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176

Matthias Strifler

Economics of Wage Premia and Wage Rigidity

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Editors
Tuomo Takala
Jyväskylä University School of Business and Economics
Pekka Olsbo, Ville Korkiakangas
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ABSTRACT

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The focus of this dissertation is on the effects of specific employer characteristics on wages and wage rigidity and how these characteristics enter the wage-setting process. The dissertation includes an introductory chapter and five separate essays. The introduction provides motivation, background on the main keywords and an overview of the thesis. Chapters two and three study how internal references affect wages and wage rigidity from a theoretical perspective. The fourth chapter estimates the effect of firm size on wages in the Finnish labor market. Chapter five develops on the preceding and analyses how profit sharing schemes affect the firm size premium. Chapter six studies how internal references can induce profit sharing and wage rigidity from an empirical perspective.

Chapter two analyses how fairness considerations of workers affect the union wage-setting process and ultimately on wages, employment and wage rigidity. Fairness is modeled as internal reference where workers compare wages to firm productivity respectively profitability. If the internal reference is high relative to the outside option, wage pressure results through a productivity/profitability premium as well as real wage rigidity.

The third chapter reviews the core research on internal references and wage rigidity. With one exception it suggests that internal references unambiguously increase wage rigidity. In contrast, this chapter provides analytical proofs, calibration results and impulse response functions which show that the effect is ambiguous. The effect of the internal reference relative to the external reference determines whether wage rigidity increases or decreases.

Chapter four explores the relationship between wages and firm size in the Finnish labor market. Using a large register data set the effect of firm size is found to be negligible after controlling for a large set of worker and firm characteristics and across different identification strategies.

Chapter five analyzes the interaction of the firm size wage premium and profit sharing schemes. A simple theoretical analysis shows that the firm-size wage premium decreases in the presence of profit sharing. Using a rich linked employer-employee data set the empirical analysis shows that besides profit sharing, assortative matching and monopsony behavior decrease the firm size premium.

The sixth chapter analyses the connection between profit sharing and wage rigidity where profits per worker are measured directly through the balance sheet panel. Profit endogeneity is accounted for by instrumentation as well as the self-selection of firms in different categories of profitability. Profits are shared if positive or increasing while there is no downward adjustment of wages if profits are negative or decreasing. This finding suggests that profits per worker function as internal reference.

Keywords: Wage rigidity, profit sharing, firm size, wage premium, internal reference, external reference, fairness, labor unions, efficiency wages

Author	Matthias Strifler School of Business and Economics University of Jyväskylä
Supervisors	Professor Jaakko Pehkonen School of Business and Economics University of Jyväskylä
	Professor Ari Hyytinen School of Business and Economics University of Jyväskylä
Reviewers	Professor Jari Vainiomäki School of Management University of Tampere
	Dr. Juuso Vanhala, Advisor Monetary Policy and Research/Forecasting Bank of Finland
Opponent	Professor Pekka Ilmakunnas Department of Economics Aalto University School of Business

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I suppose the story of how I became a doctoral student at the University of Jyväskylä has taken a few more turns than is usual. I contacted Jaakko Pehkonen in the autumn of 2010 for the first time, inquiring about a possible visit to Jyväskylä. At the time, I was a research associate at the University of Hohenheim which meant that I was practically teaching fulltime and getting paid halftime. During my subsequent visit in the spring of 2011, I was warmly welcomed and taken care of. I still remember Kari Heimonen making it possible for me to attend the Annual Meeting of the Finnish Economic Association although all the deadlines had passed and I had just arrived to Finland. I will also not forget Jukka Lahtonen who chased me at the Oulu railway station, worrying I might miss the train as I wandered away from the Jyväskyläns after the meeting.

After I learned about the doctoral program in economics and got wind of the possibilities for empirical research, I went back to Germany, quit my job, and by August 2011 found myself sitting in the FDPE Math course. In the years to follow, Jaakko has been a great supervisor to my thesis. He did not tire to comment on my ideas, he improved the exposition of my research and encouraged me at all stages of my thesis. I also had the privilege to pursue joint research projects with him, Mika Maliranta and Sampo Pehkonen. Furthermore, I am very grateful to my second supervisor Ari Hyytinen who provided me with many insightful and very precise comments, especially regarding empirical research. His criticism and suggestions made me push harder and, in my view, had a considerable impact on the level of research done in this thesis.

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Jyväskylä, March 2017

Matthias Strifler

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1 INTRODUCTION

1.1 Background

The core questions in labor economics evolve around wages and unemployment. Beginning with Mincer (1958), empirical labor economics studied the determinants of wages with a special focus on worker characteristics. More recently, thanks to an increase in the amount and quality of data, substantial improvements in empirical methods and not least a surge in computing power many more avenues have been explored: the impact of different labor market institutions (Neumark and Wascher, 2008; Botero et al., 2004; Schmieder et al., 2016), unionization (Aidt and Tzannatos, 2002), frictions (Berg and Vuuren, 2010), local unemployment (Blanchflower and Oswald, 1996) and firm characteristics (Abowd et al., 1999).

Most of the empirical research is inspired and motivated by theoretical modeling which discards the assumption of perfect competition and incorporates involuntary unemployment. Among the most prominent strands of that literature are studies which consider market power on the firm side, i.e. monopsony wage setting (Manning, 2003), workforce organization and union wage setting (Dunlop, 1944; Booth, 1995), search frictions and worker-firm matching (Mortensen and Pissarides, 1994; Pissarides, 2000) and the motivational aspects of pay (Shapiro and Stiglitz, 1984; Yellen, 1984). Probably the most common feature the theoretical literature shares, is the assumption of the homo economicus. However, based on evidence from economic psychology (Kahneman et al., 1986; Tversky and Kahneman, 1986) and experimental economics (Fehr et al., 1997; Fehr and Gächter, 1998; Bolton and Ockenfels, 2000) there is growing research which departs from that assumption and acknowledges that concerns of equity, reciprocity and fairness are an important determinant of wage setting and worker behavior (Akerlof, 1982; Danthine and Kurmann, 2007; Egger and Kreickemeier, 2012).

Against this backdrop emerge some specific dividing lines within the literature. With regard to wages and wage setting, the most prominent is between the more macro-labor oriented literature, with focus on wage changes and dynamics and ultimately wage rigidity (e.g. Dickens et al., 2007), and the more micro oriented literature, with focus on the level of wages and many different types of wage differentials (e.g. Groshen, 1991).[1] The main reason for this division does not necessarily stem from different research questions, but rather from the different sets of methods used to answer these questions. The division is found in empirical as well as theoretical research.

First, in the theoretical literature on wage rigidity mainly (dynamic stochastic) general equilibrium models are used to analyze wage responses to aggregate supply or demand shocks. Usually these models build on quite specific features or assumptions which drive the results on wage rigidity. However, the potential impact of these assumptions on the level of pay or on pay differences are often beyond the scope of these studies (Knell, 2013; Hall, 2005).[2] Second, in the empirical literature on wage rigidity the focus is mainly on wage adjustments over the business cycle. Although results are often motivated by micro-level fairness considerations of workers who resist wage cuts (Bewley, 1999), the microeconomic causes or circumstances which lead to that type of wage behavior are not pinned down.

Third, among the large micro-econometric literature on the determinants of wages, the question, what determines wage changes, respectively nonexistent downward wage changes, is far less often asked (for an exception, see Martins, 2009; Arai and Heyman, 2009). This is insofar plausible as many factors which influence wages, such as the level of education, experience, gender, the bargaining framework, the industry or information asymmetries are quite stable over time or change only gradually. However, since wage differentials between firms are large and firm characteristics are an important determinant of wages (Brown and Medoff, 1989; Abowd et al., 1999) demand shocks are likely to impact on profitability and financial health of firms in the short term. This provides a basis for the study of wage adjustments and therefore also potentially nonexistent downward adjustments.

The research presented in this thesis moves along and attempts to bridge that divide at several points. As such it covers a wide range of methods reaching from general equilibrium (and DSGE) modeling to applied micro-econometric analysis. The focus of the thesis is on fair wage setting and the impact of employer characteristics on wages as well as their interaction. The thesis contains five essays. The first analyzes the effect of fairness considerations in labor union wage setting on wage rigidity and wage pressure. The second analyzes some of the most prominent fair wage models and shows that fairness as modeled in these papers does not necessarily lead to wage rigidity. The effect of firm size and coordinated wage setting in the Finnish context is analyzed in the third essay. Essay four develops on the preceding one and studies the effect of profit sharing schemes on the firm-size wage premium. The fifth essay analyzes the link between profit sharing and wage rigidity which is likely to be established by

1 There is only little research which deals with both (see e.g. Agell and Lundborg, 1995; Meckl and Zink, 2004; Maczulskij, 2013; Neumuller, 2015).

2 An important exception is Danthine and Kurmann (2010).

fairness considerations.

The remainder of the introduction is structured as follows. Section 1.2 reviews some empirical and theoretical evidence on the main topics studied in the thesis: wage rigidity, fairness considerations, wage effects of firm size and profit sharing. An overview of the thesis, the research questions asked and the contributions made in the respective essays are presented in section 1.3. Although the short background provided here already suggests a close connection between the essays more light is shed on the linkages between them. Some concluding remarks and suggestions for future research are offered.

1.2 Fairness, wage rigidity and wage premia

1.2.1 Wage rigidity

Downward nominal and real wage rigidity have been thoroughly studied over the last two decades. Especially more micro level evidence has been provided after the establishment of the procedure from the International Wage Flexibility Project (IWFP), see Dickens and Goette (2006) and Dickens et al. (2007). Wage rigidity was also studied in the Wage Dynamics Network (WDN) within the European System of Central Banks, see e.g. Babecký et al. (2010), Du Caju et al. (2012) and Messina et al. (2010). The literature reveals substantial variation in the degree of wage rigidity, nominal as well as real, between countries and also over time (Dickens et al., 2007; Knoppik and Beissinger, 2009; Messina et al., 2010). Regarding Finland, Böckerman et al. (2007) and (2010) report that real wages were very rigid in the 1990s, whereas Maczulskij (2013) finds more flexibility at the beginning of the 2000s.

