C. eds. (2003). *International handbook of trade unions.* Cheltenham, UK: Edward Elgar.

Allen, S. G. (1988). 'Productivity levels and productivity change under unionism'. *Industrial Relations: A Journal of Economy and Society*, 27(1): 94-113.

Alsos, K., Nergaard, K. and Svarstad, E. (2021). *Arbeidsgiverorganisering og tariffavtaler*. Oslo: Fafo.

Barth, E., Bryson, A. and Dale-Olsen, H. (2020). 'Union Density Effects on Productivity and Wages'. *The Economic Journal*, 130(631): 1898–1936.

Belman, D. (1992). 'Unions, the quality of labor relations, and firm performance'. In L. Mishel and P. B. Voos (eds.), *Unions and economic competitiveness*. New York: Economic Policy Institute and M. E. Sharpe, pp. 41-107.

Bergh, T. (2010). *Avtalt Spill. 75 år Hovedavtalen LO–NHO.* Oslo: LO media.

Blanchflower, D. G. and Bryson, A. (2020). 'Now Unions Increase Job Satisfaction and Well-being'. NBER Working Paper, No. w27720.

Blanchflower, D. G. and Freeman, R. B. (1992). 'Unionism in the United States and other advanced OECD countries'. *Industrial Relations: A Journal of Economy and Society,* 31(1): 56-79.

Brown, C. and Medoff, J. (1978). 'Trade unions in the production process'. *Journal of political economy,* 86(3): 355-378.

Bryson, A., Cappellari, L. and Lucifora, C. (2010). 'Why So Unhappy? The Effects of Unionization on Job Satisfaction'. *Oxford Bulletin of Economics and Statistics,* 72(3): 357-380.

Bryson, A., Charlwood, A. and Forth, J. (2006). 'Worker voice, managerial response and labour productivity: an empirical investigation'. *Industrial Relations Journal,* 37(5): 438-455.

Bryson, A. and Davies, R. (2018). 'Family, Place and the Intergenerational Transmission of Union Membership'. *British Journal of Industrial Relations,* 57(3): 624-650.

Caves, R. E. (1980). *Productivity differences among industries. Britain's economic performance*. Washington: Brookings Institution.

Clark, K. B. (1980). 'The impact of unionization on productivity: A case study'. *ILR Review,* 33(4): 451-469.

Connolly, R. A., Hirsch, B. T. and Hirschey, M. (1986). 'Union rent seeking, intangible capital, and market value of the firm'. *The Review of Economics and Statistics,* 68(4): 567-577.

Coutrot, T. (1996). 'Social relations and economic performance: A preliminary empirical analysis of the French case'. *Travail et Emploi,* 66: 39-58.

Dahl, G. B., Kostøl, A. R. and Mogstad, M. (2014). 'Family Welfare Cultures'. *The Quarterly Journal of Economics,* 129(4): 1711-1752.

DiNardo, J. and Lee, D. S. (2004). 'Economic impacts of new unionization on private sector employers: 1984-2001'. *The Quarterly Journal of Economics*, 119(4): 1383-1441.

Doucouliagos, H., Freeman, R. B. and Laroche, P. (2017). *The economics of trade unions: A study of a research field and its findings.* New York: Routledge.

Flaherty, S. (1987). 'Strike activity, worker militancy, and productivity change in manufacturing, 1961–1981'. *ILR Review*, 40(4): 585-600.

Freeman, R. B. (1976). 'Individual mobility and union voice in the labor market'. *The American Economic Review*, 66(2): 361-368.

Freeman, R. B. and Medoff, J. L. (1979). 'The two faces of unionism'. NBER Working Paper, No. 364.

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

García-Serrano, C. (2009). 'Job satisfaction, union membership and collective bargaining'. *European Journal of Industrial Relations*, 15(1): 91-111.

Garnero, A., Rycx, F. and Terraz, I. (2020). 'Productivity and Wage Effects of Firm-Level Collective Agreements: Evidence from Belgian Linked Panel Data'. *British Journal of Industrial Relations*, 58(4): 936–972.

Griliches, Z. and Mairesse, J. (1999). 'Production Functions: The Search for Identification'. In S. Strøm (ed.), *Econometrics and Economic Theory in the 20th Century*. Cambridge: Cambridge University Press, pp. 169-203.

Grout, P. (1984). 'Investment and Wages in the Absence of Binding Contracts: A Nash Bargaining Approach'. *Econometrica*, 52(2): 449-460.