The strong interest, especially in downward nominal wage rigidity stems from its consequences for employment and its implications for monetary policy. Based on the hypothesis of Tobin (1972), who suggested that low inflation could lead to unemployment in presence of nominal wage rigidity, Akerlof et al. (1996) showed that the Philips curve is not vertical at low levels of inflation. This suggests a trade-off between unemployment and inflation. Although the empirical evidence on wage rigidity is pervasive, more recently Elsby (2009) and Stüber and Beissinger (2012) showed that the macroeconomic consequences of nominal wage rigidity appear to be limited.

There is limited quantitative evidence on the causes (micro-foundation) of wage rigidity. Nevertheless the absence of downward wage adjustments is commonly motivated by either one of the following: fairness considerations or institutional respectively contractual reasons.[3] The rationale of the first is based on worker behavior. Workers feel entitled to a fair remuneration and therefore wage cuts tend to impair worker effort and morale which makes firms to refrain from

[3] Several studies motivate wage rigidity also by money illusion, see Shafir et al. (1997), and also by a combination of fairness considerations and money illusion.

downward wage adjustments (Fehr et al., 1998). This is discussed in more detail in chapter 1.2.2. The rationale of the second is usually based on unionization or wage bargaining (and matching) where it is difficult for the contracting parties to deviate from the provisions of the contract (see, e.g. Hagedorn and Manovskii, 2008; Krusell and Rudanko, 2016; Gertler and Trigari, 2009; Hall and Milgrom, 2008). Even if a collective agreement expires and no new agreement is found, firms can not unilaterally adjust wages (Holden, 2004). Usually the two reasons are rather seen to be complementary than substitutive (Holden, 2004). In short, contracts can be interpreted as a condensed set of rules which are acknowledged to be fair by both contracting parties. See Beissinger and Knoppik (2005) for a more detailed discussion.

A substantial share of the theoretical literature on wage rigidity assumes wage changes to be exogenously given and focuses entirely on the study of its macroeconomic consequences (Shimer, 2004; Smets and Wouters, 2003; Christiano et al., 2005). However, there is a small but growing literature which endogenizes wage rigidity by incorporating fairness considerations: Danthine and Kurmann (2006), (2007) and (2010) and Koskela and Schöb (2009) include fairness considerations through internal wage references. Workers compare wages to the firm's product per worker and thereby decide on the fairness of the wage offer and ultimately on the effort they are going to provide in return. The main result of this literature is that fairness considerations lead to very high levels of wage rigidity.

1.2.2 Fairness considerations

Over many decades economic theories and economic thought in general were based on the assumption of the homo economicus. Although there have been several debates whether this assumption also covers preferences beyond self-interest (Becker, 1993), large parts of the literature opposed this view as it could lead to the acceptance of any kind of set of preferences. Ultimately all kinds of (irrational) behavior (Kirchgässner, 2008) could be rationalized. However, based on overwhelming evidence from different fields, such as evolutionary biology, economic psychology and experimental economics, fairness is now perceived to be an integral part of human motivation. As such it is able to explain certain economic outcomes, for example wage rigidity. Following that evidence, fairness considerations can be traced back to reciprocal behavior, which ultimately gave birth to the concept of homo reciprocans (Bowles and Gintis, 2002).

In evolutionary biology it seemed at first at odds with the process of natural selection, that individuals do favors for others (Gintis, 2000), punish others who do not abide by the rules at own cost (Fehr and Gächter, 2002) and abide by the rules even when deviating yielded benefits and no one found out (Burger et al., 2009). In biological terms such behavior reduces individual fitness and thus decreases the probability of successful reproduction, and as such, stands opposed to the process of natural selection (Williams, 1988). However already Darwin (1871) proposed that selection may not only take place at the level of individuals but groups. This implies that more cooperative groups would be the result of the selection process. Based on group selection, several modern theories have been established which consider fairness to be an outcome of natural selection (see e.g. Hamilton, 1964; Trivers, 1971; Nowak and Sigmund, 1998; Sober and Wilson, 1998). All of those theories refer to different types of reciprocal behavior while in it's strongest form, it can explain a wide range of human cooperation. Strong reciprocity implies that favors are returned and individuals who violate social norms are punished even if this is costly and no benefits accrue to the reciprocator (Fehr and Henrich, 2003).

As there are no external benefits to this kind of behavior the reciprocator is, from a psychological point of view, intrinsically motivated (Deci and Ryan, 1985). In addition, the response to a certain action, such as the (potential) violation of a social norm, depends on whether it is actually perceived to be unfair. Perception in turn depends on the framing of the situation: Tversky and Kahneman (1986) show that individuals react differently to the exact same situation, depending on how the situation is presented. The framing of the situation makes individuals choose different kinds of reference points. Based on the comparison of the (outcome of the) action to such a reference point is how the action is assessed and thus judged to be fair or not (Fehr and Henrich, 2003).[4]

With the rise of experimental economics many predictions based on the concept of the homo economicus, especially by game theory, were shown to be incorrect. These so-called anomalies are found in a wide range of games including gift-exchange, public goods and ultimatum games among many others (see e.g. Camerer and Thaler, 1995; Charness, 2004). However, the concept of strong reciprocity is able to motivate many of these anomalies, especially in settings with incomplete contracts (Gächter and Falk, 2002; Fehr et al., 1998). As the labor market is dominated by incomplete contracts, fairness considerations of both, employers as well as employees are of importance to labor economics.

1.2.3 Wage premia I: the effect of firm size

Beginning with Abowd et al. (1999) a large literature evolved on firm-size wage effects based on linked worker-firm data. This research shows that larger firms, tending to be more capital intensive and productive, pay significantly higher wages than small firms. This finding holds over many different countries and at different points of time (Albaek et al., 1998; Oi and Idson, 1999; Lallemand et al., 2007; Barth and Dale-Olsen, 2011). Two broad sets of theories, more complementary than substitutive, are able to motivate this finding. The first set is more focused on the labor market, while the second set is more focused on the goods market. Table 1 gives an overview over the findings and theoretical motivations of selected papers.

Among the first set of theories are the following: differences in production

4 In an economic setting, judgements of fairness are likely to be taken based on nominal terms, which initially gave rise to fairness considerations being considered to cause nominal wage rigidity (Shafir et al., 1997).

TABLE 1 Summary of findings on firm size wage premium

Wage premium in %	Continuous firm size measure	Country	Theoretical motivation	Literature
1.5 - 3.8	no	United states	Individual heterogeneity, compensating differentials, union threat, price-setting power, monitoring, monopsony	Brown and Medoff (1989)
0 - 10	yes	France	heterogeneity	Abowd et al. (1999)
0 - 3.6	yes	Denmark, Finland, Norway, Sweden	capital-skill complementarity, compensating differentials, market power, unionization, imperfect information, monitoring	Albaek et al. (1998)
3.5 - 7.8	no	United States	worker productivity	Idson and Oi (1999)
4.8 - 13.3	no	Britain	monopsony	Green et al. (1996)
0.6 - 6.8	yes	Belgium, Denmark, Ireland, Italy, Spain	assortative matching, compensating differentials, job stability, monitoring, collective bargaining	Lallemand et al. (2007)
1,1 - 22,6	no	Canada	sorting, monitoring	Ferrer and Lluis (2008)
0 - 2.9	yes	Norway	monopsony, skill group size	Barth and Dale-Olsen (2011)

technology as well as different types of imperfections in the labor market such as frictions, monopsony wage setting and efficiency wages. Regarding the production technology approach the main idea is straightforward: due to higher capital intensity and capital-skill complementarity the larger firms hire the more qualified workers (Hamermesh, 1980; Brown and Medoff, 1989). Regarding imperfections in the labor market there are many different reasons why a firm-size wage premium might result. Based on frictions and firm as well as worker heterogeneity, assortative matching of workers and firms can explain the firm-size wage premium: better, or more productive firms are likely to attract better, respectively more qualified workers. Even in case of worker homogeneity, frictions and on-the-job search can lead to the effect that firms which try to obtain a larger share of workers, pay higher wages along the increasing labor supply curve (Burdett and Mortensen, 1998). As such, this approach is closely related to monopsony wage setting: The larger the firm the lower is its labor supply elasticity which directly translates into higher wages (Green et al., 1996; Manning, 2003). Finally, efficiency wage theory can motivate the firm-size wage premium, as labor turnover is larger and monitoring of workers is harder in larger firms (Shapiro and Stiglitz, 1984; Kruse, 1992; Brown and Medoff, 1989).

Among the second set of theories are monopsony price setting and profit sharing. Based on empirical evidence, which suggests a lower demand elasticity for large firms (Kugler and Verhoogen, 2012; Johnson, 2012), the rents firms are able to achieve on the product market increase in firm size. Either these rents are partially transferred to workers by unions and wage bargaining or the firm decides unilaterally to share rents i.e. profits (Machin, 1991; Miller and Mulvey, 1996; Weitzman, 1984). Complementary to above this might be motivated by reducing turnover or by a gift-exchange perspective (Akerlof, 1982). The following section sheds more light on profit sharing.

Finally a different approach is discussed by Brown and Medoff (1989), who suggest that larger firms might pay higher wages in order to prevent workforce unionization. More recently Barth and Dale-Olsen (2011) suggested that the firm-size wage effect might be explained by a skill group size effect. This argument builds on the theory of monopsony wage setting discussed above.

1.2.4 Wage premia II: profit sharing

Similar to the firm-size wage premium, profit respectively rent sharing creates a wage differential based on employer characteristics. The differential is based on the firm's profitability situation: workers employed in more profitable firms tend to earn higher wages than those employed in less profitable firms. A large number of empirical studies provide evidence on the wage profit association at the industry level (Dickens and Katz, 1987; Katz and Summers, 1989; Blanchflower et al., 1996; Estevao and Tevlin, 2003), the firm level (Reenen, 1996; Hildreth and Oswald, 1997; Long and Fang, 2012) and more recently at the individual level based on linked employer-employee data (Kramarz, 2003; Guertzgen, 2009; Card et al., 2014). Table 2 gives an overview over the findings and methods of selected papers using linked data.

Several theories have been proposed to motivate profit sharing: frictions, risk sharing, human capital and turnover, wage bargaining, and fair wage models (Blanchflower et al., 1996; Long and Fang, 2012; Danthine and Kurmann, 2010). Search frictions in the labor market induce high productivity firms to offer higher wages in order to fill costly vacancies at a faster rate (McLaughlin, 1994). The theory of risk sharing proposes that firms have an incentive to offer a fixed base wage and a flexible profit share in order to ensure a smoother adjustment to product demand shocks. While profits are shared and a premium is paid to workers in times of high firm profits, this premium can be cut in case of low profitability. Not only firing costs are saved but also complicated negotiations with works councils and union representatives (Weitzman, 1984; Kruse, 1993; 1996).