Hirsch, B. T. and Addison, J. T. (1986). *The Economic Analysis of Unions: New Approaches and Evidence.* Boston: Allen & Unwin.

Holmund, H., Lindahl, M. and Plug, E. (2011). 'The Causal Effect of Parents' Schooling on Children's Schooling: A Comparison of Estimation Methods'. *Journal of Economic Literature*, 49(3): 615–651.

Jaramillo, F., Mulki, J. P. and Marshall, G. W. (2005). 'A meta-analysis of the relationship between organizational commitment and salesperson job performance: 25 years of research'. *Journal of Business research*, 58(6): 705-714.

Jennings, M. K., Stoker, L. and Bowers, J. (2009). 'Politics across Generations: Family Transmission Reexamined'. *The Journal of Politics*, 71(3): 782-799.

Kalleberg, A. L. and Mastekaasa, A. (1994). 'Firm internal labor markets and organizational commitment in Norway and the United States'. *Acta Sociologica*, 37(3): 269-286.

Laroche, P. (2004). 'Présence syndicale et performance financière des entreprises: une analyse statistique sur le cas français'. *Finance Contrôle Stratégie*, 7(3): 117-146.

Laroche, P. (2016). 'A meta-analysis of the union–job satisfaction relationship'. *British Journal of Industrial Relations*: 709-741.

Laroche, P. (2020). 'Unions, Collective Bargaining and Firm Performance'. GLO Discussion Paper, No. 728.

Lazear, E. P. (2000). 'The power of incentives'. *American Economic Review*, 90(2): 410-414.

Levinsohn, J. and Petrin, A. (2003). ‘Estimating Production Functions Using Inputs to Control for Unobservables’. *The Review of Economic Studies*, 70(2): 317–341.

Marschak, J. and Andrews, W. H. (1944). ‘Random Simultaneous Equations and the Theory of Production’. *Econometrica*, 12(3-4): 143-205.

Mathieu, J. E. and Zajac, D. M. (1990). ‘A review and meta-analysis of the antecedents, correlates, and consequences of organizational commitment’. *Psychological Bulletin*, 108(2): 171-194.

OECD (2019). *Negotiating Our Way Up: Collective Bargaining in a Changing World of Work*. Paris: OECD Publishing.

Olley, S. G. and Pakes, A. (1996). ‘The Dynamics of Productivity in the Telecommunications Equipment Industry’. *Econometrica*, 64(6): 1263-1297.

Pencavel, J. H. (1977). ‘The distributional and efficiency effects of trade unions in Britain’. *British Journal of Industrial Relations*, 15(2): 137-156.

Rovigatti, G. and Mollisi, V. (2018). ‘Theory and practice of total-factor productivity estimation: The control function approach using Stata’. *The Stata Journal*, 18(3): 618-662.

Syverson, C. (2011). ‘What Determines Productivity?’. *Journal of Economic Literature*, 49(2): 326-365.

Whitman, D. S., Van Rooy, D. L. and Viswesvaran, C. (2010). ‘Satisfaction, citizenship behaviors, and performance in work units: A meta-analysis of collective construct relations’. *Personnel psychology*, 63(1): 41-81.

Wooldridge, J. M. (2009). ‘On estimating firm-level production functions using proxy variables to control for unobservables’. *Economics Letters*, 104(3): 112-114.

Appendix

Table A1 Descriptive statistics.