The theories of human capital and labor turnover have similar implications regarding profit sharing. Firms which demand highly qualified employees offer higher wages in order to attract and retain those employees. This is also referred to as so-called high-road approach to worker relations (Kochan et al., 1993; Azfar and Danninger, 2001). Besides risk sharing, wage bargaining and unionization is often held responsible for the effect of profit sharing (Blanchflower et al., 1996; Estevao and Tevlin, 2003). The role of unionization is similar to the one which motivates the firm-size premium: it leads to a transfer of the firms' profits obtained in the product market to workers through wage negotiations. In that context, especially efficient bargaining solutions are proposed, as they directly suggest a wage equation which depends on profits per worker (Martins, 2009; Arai and Heyman, 2009).

Finally fair wage theory suggests a similar wage equation mainly based on efficiency wage considerations of the gift-exchange type (Akerlof, 1982; Danthine and Kurmann, 2007). In that literature, workers consider firm productivity as a reference point in order to judge about the fairness of the wage offer. As a consequence, firms share profits in order to keep workers motivated. So far no empirical work has been done based on fairness as a motive for profit sharing.

Profit sharing is thought of as a possible explanation for the firm-size wage premium. In fact, larger firms are more likely to engage in profit sharing (Kruse et al., 2010; Andrews et al., 2010). This finding also holds in the Finnish labor market, where larger firms are more prone to offer profit sharing schemes than small firms (Pehkonen et al., 2016).

1.3 Overview of the thesis

1.3.1 Research questions, data and methods

The thesis contains five separate essays presented in the chapters below. Each essay studies one, or a combination of the following major topics: wage rigidity, fairness considerations in labor relations, the firm-size wage premium and profit

TABLE 2 Summary of findings on profit sharing

Profit share in %	Country	Simultaneity addressed by		by profit categories	Self-selection addressed	Unobserved heterogeneity controlled	Literature
		quasi rents	instrumentation				
2 - 11	Belgium		profits per capita, Herfindahl index	positive	no	no	Rusinek and Rycx (2013)
1.4 -22.1	Portugal		exchange rate interacted with share of exports among revenue	increasing, decreasing	no	yes	Martins (2009)
1 - 10	Sweden		lagged profits, product demand elasticity, firm export revenue, energy costs	increasing, decreasing	no	yes	Arai and Heyman (2009)
1 - 2	Sweden		lagged profits	no	-	yes	Arai (2003)
1 - 10	Italy	yes	revenue per worker for firms in same industry and year in different region	no	-	yes	Card et al. (2014)
0.6 - 3	France, Norway		sales per worker, subsidies per worker	no	-	yes	Margolis and Salvanes (2001)
1.2 - 6	Germany	yes	lagged profits	no	-	yes	Guertzgen (2009)

sharing. Although, at first sight, (some of) these are seemingly unrelated fields of research there are many linkages and interdependencies between these topics. The overview given in the previous chapter already points in that direction. This thesis provides new insights on these topics and, maybe more importantly, on the connections between them. Chapters 2 and 3 study fair wages and their impact on remuneration and wage rigidity. Chapters 4 and 5 study the impact of employer characteristics on wages and finally chapter 6 focuses on employer characteristics and wage rigidity. More precisely, the research questions of the thesis are:

- Chapter 2: How do fairness considerations affect union wage setting? How does firm performance, measured by product and profits per worker, impact on the level of pay, wage rigidity and employment? How important is the size of the internal wage reference for this impact?
- Chapter 3: Do internal references (unambiguously) lead to wage rigidity?
- Chapter 4: Is there a wage premium attached to firm size in the Finnish labor market? How sizeable is it?
- Chapter 5: How does profit sharing affect the firm-size wage premium? Can the firm-size premium be explained entirely by profit sharing, assortative matching and monopsony wage setting?
- Chapter 6: Are profits per worker an internal wage reference? Is there a connection between profit sharing and wage rigidity?

Chapter 2 analyzes fairness considerations in a unionized labor market from a theoretical perspective. Assuming monopolistic competition on the goods market based on Dixit and Stiglitz (1997) preferences, unions transfer rents to the workers according to their fair wage considerations. Following the theoretical modeling of Danthine and Kurmann (2010) and Koskela and Schöb (2009) and consistent with qualitative and survey evidence from Bewley (1999) and Rees (1993) fairness considerations are integrated in form of a firm-specific internal reference which is used as a reference point for wage comparisons. Besides the product per worker also profits per worker are considered as internal reference. This makes the essay the first to acknowledge that fairness considerations are likely to be directly targeted at the firm's earnings situation. A fairness parameter is introduced which allows the internal reference to be a strictly positive function of product, respectively profits per worker. A continuum of workers and firms and an alternative wage which contains the workers' earnings opportunities outside the firm are assumed. As such, the fairness considerations are nested in a general equilibrium model which allows to study the impact on aggregate wages, wage rigidity and (un)employment. The main limitation of the essay can be found in the missing detailed calibration of the model due to unavailable target statistics. This would have provided more specific knowledge about how sizeable the predicted effects are.

Chapter 3 reviews and analyzes three prominent models of internal references and their conclusions on wage rigidity: the static general equilibrium models in Danthine and Kurmann (2007) and Koskela and Schöb (2009) as well as the dynamic stochastic general equilibrium model in Danthine and Kurmann (2010). With one exception these models suggest that internal references unambiguously imply higher degrees of wage rigidity. Danthine and Kurmann (2007) provide mainly evidence from calibration exercises and show that an increase in the weight on the internal reference leads to an increase in wage rigidity. This result is examined by an analytical determination of the exact equilibrium employment respectively wage elasticities as well as calibration exercises. Koskela and Schöb (2009) provide calibration results based on a shift of labor demand along the wage setting curve and conclude that internal references increase wage rigidity. Similarly to above this is examined by an analytical derivation of equilibrium wage and employment elasticities and calibration exercises. Danthine and Kurmann (2010) present wage responses which show an ambiguous effect on wage rigidity in case of a technology shock but again an unambiguous effect in case of a monetary shock. Their model falls short of considering the full alternative wage of workers, or in other words, zero unemployment benefits are assumed implicitly. A well-founded modification of the model is presented and the impact on wage rigidity is tested by an analysis of the impulse response of wages.

Chapter 4 estimates the impact of firm size on wages using a 20 % sample of Finnish private sector wage earners linked to firms covering the years 2003-2010. Although the firm-size wage premium is a well-studied phenomenon (see e.g. Brown and Medoff (1989), Lallemand et al. (2007), Barth and Dale-Olsen (2011)), there is only one study, namely Albaek et al. (1998), which studies the premium in Finland as part of a multi-country analysis. As such, this essay is the first to make full use of the rich linked panel data mentioned above. The firm-size wage premium is estimating based on different identification strategies. Using the method proposed by Abowd et al. (1999), the premium is identified as follows: First, for job-stayers with a changing firm size, second, for workers moving between firms of different size, and third, job moves of displaced workers. The data allows to control for a large set of variables for workers as well as firms. This goes beyond the scope of many previous studies as controls such as capital intensity, skill group size, working conditions and a precise measure of local labor market tightness are used. The main limitation of the essay remains the unresolved problem of firm size endogeneity.

Chapter 5 develops on the previous essay and focuses on the impact of profit sharing on the firm size premium from a theoretical as well as empirical perspective. A general equilibrium model with firm heterogeneity, imperfect competition on the goods market and Nash (1950) wage bargaining is presented. Profit sharing is included in the model following the timing structure of Holmlund (1990) and Koskela and Stenbacka (2012). In an extended version of the model also profit sharing is endogenized: this leaves workers and firms negotiating over the profit share as well as over wages. The empirical analysis is based on the same data set described above. It contains detailed information on the adoption of profit sharing schemes which is measured at the firm as well as individual level. This allows not only to control for unobserved individual but also firm heterogeneity. Detailed controls on job characteristics, capital intensity and others as well as skill group size and local unemployment enable the measurement of the importance of assortative matching, respectively monopsony wage setting. As such, the empirical analysis approaches the firm size-wage premium from many different angles. There are several limitations to this essay. First, the theoretical model would benefit from incorporating assortative matching as well as profit sharing in order to study potential interdependencies and their joint effect on the firm size-wage premium. Second, the adoption of profit sharing schemes is treated as exogenous. Although there is reason to assume that profit sharing is related to overall firm quality, which is approximately captured by several firm control variables, the effect of profit sharing has to be interpreted with caution.

Chapter 6 presents, similarly to the previous essay, theoretical modeling to motivate the main empirical analysis. As discussed in more detail in chapter 1.2.4, there are several motives for profit sharing. This essay reviews the impact on wage rigidity implied by these theories. More precisely, equilibrium wage elasticities are determined for the basic models of risk sharing as well as efficient bargaining. The empirical analysis estimates the effect of average operating profits on wages. Large register data is used to conduct the analysis: All Finnish private sector workers and firms from 2000-2012 are included. Similarly to the previous two essays, detailed individual as well as firm level controls are available in the data and unobserved individual and firm heterogeneity is controlled for. Following Martins (2009) and Arai and Heyman (2009) the degree of profit sharing is estimated over several different profitability categories: positive, increasing, positive & increasing, negative, decreasing and negative & decreasing. In order to account for simultaneity problems as well as self-selection of workers into profit categories, an interaction specification is proposed: three endogenous variables are instrumented by four instruments. As such, this essay is the first to account for both, the endogeneity of profits as well as profit categories. The main limitation of the essay is to be found in the large decrease of observations in the IV-interaction estimation. External validity is examined by IV estimations over profit categories (leaving self-selection unresolved) and by comparison of results from pooled OLS on the whole data and the IV-interaction sample.

1.3.2 Main results

The results of the thesis are summarized by chapter. The analysis in the second chapter shows that fairness considerations lead to a modified union wage setting behavior: depending on the size of the internal reference the trade-off between wages and employment is affected differently. As the internal reference is high compared to the alternative wage, marginal utility of employment is low. This results in higher wages respectively profit sharing and lower levels of employment. The opposite is true if the internal reference falls below the alternative wage. An increase in the fairness parameter leads to an amplification of these deviations from the standard model. This holds not only for a single union but also at the aggregate level which is reflected in a U-shaped wage-setting curve.

Due to the internal reference, which is a function of the firm's key performance measures (productivity respectively profitability), not only labor demand but also wage-setting is directly affected by adverse shocks. Exactly along the differential impact discovered for the level of pay and employment described above, there are differences in how wages and employment adjust to shocks. If the internal reference is high compared to the outside option, wage adjustment is more sluggish and vice versa. As such, this model establishes a connection between wage pressure and the degree of wage rigidity.

As described above in chapter 1.3.1, with one exception the theoretical literature on internal wage references finds an unambiguous effect on the degree of wage rigidity. In contrast to that literature, the essay contained in chapter 3 shows that internal references do, without exception, lead to ambiguous effects on wage rigidity. The literature models internal references as a weighted average with the outside option. This implies that the internal reference relative to the outside option determines equilibrium wage and employment reactions and therefore the degree of wage rigidity.

Chapter 4 finds a small but statistically significant effect of firm size on wages for Finland. While doubling firm size is associated with an increase in wages by 1.9 % according to pooled OLS results, this figure decreases to 0.7% when a large set of observable variables is controlled for. 40 % of the decrease in the estimate can be attributed to individual heterogeneity and 60 % to firm heterogeneity. This is different from the literature, where usually more importance is ascribed to individual heterogeneity. Accounting also for unobserved worker and firm heterogeneity leaves a firm size-wage premium of 0.8 %. Estimations based on voluntary as well as exogenous job moves decreases the premium further and renders it insignificant when unobserved firm heterogeneity is controlled for. In comparison to many other studies we find a relatively small effect of firm size. The intuition for this result could be found in the Finnish coordinated wage setting schedule which tends to decrease wage differentials.

The theoretical analysis contained in chapter 5 finds a trade-off between firm size and profit sharing premium. The total (or combined) pay premium, resulting from product market price setting power, remains unchanged. This finding motivates the empirical analysis: we propose a specification which contains firm size, profit sharing adoption as well as their interaction as main variables of interest. Over several different methods, controlling for worker respectively firm unobserved heterogeneity, the size-profit interaction is found to be negative (- 0.1 %). This implies that the firm size-wage premium can be partially explained by profit sharing. More precisely, this implies that an increase in firm size leads to a lower increase in wages for workers who belong to a profit sharing scheme. This result is in accordance with the findings of the theoretical model. Including controls for monopsony wage setting leads to a decrease in the firm size-wage premium from 0.9 to 0.7 % in the spell fixed effects estimation. In contrast the inclusion of assortative matching controls leaves the premium virtually unchanged but takes significance from the size-profit interaction. As there is little variation in profit sharing adoption within firms over job spells also individual fixed effects are estimated. This allows to measure profit sharing at the firm level. Considering job movers, the size-profit interaction remains significant but very small in size.

The theoretical analysis presented in chapter 6 shows that basic risk sharing as well as the efficient bargaining model do not carry particular implications for the degree of wage rigidity. This leaves models of internal references as the only type of model family motivating both, a high degree of wage rigidity connected to profit respectively rent sharing. Fixed effects estimations reveal a positive association between firm profitability and wages if it benefits the worker: if profits are positive, increasing and positive & increasing. This association seems not to hold if it implies downward wage adjustments. Results from IV fixed effects, accounting for simultaneity, self-selection of firms into profit categories, unobserved individual as well as firm heterogeneity, indicate the following: an increase in profits per worker by ten thousand Euros leads to an increase in log hourly wages by approximately 1.8 % which amounts to a profit share of over 6 % for the average wage earner. Moreover, clear evidence is provided that there is no downward wage adjustment i.e. wage rigidity face to an unfortunate development of profitability: In firms with negative, decreasing and negative & decreasing profits the effect of profits on wages is close to zero or even negative. In light of the theoretical evidence on the connection between profit sharing and wage rigidity it appears that profits per worker serve as an internal wage reference.

Regarding the theoretical research on fair wages a more careful integration and analysis of internal references is necessary. Like the results from chapter 3 indicate this also requires the study of the worker's outside option and especially the relation of internal references to the outside option. More attention should also given to the production technology of firms. It directly impacts on the internal reference. A straightforward suggestion for empirical research would be to estimate the effect of firm productivity on wages and wage rigidity. The majority of fair wage models suggest output per worker as internal reference. Of course it would be interesting to know if a similar link between profit sharing - wage rigidity can be found in other countries which have different labor market institutions. Research along those lines is likely to reveal further links between micro and macro labor economics as well as between seemingly separate economic phenomena.

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2 FAIRNESS CONSIDERATIONS IN LABOR UNION WAGE SETTING – A THEORETICAL ANALYSIS

Abstract[*]
We consider a theoretical model in which unions not only take the outside option into account, but also care about the performance of the firm and base their wage-setting decisions on a firm internal reference, called the fairness reference. Two references, which measure the earnings situation of the firm, are considered: productivity and profits per worker. Wage and employment outcomes as well as the degree of wage rigidity depend on the size of the fairness reference relative to the outside option. A high fairness reference leads to wage pressure and real wage rigidity, whereas a low fairness reference leads to wage moderation and real wage flexibility. An increase in the weight on the fairness reference amplifies these deviations from the standard model.

Keywords: Labor Unions, Fairness, Wage Pressure, Wage Moderation, Wage Rigidity, Wage–Setting Curve, Wage–Setting Process, Unemployment

2.1 Introduction

Our theoretical analysis is based on the assumption that workers care about fairness and labor unions have the necessary market power to transform these fairness considerations into actual market outcomes. We develop a model in which unions not only take the outside option into account, but also base their wage-setting decisions on a firm internal reference. This deviation from standard union

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models profoundly changes the workings of the wage–setting process and the reaction of the aggregate economy to macroeconomic shocks. It is shown that the inclusion of fairness considerations nests both, increased wage pressure as well as wage moderation depending on the firm's earnings situation. It is also demonstrated that the extent of real wage rigidity in the economy is affected differently, again depending on the firm's earnings situation.

In the light of the available empirical evidence, it is highly likely that fairness in the form of relative comparisons indeed plays an important role for the wage–setting process when unions bargain with firms over wages. For example, Strøm (1995) found empirical evidence that Norwegian unions compare wages to an internal reference. Agell and Bennmarker (2003) and (2007) did a representative survey on wage setters in Sweden. According to their results wages are compared to a within firm reference level as well as to the outside option. Results from experimental economics and psychology also make it evident that it is a too narrow conception of utility if workers, or agents in general, are restricted to care only about material gains. Especially in settings with incomplete contracts, such as labor contracts, the phenomenon of reciprocal behavior based on the notion of fairness plays an important role, see, for example, Fehr et al. (1998), Fehr et al. (2002), Charness (2004), and Falk and Fischbacher (2006).[1] Bolton and Ockenfels (2000) find that fairness is important in many different economic situations.

Fairness entered the labor union literature with Ross (1948) who considered fairness and equity comparisons to be major issues in union wage determination. Apart from some works discussing union rivalry, see Oswald (1979) and Gylfason and Lindbeck (1984) or "status" associated with an occupation, see Sessions (1993), fairness has been mainly incorporated in form of relative wages. Beginning with Wood (1978) who considered pay norms to be beliefs about fair relativities, workers have been mainly modeled to compare their wages to some sort of wage reference. Fuhrer and Moore (1995) modeled workers to compare their wages with the past wages of other workers. Following Bhaskar (1990), Holden and Driscoll (2003) and Driscoll and Holden (2004) and others considered workers to compare wages to the current wage of other workers. The main focus of the more recent work was on integrating fairness in order to explain inflation persistence.

Our analysis differs from previous work in two respects. First, we include fairness into a labor union model in form of a pay norm which aims directly at the firm's ability to pay. Some recent works in the efficiency wage literature, see Danthine and Kurmann (2007, 2010) and Koskela and Schöb (2009) and in the international trade literature, see Egger and Kreickemeier (2012) and Egger et al. (2013) use these firm-specific wage references. Second, our focus is on the consequences of the fair wage-setting mechanism for the level of pay and its connection to wage rigidity rather than inflation.

The paper is organized as follows. Section 2.2 explains how we include fairness into the union's utility function and how this affects the labor union's

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1 Moreover there exists some empirical literature which pursued the wage reference perspective to explain wage rigidity, see Pehkonen (1990).

marginal rate of substitution between wages and employment. Section 2.3 presents the theoretical model. We first analyze the wage-setting behavior of the union on the micro level and then discuss the implications for the wage-setting curve and for labor-market outcomes on the aggregate level. In Section 2.4 it is analyzed how fairness modifies the reaction of the economy if hit by an adverse technology shock. Section 2.5 concludes.

2.2 Fairness in the Union Utility Function

Our analysis is based on firm-level labor unions. Regarding the modeling of labor unions' preferences, there is some consensus in the literature that, as some kind of minimum requirement, utility U_i of labor union i should at least contain the following arguments: $U_i = U_i(w_i, N_i, \overline{w})$, where w_i and N_i denote the real wage and employment in firm i, respectively, and $\overline{w}$ denotes the expected alternative income the worker would earn when he or she is not employed at firm i. Utility should be increasing in the first two arguments and be decreasing in the third one.[2] Under the assumption that union members are risk-neutral, a more specific union utility function often used in the literature is

$$U_i^s = N_i \cdot \Omega_i^s \qquad \text{with} \quad \Omega_i^s \equiv (w_i - \overline{w}), \tag{1}$$

where the superscript s denotes the "standard model". As is outlined in Appendix 2.A.1, one possibility to link this union utility function to individual preferences is the well-known and often used expected utility assumption for the preferences of the representative union member suggested by McDonald and Solow (1981).[3] However, this justification of eq. (1) faces some consistency problems in a general equilibrium analysis. Alternatively, eq. (1) may be interpreted as depicting the preferences of a rent maximizing labor union, as has been suggested by Rosen (1969) and Menil (1971), among others. We favor the latter interpretation of eq. (1) as a starting point of our analysis and justify this equation as follows.

All workers employed in firm i are members of the labor union dealing with firm i. Workers who are dismissed or voluntarily leave the firm also leave the labor union. This assumption accounts for the fact that, at least in many continental European countries, almost no unemployed person is affiliated to a labor union (Besancenot and Vranceanu, 1999). Each union member in firm i obtains a rent $\Omega_i^s = w_i - \overline{w}$ that is generated by this employment relationship. Total util-

[2] The inclusion of employment in the utility function has been questioned by some economists arguing that lay-offs are by inverse seniority (Oswald, 1985). Hence, if changes in employment are not too large, the union member with median seniority should not be afraid of losing his job. However, in the literature convincing arguments have been put forward why the median member might also be interested in the employment level. See, for example, Lever and van Veen (1991) and Pencavel (1985).