	Obs.	*Firms*	*Average years*	*Min*	*Max*	*Mean*	*SD. Overall*	*SD. Within*	*SD. Between*
Log value added	1 170 670	178 438	6.6	0	25.83	14.82	1.45	0.52	1.39
Log capital	1 170 670	178 438	6.6	0	25.6	12.91	2.20	0.94	2.02
Log hours, low-skilled	1 170 670	178 438	6.6	-3.98	12.33	2.58	2.30	1.02	2.05
Log hours, med-skilled	1 170 670	178 438	6.6	-4.20	12.95	3.98	2.03	0.78	2.00
Log hours, high-skilled	1 170 670	178 438	6.6	-3.28	12.03	2.08	2.26	0.95	1.98
Log hours, top-skilled	1 170 670	178 438	6.6	-0.98	12.45	0.82	1.72	0.74	1.46
Union density (UD)	1 170 670	178 438	6.6	0	1	0.17	0.26	0.13	0.25
Collective agreement (CA)	1 170 670	178 438	6.6	0	1	0.13	0.33	0.12	0.26
Occupational share 0 and 9	1 109 842	173 247	6.5	0	1	0.06	0.18	0.10	0.18
Occupational share 1-3	1 109 842	173 247	6.5	0	1	0.37	0.38	0.15	0.38
Occupational share 4-5	1 109 842	173 247	6.5	0	1	0.29	0.35	0.14	0.35
Occupational share 6-8	1 109 842	173 247	6.5	0	1	0.27	0.37	0.11	0.36
Low-skilled worker share**	1 161 166	176 243	6.4	0	1	0.23	0.26	0.12	0.27
Med-skilled worker share	1 161 166	176 243	6.4	0	1	0.53	0.32	0.14	0.33
High-skilled worker share	1 161 166	176 243	6.4	0	1	0.18	0.26	0.11	0.28
Top-skilled worker share	1 161 166	176 243	6.4	0	1	0.06	0.18	0.06	0.20
Share Norwegians	1 170 670	178 438	6.6	0	1	0.80	0.28	0.12	0.30
Share immigrants from Nordic countries	1 170 670	178 438	6.6	0	1	0.04	0.12	0.06	0.13
Share immigrants from EU countries in Eastern Europe	1 170 670	178 438	6.6	0	1	0.04	0.13	0.06	0.15
Share immigrants from other EU countries	1 170 670	178 438	6.6	0	1	0.03	0.10	0.05	0.11
Share immigrants from the rest of the world	1 170 670	178 438	6.6	0	1	0.08	0.19	0.08	0.22
Share low-age	1 170 670	178 438	6.6	0	1	0.10	0.18	0.11	0.18
Share med-age	1 170 670	178 438	6.6	0	1	0.71	0.29	0.17	0.28
Share high-age	1 170 670	178 438	6.6	0	1	0.18	0.27	0.15	0.25
Share top-age	1 170 670	178 438	6.6	0	1	0.01	0.05	0.05	0.04

* Occupational shares are calculated at 1-digit (ISCO 08) level. **2-digit NUS2000 codes, translatable to ISCED97.

Table A2 Input elasticities corresponding to Table 3

	Model 1a FE	***Model 1b*** FE	***Model 1c*** FE	***Model 1d*** FE	***Model 1e*** LPW-GMM	***Model 1f*** LPW-GMM	***Model 1g*** LPW-GMM
log Capital	0.077***	0.077***	0.077***	0.075***	0.087***	0.087***	0.087***
	(82.64)	(82.55)	(82.55)	(81.99)	(104.54)	(104.54)	(104.54)
log Hours, low-skilled	0.080***	0.080***	0.080***	0.078***	0.108***	0.108***	0.108***
	(109.74)	(109.24)	(109.28)	(106.57)	(269.95)	(269.95)	(269.95)
log Hours, med-skilled	0.147***	0.146***	0.146***	0.144***	0.242***	0.242***	0.242***
	(126.96)	(126.55)	(126.53)	(125.46)	(391.60)	(391.60)	(391.60)
log Hours, high-skilled	0.071***	0.070***	0.071***	0.069***	0.142***	0.142***	0.142***
	(93.64)	(93.37)	(93.47)	(91.25)	(359.91)	(359.91)	(359.91)
log Hours, top-skilled	0.059***	0.059***	0.059***	0.056***	0.160***	0.160***	0.160***
	(60.34)	(59.97)	(60.08)	(57.19)	(294.38)	(294.38)	(294.38)

Note: Union density measured as a rate between 0 and 1. Collective agreement measured as a dummy variable. All estimations include year dummies. Demographics include age intervals, sex, and country of origin. *t* statistics in parentheses. *Model 1e - Model 1g* use as regressand the residuals from an LPW-GMM estimation of value added on capital and labor inputs only. Robust standard errors clustered at firm level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A3 Estimation results using labor productivity (value added per hour worked) as endogenous variable