[3] The heterogeneity of agents is not taken into account, thus neglecting the question of preference aggregation and principal-agent problems within the union.

ity U_i^s of the labor union is this rent times the number of workers N_i employed at firm i. The expected alternative income $\overline{w}$ serves as an external reference wage that is also called the outside option or simply the outside wage. If the earned wage does not exceed this reference, no rent is obtained. In this case the pecuniary gain of being a union member in the firm under consideration equals zero. In traditional labor union models it is argued that the pecuniary gain of trade union membership is all that should matter for workers.

As shown in the influential studies of Bolton and Ockenfels (2000) and Fehr and Schmidt (1999), among others, many important aspects of social interactions can only be understood by assuming that individual utility not only depends on the own pecuniary payoff but also on the relative payoff. Such relative payoff comparisons are related to the concept of fairness. For example, Rees observes that "fairness always seemed to be judged by making some kind of wage comparison" (Rees, 1993, p. 244). Noticing that "comparisons play a large and often dominant role as a standard of equity in the determination of wages under collective bargaining" (Ross, 1948, p. 50), we integrate fairness considerations into the trade union utility function by assuming that workers also obtain a utility gain when they perceive the wage paid to be equitable. Bolton and Ockenfels (2000) argue that the individual utility function, called motivation function in their paper, may be understood as some kind of expected utility function comprising the own pecuniary payoff and the relative payoff. In line with this argument, we assume that the trade union utility function consists of a weighted average of the economic rent generated by the trade union and a "fairness (or psychological) rent", where the latter is related to a firm-specific internal reference IR. Therefore,

$$U_i = N_i \cdot \Omega_i \qquad \text{with} \quad \Omega_i \equiv \rho\,[w_i - \text{IR}\,] + (1-\rho)\,[w_i - \overline{w}]\,, \tag{2}$$

with $0 \leq \rho < 1$. With $\rho = 0$ the standard model of a rent–maximizing union is obtained, whereas with $\rho \to 1$ only the fairness reference matters. Notice that the marginal rate of substitution between material rent and fairness rent depends on the parameter ρ which is called the "fairness parameter".[4]

The first term on the right–hand side of eq. (2), according to which workers compare their wage with a firm-specific internal reference, is in line with Bewley (1999) and Rees (1993) who consider fairness to be a local phenomenon, meaning that wage comparisons are based on a reference which is close by. We consider two different variants of the internal reference. In line with the efficiency wage models of Danthine and Kurmann (2010) and Koskela and Schöb (2009), we will first assume that workers compare their wage to the firm's output per worker Y_i/N_i. To ensure non–negative profits, wages can not be higher than average productivity. Employees know that and act rationally in not setting the

[4] In our model all workers and workplaces are identical, so in each firm only one wage is paid. We therefore do not analyze the consequences of a fair or unfair wage structure within a firm, though this also is a relevant aspect of the wage formation process.

fairness reference level too high. Hence, the first fairness reference we consider is

$$\mathrm{IR}_1 \equiv v \cdot \frac{Y_i}{N_i}, \tag{3}$$

with $0 < v < 1$. Notice that the parameter v influences the size of the fairness reference. As an alternative internal reference we consider the firm's profit per worker.

$$\mathrm{IR}_2 \equiv v \cdot \frac{\Pi_i}{N_i} \tag{4}$$

In our view, it would be too restrictive to assume that the fairness reference exactly equals profits per worker. A more general specification is obtained by multiplying profits per worker by the parameter $v > 0$. Hence, with the parameter v we capture in a very simple way the idea that the fairness reference should be a strictly positive function of output per worker or profits per worker, but must not necessarily be equal to these firm-specific variables.

The fairness reference mirrors the principle of dual entitlement, see Kahneman et al. (1986b). Workers (and firms) behave as if they have an entitlement to the terms of the reference level. If the earned wage is higher than the fairness reference workers derive psychological utility whether or not the wage is low compared to the outside wage. With regard to the second term in the definition of Ω_i in eq. (2), Koskela and Schöb (2009, p. 81) ascribe unionization to play a "leading role here since it increases workers' knowledge about external wages".[5]

To see the implications of the labor union's utility function more clearly, the marginal rate of substitution (MRS) between employment and wages is computed. In the following, we will focus on the utility function with output per worker as firm-specific internal reference. The case with profits per worker as internal reference is considered in Appendix 2.A.2. With IR_1 as internal reference, the MRS becomes

$$\mathrm{MRS} = \frac{\partial U_i / \partial N_i}{\partial U_i / \partial w_i} = \frac{w_i - \overline{w} - \rho\left[\varepsilon_{YN} \cdot v \cdot (Y_i/N_i) - \overline{w})\right]}{N_i}, \tag{5}$$

Labor is the only variable input of production, hence $Y_i = Y_i(N_i)$. The variable ε_{YN} denotes the elasticity of output with respect to employment. We assume that the production function is subject to diminishing marginal returns to labor which are important for the workings of the model later on. Because of this assumption ε_{YN} is smaller than one.

The expression in eq. (5) can be easily compared with the marginal rate of substitution in the standard model by setting the fairness parameter ρ equal to zero. In this case results:

$$\mathrm{MRS}^s = \frac{\partial U_i^s / \partial N_i}{\partial U_i^s / \partial w_i} = \frac{w_i - \overline{w}}{N_i} \tag{6}$$

5 However, they disregard their insight by discussing the importance of the external wage within an efficiency wage model instead of a labor union model.

Obviously, the difference in the marginal rate of substitution, and therefore in the slope of the indifference curve, is determined by the marginal utility of employment. In the standard case $\partial U_i^s/\partial N_i$ denotes the rent Ω_i^s which the marginal worker receives. In the general setting it holds that $\partial U_i/\partial N_i = \Omega_i + N_i \partial \Omega_i/\partial N_i$. Notice that the difference in the rents obtained depends on whether the fairness reference is higher, equal or lower than the outside wage, or in more formal terms $\Omega_i \lesseqqgtr \Omega_i^s$ if $v(Y_i/N_i) - \overline{w} \gtreqqless 0$. Because the rent Ω_i is a positive function of the firm's employment level, $\partial U_i/\partial N_i$ denotes not only the rent Ω_i which the marginal worker receives, but additionally the change of the rent for all workers already employed. The latter effect arises because an increase in employment leads to a decline in output per worker, thereby lowering the fairness reference level. This leads to an increased differential to the wage paid, thus increasing fairness utility for all workers taken together by $v \cdot (1 - \varepsilon_{YN}) \cdot (Y_i/N_i)$, where $(1 - \varepsilon_{YN})$ is the elasticity of labor productivity with respect to employment in absolute values. Summing up, the difference in the marginal utility of employment does not only depend on the different rents of the marginal worker but also on the effect of a change in employment on the rent of all non-marginal workers. The *net effect* of the fairness reference on marginal utility of employment is equal to $v \cdot \varepsilon_{YN} \cdot (Y_i/N_i)$. This expression must be compared to the outside option in order to determine whether marginal utility of employment (and therefore the MRS) is higher or lower than the one in the standard model.

For the trade-off between wages and employment therefore the following two cases can be distinguished:

$$\begin{aligned} &\text{MRS} < \text{MRS}^s \quad \text{for} \quad v \cdot \varepsilon_{YN} \cdot \frac{Y_i}{N_i} > \overline{w} \qquad \text{case 1} \\ &\text{MRS} > \text{MRS}^s \quad \text{for} \quad v \cdot \varepsilon_{YN} \cdot \frac{Y_i}{N_i} < \overline{w} \qquad \text{case 2} \end{aligned}$$

In case 1 $\partial U_i/\partial N_i$ is smaller than in the standard case, which leads the union to be willing to give up more employment for an increase in wages. Thus, the indifference curve runs flatter in $w_i - N_i$ space than in the standard case. This case occurs when the fairness reference is of such a size that the rent of the marginal worker Ω_i plus the change in the fairness utility of all workers already employed is below the standard rent. Case 2 can be interpreted analogously. The threshold between the two yields the same MRS as in the standard model. Note that these cases are independent of the fairness weight ρ. What matters is the relative size of the fairness reference.

This discussion shows that the trade-off between wages and employment depends on whether and how social norms are included into the analysis. In line with this notion fairness considerations already found their way into the labor market literature, especially in efficiency wage theory, see, for example, Akerlof (1982) and Akerlof and Yellen (1990) or more recently Skott (2005) as well as the labor union literature, see Bhaskar (1990) and Driscoll and Holden (2004).[6] In the

6 More recently, fairness considerations are also taken into account in the international trade

innovative work of Danthine and Kurmann (2006) the "internal reference perspective" is developed by including a fairness based utility function in an efficiency wage model. Koskela and Schöb (2009) expand this model by considering as relevant reference a weighted average of the internal and external perspective. Because of the linear specification of Ω_i in eq. (2), this is equivalent to our formulation. Nevertheless, we would like to point out that here the references gain a different interpretation, more in line with findings from psychology. References are crucial to perform judgments of fairness, see Kahneman et al. (1986a). The choice of these reference transactions are subject to framing effects (Tversky and Kahneman, 1986 and Kubon-Gilke, 1990) which makes it rather implausible to determine a reference as weighted average of two references. The definition of Ω_i stresses the assumption that workers derive utility from fairness considerations as well as consumption possibilities with each having a single reference level.[7] The notion to incorporate material and fairness utility can already be found in a paper of Rabin (1993). Considering the importance ascribed to unions in this context by Agell and Bennmarker (2003) and (2007) or by Koskela and Schöb (2009) this paper, to the best of our knowledge, is the first to analyze the macroeconomic consequences of a firm-specific internal reference in a unionized economy. Furthermore, we do not only analyze the implications of the weights of the references, but also consider the impact of the relative size of the fairness reference and varying degrees of competition on the goods market on the level of wages and employment, and the degree of wage rigidity.

2.3 The Model

2.3.1 Wages and employment at the firm level

The goods market is described by a standard monopolistic competition framework. In the economy there is a continuum of firms, indexed by $i \in [0,1]$, each of which has a labor demand function $N_i = N_i(w_i)$ with $\partial N_i / \partial w_i < 0$. Labor unions unilaterally determine wages at the firm level.[8] Maximization of union utility in eq. (2) subject to the labor demand function leads to:

$$N_{ij}\left[\frac{\partial \Omega_{ij}}{\partial w_{ij}} + \frac{\partial \Omega_{ij}}{\partial N_{ij}}\frac{\partial N_{ij}}{\partial w_{ij}}\right] = -\frac{\partial N_{ij}}{\partial w_{ij}}\Omega_{ij} \qquad \text{for} \quad j = 1,2 \tag{7}$$

Subscript $j = 1,2$ indicates the specification of the model. Specification 1 has average productivity as internal reference and specification 2 average profits as

literature, see, e.g., Egger and Kreickemeier (2012).

7 Of course, the fairness reference influences wages set and therefore has an effect on consumption.

8 We consider a monopoly union model instead of a bargaining model in order to keep the analysis as simple as possible. A Nash bargaining model would lead to the same qualitative results.

outlined in eqs. (3) and (4), respectively. In the utility maximum the marginal utility of wages (on the left-hand side) equals marginal costs (on the right-hand side). Marginal costs reflect the fact that the dismissed employees lose the rent related to the employment relationship. Marginal utility comprises both a direct and an indirect effect. The direct effect is the increase in the rent Ω_{ij} for all employees because of the increase in the wage rate. The indirect effect emerges because the resulting decrease in employment increases productivity respectively profits per worker and therefore the fairness reference. As a consequence, the fairness rent decreases for all employees. The indirect effect only appears because of the inclusion of fairness considerations into the analysis. This effect lowers marginal utility of wages and *cet. par.* leads to lower wage pressure in comparison to the standard model. However, the rent Ω_{ij} that is lost in case of dismissal also differs from the traditional model. For example, if the fairness reference is higher than the outside wage, then $\Omega_{ij} < \Omega^S$, hence marginal cost is lower than in the standard model. In order to see whether the real wage is higher or lower than in the standard model, we rewrite eq. (7) as

$$w_{ij} = \frac{\varepsilon_{NW}}{\varepsilon_{NW} - \psi_j} \left\{ \overline{w} + \rho \left[\varepsilon_j \cdot IR_j - \overline{w} \right] \right\} \qquad \text{for} \quad j = 1, 2 \tag{8}$$

where in the first specification $\psi_1 = 1$, $\varepsilon_1 = \varepsilon_{YN}$, and $IR_1 = vY_i/N_i$ and in the second $\psi_1 = 1 + \rho v$, $\varepsilon_2 = \varepsilon_{\Pi N}$, and $IR_2 = v\Pi_i/N_i$. ε_{NW} denotes the elasticity of labor demand with respect to the real wage (in absolute values). To facilitate the comparison with the standard model (in which $\rho = 0$), we now consider a more specific version of the model in which the labor demand elasticity is constant and therefore does not depend on the real wage. To derive a labor demand function with this property, it is assumed that each firm faces a goods demand function of the form $Y_i = p_i^{-\eta} Y$ with $\eta > 1$, where p_i is the price of the firm's product relative to the aggregate price level. The elasticity of the demand for goods is constant and equals η (in absolute values).[9] The variable Y denotes an index of aggregate output which from the firm's point of view is taken to be exogenous because of the assumed large number of firms. The production function is $Y_i = AN_i^{\alpha}$ with $0 < \alpha < 1$, where A describes the state of technology. In the first specification, ε_{YN}, the elasticity of output with respect to employment, is constant and equals parameter α. In the second, the elasticity of profits with respect to employment depends on firm variables: $\varepsilon_{\Pi N} = \alpha\kappa - (1 - \alpha\kappa) w_i N_i / \Pi_i$, where $\kappa \equiv (\eta - 1)/\eta$. In both specifications profit maximization of the firm leads to the following labor demand (LD) function.

$$N_i = N_i(w_i) = \left[\alpha\kappa \, A^{\kappa} \, Y^{1-\kappa} \, w_i^{-1} \right]^{1/(1-\alpha\kappa)} \tag{9}$$

As a consequence, the elasticity of labor demand with respect to the real wage is constant and equals $\varepsilon_{NW} = 1/(1 - \alpha\kappa)$ in absolute values. With these more

9 This isoelastic goods demand function of the Blanchard and Kiyotaki (1987) type is often used in the literature and can be derived from Dixit and Stiglitz (1997) preferences.

specific assumptions, eq. (8) can be rewritten as

$$w_{ij} = \frac{1}{\alpha\kappa} \left\{ \overline{w} + \rho \left[\theta_j IR_j - \overline{w} \right] \right\}, \qquad \text{for } j = 1, 2 \tag{10}$$

with $\theta_1 \equiv \alpha$ and $\theta_2 \equiv \alpha\kappa$. In both specifications it only depends on the terms in square brackets whether the inclusion of fairness considerations lowers or increases wage pressure in comparison to the standard model. It therefore holds that[10]

$$\begin{array}{lllll} w_{ij} > w_i^s & \text{and} & N_{ij} < N_i^s & \text{in case 1:} & \theta_j IR_j > \overline{w} \quad (\text{“wage pressure”}) \\ w_{ij} < w_i^s & \text{and} & N_{ij} > N_i^s & \text{in case 2:} & \theta_j IR_j < \overline{w} \quad (\text{“wage moderation”}) \end{array}$$

Note that if wages and employment deviate from the respective levels of the standard model, i.e. if the term in square brackets in eq. (10) is not equal to zero, the fairness parameter ρ amplifies the deviations of wages and employment from those of the standard model. The direction of the change depends on which of the above cases prevails. Thus, the fair wage considerations of unions do not necessarily lead to higher wage pressure than in the standard model. Unions which care about the performance of the firm also support wage moderation if the firm's productivity respective profitability situation calls for it. Given that the fair wage mechanism can lead to wage moderation the question arises whether workers who are currently employed at a bad performing firm have an incentive to move to another firm. However, as long as they are treated fairly, workers have no incentive to leave the firm or union because they are remunerated according to their fair wage preferences which take the performance of the firm into account. The fair wage preferences make the wage adjust to the firm's earnings situation. The next section analyzes whether and how this mechanism is transferred to the aggregate economy and what parameters exactly determine these deviations from the standard model.

2.3.2 Fair wage-setting and general equilibrium

In equilibrium all prices and wages are identical, thus $p_i = 1$ and $w_i = w$. Workers are homogenous and given by a [0-1] continuum such that $N_i = n$, where n denotes the employment rate. In order to derive the wage-setting equation, the outside option must be specified more precisely. It is assumed that with probability n workers get a job elsewhere in the economy and earn w, whereas with probability $(1 - n)$ workers become unemployed and receive unemployment benefits b.[11] Utility related to the outside option then is $\overline{w} \equiv nw + (1 - n)b$. Inserting

10 In the first specification one obtains the same case distinctions that have already been derived for the differences in the marginal rate of substitution in section 2.2. In the second specification the case distinction differ from the ones derived in Appendix 2.A.2 since unions take optimal profits into account when determining optimal wages.

11 The assumption that the employment probability equals the employment rate is made for simplicity. Beissinger and Egger (2004) consider an intertemporal model and show for various benefit systems that the employment probability in the steady state is a more com-

this expression into eq. (10), the following equation for the wage-setting curve (WS) can be derived:

$$w_j = \frac{\rho\,\theta_j\,\mathrm{IR}_j + (1-\rho)(1-n_j)b}{\alpha\kappa - (1-\rho)n_j} \qquad \text{for} \quad j = 1,2, \tag{11}$$

with $\theta_1 \equiv \alpha$ and $\theta_2 \equiv \alpha\kappa$. The subscript j again refers to the two variants of the firm internal reference as defined in eqs. (3) and (4). Wages are set as markup on the fairness reference and unemployment benefits. In contrast, in the standard model (with $\rho = 0$) wages are set as markup on unemployment benefits only:

$$w^s = \frac{1-n}{\alpha\kappa - n} b \tag{12}$$

In the standard model the wage-setting curve approaches an asymptote at $n^s_{\max} = \alpha\kappa < 1$ that constitutes an upper bound for employment. In contrast, in the fairness model the WS curve reaches an asymptote at $n = \alpha\kappa/(1-\rho)$. If $0 < \rho < 1 - \alpha\kappa$, this asymptote defines the upper bound for the employment rate, denoted $n_{\max}$. In the complementary case, $1 - \alpha\kappa \leq \rho < 1$, the asymptote of the WS curve is not a binding constraint for the employment rate, because it must hold that $n \leq 1$. In this case $n_{\max} = 1$.

Taking into account that the firm internal reference IR_j can be written as a function of employment, eq. (11) for the wage-setting curve becomes[12]

$$w_j = \frac{\rho v \lambda_j A n_j^{\alpha-1} + (1-\rho)(1-n_j)b}{\alpha\kappa - (1-\rho)n_j} \qquad \text{for} \quad j = 1,2 \tag{13}$$

with $\lambda_1 \equiv \alpha$ and $\lambda_2 \equiv \alpha\kappa(1-\alpha\kappa)$. The slope of the wage-setting curve is

$$\frac{\partial w_j}{\partial n_j} = \frac{\left[(2-\alpha)(1-\rho) - (1-\alpha)\frac{\alpha\kappa}{n_j}\right] \rho v \lambda_j A n_j^{\alpha-1} + [1-\rho-\alpha\kappa](1-\rho)b}{[\alpha\kappa - (1-\rho)n_j]^2} \qquad \text{for} \;\; j = 1,2 \tag{14}$$

It is easy to see that in the standard model the wage-setting curve is positively sloped over the whole range of admissible employment rates $0 < n < n^s_{\max}$. In contrast, in the fairness model the wage-setting curve follows a U–shaped pattern if the fairness parameter ρ is not too high, see Appendix 2.A.3 for details. For very high values of the fairness parameter it is even possible that the wage-setting curve is negatively sloped over the whole range of admissible employment rates.[13] The intuition behind the U–shape is the following. We have

plicated function of the (un)employment rate.

12 In the case of IR_2 it should be noted that maximum profits can be written as a function of employment: $\Pi = (1-\alpha\kappa)A^\kappa Y^{1-\kappa} n^{\alpha\kappa}$.