	Model A4a	***Model A4b***	***Model A4c***	***Model A4d***	***Model A4e***
$\log(C/HW)$			0.0636^{***}	0.0633^{***}	0.143^{***}
			(73.86)	(74.08)	(14.72)
$\log(HW)$		-0.410^{***}	-0.398^{***}	-0.403^{***}	-0.425^{***}
		(-158.70)	(-145.18)	(-147.13)	(-23.41)
Union density (UD)	-0.0689^{***}	-0.0386^{***}	-0.0427^{***}	-0.0429^{***}	-0.0468^{***}
	(-11.18)	(-7.02)	(-7.21)	(-7.26)	(-8.00)
Collective agreement (CA)	-0.00833	0.111^{***}	0.0926^{***}	0.0921^{***}	0.0928^{***}
	(-1.04)	(14.84)	(12.74)	(12.74)	(12.90)
UD x CA	0.0336^{*}	0.0621^{***}	0.0697^{***}	0.0580^{***}	0.0437^{***}
	(2.19)	(4.53)	(5.17)	(4.34)	(3.32)
Marginal effects of:					
$UD\ for\ CA = 0$	-0.0689^{***}	-0.0386^{***}	-0.0427^{***}	-0.0429^{***}	-0.0468^{***}
	(-11.18)	(-7.015)	(-7.211)	(-7.256)	(-7.997)
$UD\ for\ CA = 1$	-0.0353^{**}	0.0235	0.0270^{*}	0.0150	-0.00311
	(-2.410)	(1.811)	(2.137)	(1.201)	(-0.253)
$CA\ for\ \overline{UD}$	-0.00247	0.122^{***}	0.105^{***}	0.102^{***}	0.100^{***}
	(-0.381)	(19.77)	(17.58)	(17.24)	(17.01)
Test (p-value): $\hat{\gamma}_1 + \hat{\gamma}_3 = 0^{\dagger}$	0.0160	0.0702	0.0326	0.230	0.800
Industry by time dummies	No	No	No	Yes	Yes
Heterogen. input elasticities	No	No	No	No	Yes
R^2 (within)	0.0695	0.169	0.215	0.220	0.228
R^2 (between)	0.0614	0.00941	0.0450	0.0387	0.0483
R^2 (overall)	0.0704	0.0173	0.0558	0.0504	0.0623
N	1342530	1342530	1100463	1100262	1100262
Firms	205427	205427	170937	170894	170894
Average obs. per firm	6.535	6.535	6.438	6.438	6.438

Note: Union density measured as a rate between 0 and 1. Collective agreement measured as a dummy variable. *C* and *HW* denote capital and hours worked, respectively. All estimations include year dummies, firm fixed effects and the following controls on individual workers' characteristics (measured as shares): education, occupation, age, sex, and country of origin. *t* statistics in parentheses. †The reported test refers to the p-value of an F-test of the sum of the coefficients on UD and UD x CA. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A4 LPW-GMM estimates of union density and collective agreements on total factor productivity with various sample restrictions

	Model 2b	***Model A5a***	***Model A5b***	***Model A5c***	***Model A5d***	***Model A5e***	***Model A5f***	***Model A5g***
Union density (UD)	-0.103***	-0.0730***	-0.120***	-0.100***	0.0293	-0.108***	-0.107***	-0.0737***
	(-15.44)	(-5.37)	(-14.02)	(-10.63)	(1.32)	(-15.21)	(-15.02)	(-3.61)
Collective agreement (CA)	0.0180*	-0.0152	0.0109	0.0150	-	-	-	0.0362***
	(2.25)	(-1.31)	(0.79)	(1.01)	(.)	(.)	(.)	(3.88)
UD x CA	0.130***	0.127***	0.154***	0.139***	-	-	0.156***	0.0863***
	(8.70)	(5.46)	(6.23)	(5.37)	(.)	(.)	(6.76)	(3.70)
Marginal effects of:								
$UD\ for\ CA = 0$	-0.1035***	-0.0730***	-0.120***	-0.100***				-0.0737***
	(-15.44)	(-5.37)	(-14.02)	(-10.63)				(-3.61)
$UD\ for\ CA = 1$	0.0267	0.0537	0.0344	0.0384				0.0125
	(1.91)	(0.01)	(0.15)	(0.12)				(0.66)
$CA\ for\ \overline{UD}$	0.0399***	0.00921	0.0353**	0.0375**				0.0640***
	(6.02)	(0.94)	(3.14)	(3.07)				(9.76)
Test (p-value): $\hat{\gamma}_1 + \hat{\gamma}_3 = 0^{\dagger}$		0.00658	0.153	0.123			0.0248	0.509
Firm presence restriction		Present all years	Enters	Enters and stays				
CA restriction					Always	Never	Always or Never	Change Status
N	941 969	244 407	505 937	379 206	77 173	770 598	847 771	94 198
Firms	152 651	17 614	105 200	62 052	8 392	134 504	142 896	9 755
Average obs. per firm	6.2	13.88	4.809	6.111	9.196	5.729	5.933	9.656