13 It can be shown that the second derivative of the wage-setting equation is positive for all admissible employment rates. As a consequence the WS curve is convex. The proof is contained in appendix 2.A.7.

two wage references in the model: the outside option and the fairness reference. At low levels of employment average productivity respectively profits are high and so is the fairness reference. This leads unions to demand high wages. As employment increases, the fairness reference declines which leads to more moderate wage demands. This explains the downward sloping section of the WS–curve. However, the higher employment the higher is the outside option since the chance to find a job elsewhere in the economy increases. This effect leads unions to demand higher wages again which explains the upward sloping section of the WS–curve.[14] Given a not too high value of ρ, an increase in v or a decrease in κ leads to a more pronounced U–shape of the wage-setting curve. This is due to the fact that the mechanism just described gets strengthened.

Turning to the demand side, in both, the fairness and the standard model, aggregate inverse labor demand is given by:

$$w = \alpha\kappa A n^{\alpha-1} \tag{15}$$

It is downward sloping over the whole range of employment. Using this equation and eq. (13) for the wage-setting curve, the equilibrium employment rate n^* and equilibrium wages w^* can be determined. In Appendix 2.A.4 some restrictions for the size of the fairness reference v are introduced to guarantee that $0 < n < n_{\max}$ and that the fairness reference exceeds unemployment benefits.

In contrast to section 2.3.1 the outside option is not a constant any more but a function of the employment rate. This implies that it is not possible to infer the deviation of the fair wage from the standard equilibrium by a mere comparison of the two wage-setting mechanisms as done in eq. (10). Therefore we analyze the equilibrium directly and consider a change in the fairness parameter ρ. We know from the analysis at the firm level that ρ acts as an amplifier of the respective case. If this property is transferred to the aggregate level it should reveal the case distinction in the general equilibrium. Computing the derivative of equilibrium employment and wages with respect to ρ yields

$$\frac{\partial n_j^*}{\partial \rho} = -\frac{\alpha\kappa(\alpha\kappa - n_j^*)\left\{\frac{\theta_j}{\alpha\kappa} IR_j^* - \frac{1-n_j^*}{\alpha\kappa - n_j^*} b\right\}}{(1-\rho)(\alpha\kappa - (1-\rho)n_j^*)\left(w_j^* - b + (1-\alpha)\frac{1-n_j^*}{n_j^*} b\right)} \quad \text{for } j = 1,2 \tag{16}$$

$$\frac{\partial w_j^*}{\partial \rho} = -(1-\alpha)\frac{w_j^*}{n_j^*}\frac{\partial n_j^*}{\partial \rho} \qquad \text{for} \quad j = 1,2 \tag{17}$$

The restrictions outlined in Appendix 2.A.4 ensure that the denominator in eq. (16) is positive and therefore only the numerator determines the sign of the partial

[14] A non–standard shape for the wage-setting curve also results in the model of Sessions (1993). In that model, the relative social pressures associated with unemployment and employment lead to a local U–shape of the WS–curve. Koskela and Schöb (2009) derive a U–shaped WS–curve in their efficiency wage model, too.

derivatives. The expression in curly brackets contains the aggregate case distinction which corresponds to the one identified on the firm level. Note that the second term in curly brackets represents the standard wage-setting mechanism, see eq. (12). As shown above it is defined on the employment range $0 < n < \alpha\kappa$, which is why we first interpret eqs. (16) and (17) on that range. A positive expression corresponds to case 1 with the fair wage-setting mechanism leading to higher wage claims and lower employment, a negative expression corresponds to case 2 implying wage moderation and higher employment. The case distinction is similar to the firm level and can be written as follows.

$$w_j^* > w^{s*} \text{ and } n_j^* < n^{s*} \quad \text{in case 1:} \quad \frac{\theta_j}{\alpha\kappa} IR_j^* > \frac{1-n_j^*}{\alpha\kappa - n_j^*} b \qquad \text{(“wage pressure”)}$$

$$w_j^* < w^{s*} \text{ and } n_j^* < n^{s*} \quad \text{in case 2:} \quad \frac{\theta_j}{\alpha\kappa} IR_j^* < \frac{1-n_j^*}{\alpha\kappa - n_j^*} b \qquad \text{(“wage moderation”)}$$

So far we compared the two mechanisms in the range $0 < n < \alpha\kappa$. For $\alpha\kappa \leq n < 1$ case 2 applies. The second term in curly brackets gets negative which implies that both terms are added up. Employment increases and wages decrease compared to the standard model. Equations (16) and (17) also show that ρ acts as an amplifier of the deviation of the fair wage mechanism from the standard mechanism. The more important fairness considerations are, the larger is wage pressure in case 1 or the more pronounced is wage moderation in case 2.

To summarize, the ambiguity of the fair wage mechanism also holds on the aggregate level of the economy. Unions which care about the performance of the firm through the internal reference, can support both, higher wage claims as well as wage moderation depending on the current productivity (respective profitability) situation of firms relative to a function of unemployment benefits. The same argument as in section 2.3.1 applies why unions can also support wage moderation. Caring about the firm internal reference makes incumbent workers willing to accept a lower wage in times of bad firm performance.

Our theoretical results are in line with recent empirical evidence showing that fair wages can lead to both wage pressure as well as wage moderation. Hauptmann and Schmerer (2013) provide evidence on fair-wage premia for exporting firms and Carluccio et al. (2014) show that union wage bargaining increases the premia. Guertzgen (2009) and Rusinek and Rycx (2013) analyze rent-sharing under different bargaining regimes and find wage pressure in case of firm-level bargaining. However unions can vote for wage moderation if their bargaining partner is faced with more difficult economic conditions, too. Felbermayr et al. (2014) analyze the impact of collective bargaining on wages in exporting firms and find that it can be negative. The basic idea is that markups on international markets are smaller due to increased competition which leads to lower profits per worker and ultimately to more moderate wage claims. Arai and Heyman (2009) find wages to be positively affected by profits per worker in firms with increasing profitability, but also that wages are negatively affected by profits per worker in firms with decreasing profitability. Hirsch and Schnabel (2014) develop an index of union power which shows that the degree of wage pressure exerted by unions can vary substantially over time.

It must be born in mind that our results hold for wage bargains at the firm level. Though there is a clear tendency towards firm-level agreements, in many countries industry-level bargains are still more prevalent. This leads to the interesting question why different bargaining levels may co-exist within a country. As shown in our model, fairness considerations may lead to wage moderation at the firm level if the firm's profitability or productivity is low. Using data for Germany, Hirsch et al. (2014) show that for this reason less productive firms prefer wage bargaining at the firm level, whereas more productive firm prefer centralized wage bargaining. A general equilibrium analysis with multi-level bargains clearly is beyond the scope of our paper. However, in such a framework the outside option $\overline{w}$ may gain a different meaning and describe the centralized bargaining outcome, whereas fairness preferences can lead to deviations from the centralized bargaining outcome in both directions (case 1 and case 2).

Since the internal reference is endogenous, more precisely a function of firm-specific variables, the important question arises which exogenous parameters ultimately decide upon whether the fair wage mechanism leads to wage pressure or wage moderation in comparison to the standard model. Rearranging eq. (16) gives[15]

$$\frac{\partial n_j^*}{\partial \rho} = \frac{-\left(1-n_j^*\right) b \left\{ v\frac{\lambda_j}{\alpha\kappa} - \alpha\kappa \right\}}{(1-\rho)\left(\alpha\kappa - (1-\rho)n_j^* - \rho v \frac{\lambda_j}{\alpha\kappa}\right)\left(w_j^* - b + (1-\alpha)\frac{1-n_j^*}{n_j^*}\, b\right)} \quad \text{for } j = 1,2 \tag{18}$$

If the expression in curly brackets in eq. (18) is positive the fair wage is larger than the standard wage (case 1), and if it is negative the fair wage is smaller than the standard wage (case 2). Since $\lambda_1 \equiv \alpha$ and $\lambda_2 \equiv \alpha\kappa(1-\alpha\kappa)$, it ultimately depends on three parameters, namely v, κ and α, in which direction fair wages deviate from the standard model. In section 2.3.3, we discuss the consequences of changes in the fairness reference v. In section 2.3.4 we consider the consequences of varying degrees of competition on the goods market κ. If the model allowed for heterogeneity across firms and unions, for example in a multi-country or multi-sectoral framework, the variation in v would capture inter-union differences with respect to the fair wage level they require at a given level of firms' profits or productivity. The variation in κ would capture differences in the degree of competition in the goods market the firms are facing.

2.3.3 Changes in the size of the fairness reference

In this section we consider a change in v which enables us to study a scenario where only the internal reference is affected, whereas the wage in the standard model remains the same. Following eq. (18) we can analyze the deviation of the

15 See appendix 2.A.5 for details.

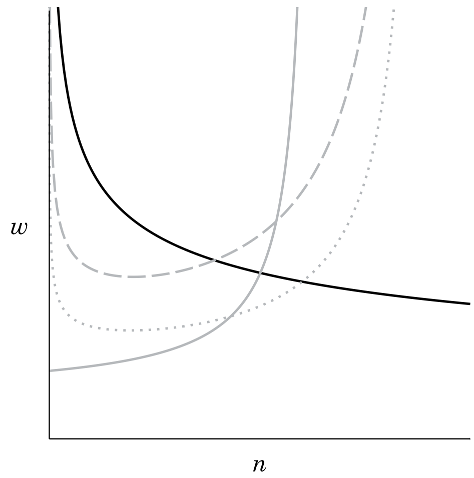
fair wage to the standard wage. Setting the expression in curly brackets equal to zero we obtain $\tilde{v_1} = \alpha\kappa^2$ for the first, and $\tilde{v_1} = \alpha\kappa/(1-\alpha\kappa)$ for the second specification of the model. If the size of the fairness reference takes this value the fair wage mechanism leads to the same equilibrium wage and employment combination as the standard model. It marks the threshold between case 1 and 2. As v exceeds the threshold, the internal reference increases leading to wage pressure and lower employment relative to the standard model. As v falls below the threshold, a low internal reference leads to wage moderation and higher employment compared to the standard model. The same conclusions can also directly be derived by noting that

$$\frac{\partial n_j^*}{\partial v} = -\frac{\rho\lambda_j A n_j^{*(\alpha-1)}}{(1-\rho)\left(w_j^* - b + (1-\alpha)\frac{1-n_j^*}{n_j^*}b\right)} < 0 \qquad \text{for} \quad j = 1,2 \tag{19}$$

$$\frac{\partial w_j^*}{\partial v} = -(1-\alpha)\frac{w_j^*}{n_j^*}\frac{\partial n_j^*}{\partial v} > 0 \qquad \text{for} \quad j = 1,2 \tag{20}$$

Hence, equilibrium employment falls and wages increase with v.