Note: All models use as regressand the residuals from LPW-GMM estimation of value added on capital and labor inputs only, with heterogeneous input elasticities across 19 groups of industries. Union density measured as a rate between 0 and 1. Collective agreement measured as a dummy variable. All models include year dummies, industry by year dummies, firm fixed effects, and controls on worker characteristics (occupation, age intervals, sex, and country of origin). In Model 2b (our reference model) there are no restrictions on the sample. Model A5a restricts the sample to firms that were in operation throughout our entire sample period. Model A5b only includes firms that enter the market during our sample period, while Model A5c only includes those that enter the market during our sample period *and* stay in the market. In Models A5d and A5e we restrict the sample of firms to those who always and those who never, respectively, have a collective agreement, while Model A5f includes all firms that do not change status during our sample period. Finally, Model A5g only includes firms that change status during our sample period (i.e. either enter or exit agreements, or both). †The reported test refers to the p-value of an F-test of the sum of the coefficients on UD and UD x CA. Standard errors of marginal effects are calculated using the delta method. *t* statistics in parentheses. Robust standard errors clustered at firm level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A5 Non-linear effects of unionization on total factor productivity

	Model 2b	***Model A6***
Collective agreement (CA)	0.018*	0.041***
	(2.25)	(5.25)
Union density (UD)	-0.103***	-
	(-15.44)	
UD x CA	0.130***	-
	(8.70)	
UD = 20-40 % (UD2)		-0.052***
		(-21.55)
UD = 40-60 % (UD3)		-0.056***
		(-13.70)
UD = 60-80 % (UD4)		-0.061***
		(-9.12)
UD = 80-100 % (UD5)		-0.001
		(-0.13)
UD2 x CA		0.028***
		(4.19)
UD3 x CA		0.039***
		(4.85)
UD4 x CA		0.060***
		(5.71)
UD5 x CA		0.036**
		(2.67)
Marginal effects of:		
$CA\ for\ \overline{UD}$	0.040***	
	(6.02)	
$CA\ for\ UD1 = 1$		0.041***
		(5.25)
$CA\ for\ UD2 = 1$		0.069***
		(9.99)
$CA\ for\ UD3 = 1$		0.080***
		(10.93)
$CA\ for\ UD4 = 1$		0.100***
		(10.54)
$CA\ for\ UD5 = 1$		0.077***
		(6.06)
N	941 969	941 969
Firms	152 651	152 651
Average obs. per firm	6.2	6.2

Note: Both models use as regressand the residuals from LPW-GMM estimation of value added on capital and labor inputs only, with heterogeneous input elasticities across 19 groups of industries. All models include year dummies, industry by year dummies, firm fixed effects, and controls on worker characteristics (occupation, age intervals, sex, and country of origin). In Model 2b, union density is measured as a rate between 0 and 1. In Model A6, union density is measured as a categorical variable taking the values {1,2,3,4,5} if the union density is within the corresponding intervals {0-0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8, 0.8-1}. The first interval is used as reference category. Collective agreement measured as a dummy variable. Standard errors of marginal effects are calculated using the delta method. *t* statistics in parentheses. Robust standard errors clustered at firm level. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure A1 Bin scatter illustrating mean collective agreement coverage as a function of the number of employees in the firm

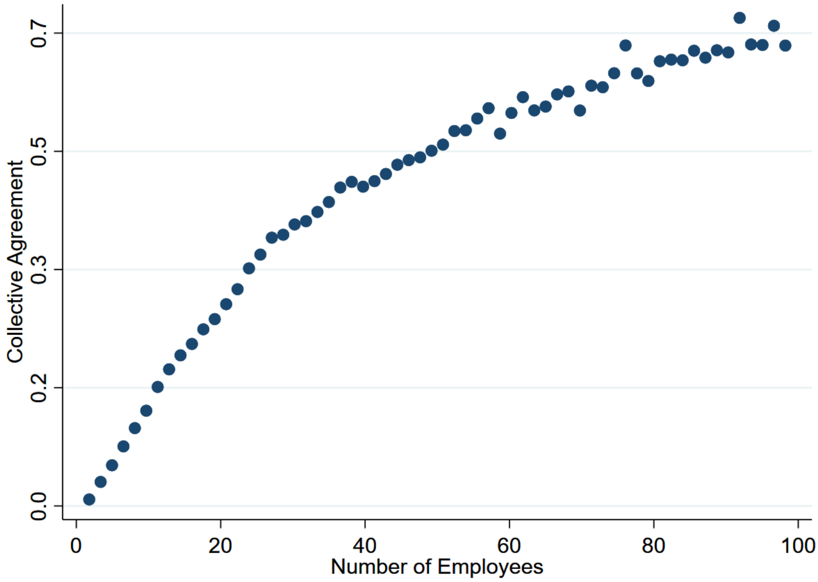


Figure A2 The effect of implementing a collective agreement, evaluated for different union density values.

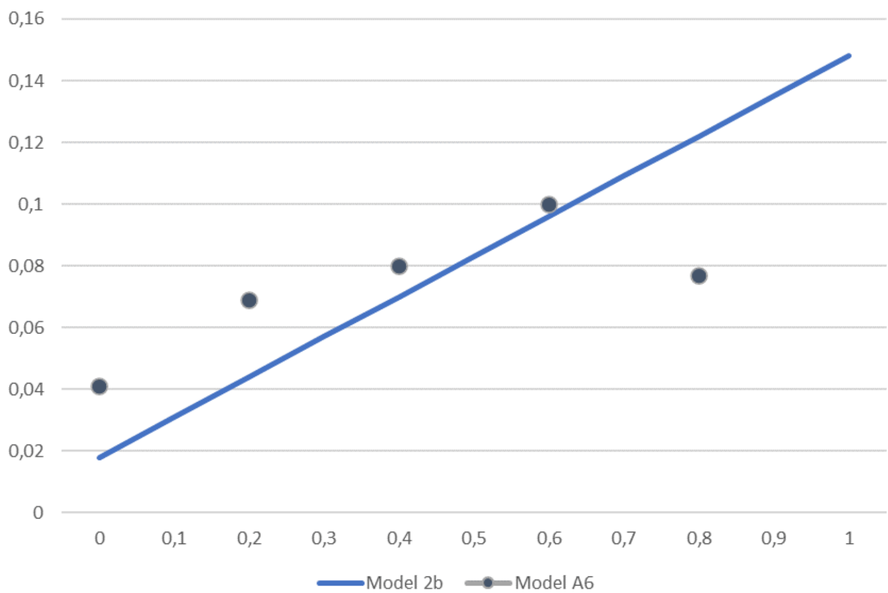
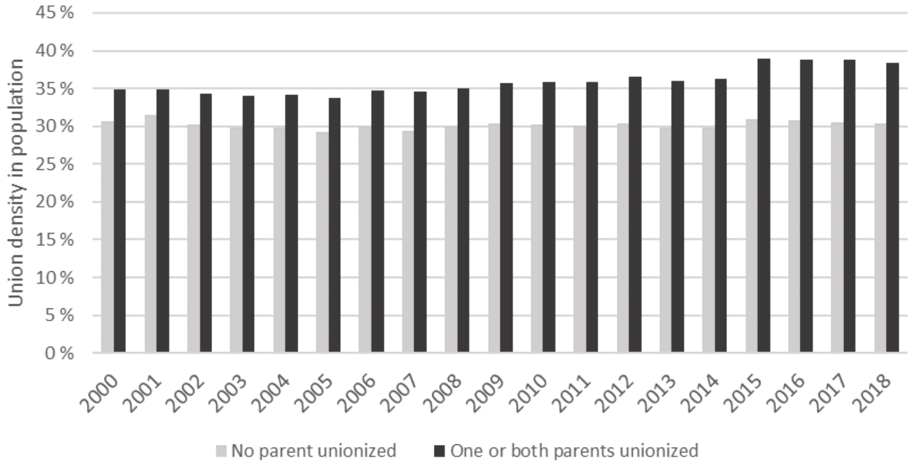


Figure A3 Union density in the sample and parental union membership (N≈500 000 individuals per year)



ISBN 978-82-326-7510-4 (printed ver.)
ISBN 978-82-326-7509-8 (electronic ver.)
ISSN 1503-8181 (printed ver.)
ISSN 2703-8084 (online ver.)

NTNU
Norwegian University of
Science and Technology