FIGURE 1 Variation of the fairness reference on the macro level



— Standard WS – – Case 1 WS ($v = 0.76$) ···· Case 2 WS ($v = 0.4$)

Figure 1 depicts the labor market equilibrium for two different values of v for the first specification of the model with output per worker as internal reference.[16] The solid black line represents labor demand which is decreasing over the

16 We parameterized the model with $\alpha = 0.8, \kappa = 0.9, A = 1, b = 0.2, \rho = 0.3$. The parametrization results for wages and employment are not meant to describe actual

whole range of employment. The standard wage-setting curve, depicted in solid grey, is increasing over all admissible employment rates. The intersection of these curves determines equilibrium wages and employment in the standard model. The dashed as well as the dotted curve represent the fair wage-setting curve at different levels of v. As discussed above it is U-shaped.[17] The intersection with labor demand yields equilibrium wages and employment in the fairness model. The dashed curve is obtained for a large size of the internal reference ($v > \tilde{v}$) which leads to a case 1 situation where equilibrium wages are larger and employment smaller compared to the standard model. The dotted curve is obtained for a low size of the internal reference ($v < \tilde{v}$) which leads to a case 2 situation with lower equilibrium wages and higher employment.

2.3.4 Varying degrees of competition in the goods market

In this section we keep v fixed and instead consider varying degrees of competition in the goods market as captured by the parameter $\kappa \equiv (\eta - 1)/\eta$, where η measures the price elasticity of the demand for goods. The higher κ, the higher is the degree of competition in the goods market and the lower are monopoly profits of firms. Since a change in κ directly affects the fairness reference IR_2 based on the firm's profits, the analysis in this section focuses on the second specification of the model.

Analogous to the above analysis for v it is possible to derive a threshold value for κ which yields the same equilibrium wage and employment combination as in the standard model. Setting the curly brackets in eq. (18) equal to zero we obtain $\tilde{\kappa}_2 = v/[\alpha(1+v)]$ for the second specification of the model.[18] This level of competition marks the threshold between case 1 and 2. With fiercer competition on the goods market the profitability of firms declines. Because of the fair wage mechanism, unions care about the performance of firms through the internal reference and are therefore willing to commit to wage moderation compared to the standard model. If the opposite happens and monopoly profits rise, unions notice that firms operate under fortunate economic conditions and ask for a share of the pie. In comparison to the standard model they exert wage pressure.

In contrast to the variation of v in section 2.3.3 a change in κ also affects equilibrium wages and employment in the standard model. Therefore it is not possible to conclude directly from the deviation of the fair wage from the standard solution whether wage pressure in case 1 is larger than in case 2 or not. In the standard model an increase in κ leads to lower wage claims because of a

economies, rather to demonstrate in a qualitative way how equilibrium outcomes depend on the cases identified in this paper. It would certainly require a more complicated model to match the theoretical outcomes with the data. Using the second specification yields a similar figure and is thus not presented separately.

17 It can also be shown that multiple equilibria can be ruled out in this model. The proof is contained in appendix 2.A.8.

18 A threshold value for κ can also be derived for the first specification of the model and equals $\tilde{\kappa}_1 = \sqrt{v/\alpha}$. However, since the fairness reference IR_1 is only indirectly affected through the change in employment, the consequences of a change in κ are less interesting to analyze for the first model specification.

higher labor demand elasticity (in absolute values), but it also leads to an increase in labor demand. As a consequence, employment increases but the effect on equilibrium wages is ambiguous. Since the standard solution is nested in our model, this implication is carried on to the fair-wage mechanism. In addition, in the fairness model the internal reference unambiguously decreases in κ, leading *ceteris paribus* to lower wage pressure. This latter effect becomes more pronounced with a higher weight of the fairness reference ρ.

Though the total effect of a change in κ on wages is ambiguous, for the deviation of the fair wage from the standard wage the analogous reasoning applies as for variations in v, i.e. $\kappa < \tilde{\kappa}_2$ leads to wage pressure and $\kappa > \tilde{\kappa}_2$ leads to wage moderation in comparison to the corresponding wage level in the standard model.

To summarize, the fair wage-setting mechanism can be governed by the degree of product market competition. In comparison to the standard model fair wage considerations can lead unions not only to adjust wage claims upwards in times of high profits but also downwards in times of low profitability.

2.4 Application: wage and employment response to macroeconomic shocks

In the preceding section it has been demonstrated that differences in the wage-setting behavior of unions may be explained by differences in the size of the fairness reference relative to the outside option. In this section it is shown that such a union model also sheds new light on the question of how an economy reacts to macroeconomic shocks. As an application of the model it is analyzed how an adverse technology shock affects wages and employment if fairness considerations play a role in union wage setting.

The adverse technology shock is modeled as a reduction in the parameter A, implying a downward shift of the labor demand curve, since

$$\left.\frac{\partial w}{\partial A}\right|_{\text{LD}} = \alpha\kappa n^{\alpha-1} > 0 \tag{21}$$

In the standard model this shift in the labor demand curve is all that happens. The resulting decline in real wages and employment provides us with a natural point of comparison for the fair wage mechanism. Contrary to the standard model, in both specifications of the fairness model the decline in A also leads to a downward shift of the wage-setting curve, because the technology parameter is part of the fairness reference:

$$\left.\frac{\partial w_j}{\partial A}\right|_{WS} = \frac{\rho v \lambda_j n_j^{\alpha-1}}{\alpha\kappa - (1-\rho)n_j} > 0 \quad \text{for} \quad j = 1,2 \quad \text{with} \quad \lambda_1 = \alpha,\ \lambda_2 = \alpha\kappa(1-\alpha\kappa) \tag{22}$$

Comparing equation (21) to (22) shows that the shift of the WS curve is always less pronounced than that of the LD curve.[19] This ensures that a negative technology shock always leads to a reduction in both, wages and employment.

Equating the wage-setting equation (13) and the labor demand equation (15), we calculate the equilibrium employment and wage elasticity for both specifications of the model:

$$\varepsilon_{n_j^* A} \equiv \frac{\partial n_j^*}{\partial A}\frac{A}{n_j^*} = \frac{1}{1-\alpha+\xi_j} > 0 \tag{23}$$

$$\varepsilon_{w_j^* A} \equiv \frac{\partial w_j^*}{\partial A}\frac{A}{w_j^*} = \frac{\xi_j}{1-\alpha+\xi_j} > 0 \qquad \text{for} \quad j = 1,2, \tag{24}$$

where ξ_j is defined as

$$\xi_j \equiv \frac{n_j^*}{1-n_j^*}\frac{1-\alpha\kappa\phi_j}{\alpha\kappa\phi_j - n_j^*}, \quad \text{with} \quad \phi_j \equiv \frac{1-\rho\frac{v}{\delta_j}}{1-\rho} \quad \text{for} \quad j = 1,2 \tag{25}$$

In the first specification of our model with average productivity as internal reference it holds that $\delta_1 \equiv \alpha\kappa^2$, and in the second specification with average profits it holds that $\delta_2 \equiv \alpha\kappa/(1-\alpha\kappa)$. It can be seen from equation (25) that $\phi_j = 1$ in the standard model with $\rho = 0$.

Following the same line of reasoning as in sections 2.3.3 and 2.3.4 we consider changes in the size of the fairness reference v as well as changes in the price setting power of firms κ. $\phi_j = 1$ also results for $\tilde{v_1} = \alpha\kappa^2$ or $\tilde{v_2} = \alpha\kappa/(1-\alpha\kappa)$, and alternatively for $\tilde{\kappa_1} = \sqrt{v/\alpha}$ or $\tilde{\kappa_2} = v/[\alpha(1+v)]$. Each yields the threshold value between case 1 and 2. Since the equilibrium employment level at the threshold is identical to that from the standard model, ξ_j in eq. (25) in combination with the respective elasticity shows that the wage response to the technology shock is identical, too.

Case 1 results by choosing either a value for v larger than $\tilde{v_j}$ or κ smaller than $\tilde{\kappa_j}$, leading to a value of ϕ_j smaller than one. In addition, it has already been shown that equilibrium employment is lower than in the standard model. It can therefore be concluded that ξ_j in eq. (25) is smaller than in the standard model. Considering the respective elasticities, this implies that wages react less and employment more than in the standard model. That fairness considerations might lead to higher wage rigidity has already been pointed out in efficiency wage models with an internal reference (see Danthine and Kurmann, 2007 and Koskela and Schöb, 2009). However, this result does not hold in case 2. With v smaller than $\tilde{v_j}$ or respectively κ larger than $\tilde{\kappa_j}$ a value of $\phi_j > 1$ results. In addition, employment is larger than in the standard model implying that now ξ_j in eq. (25) is larger, too. Hence, the equilibrium response of wages (employment) in case 2 is stronger (weaker) than in the standard union model. In case 2 the fair

[19] This can be shown by considering the respective parameter restrictions. For details see Appendix (2.A.4).

wage mechanism therefore leads to higher wage flexibility. To summarize, the inclusion of fairness considerations into a labor union model leads to ambiguous effects on wage rigidity.

The intuition for these results is straightforward. An adverse technology shock leads *cet. par.* to a decrease of the fairness reference. The downward shift of the WS curve and the (stronger) downward shift of the LD curve lead to a decline in wages and employment. In case 1 (high v or low κ) the wage level is relatively high and the employment rate is relatively low in the initial equilibrium in comparison to the standard model. The reduction in employment then leads to a strong increase in average productivity (or profits) and to a corresponding strong increase in the fairness reference thereby attenuating the decrease in wages.

In case 2 (low v or high κ) the wage level is lower and the employment rate is higher in the initial equilibrium in comparison to the standard model. A change in the employment rate at this level has a much smaller effect on average productivity (or profits) and therefore the fairness reference. The overall effect of an adverse technology shock then leads to a significant drop in wages. To summarize, it is evident that in our model the inclusion of fair wage considerations does not always lead to real wage rigidity. Depending on the size of the fairness reference, or on the degree of competition firms face on the product market, it is even possible that wages are more volatile than in the standard model. The degree of wage rigidity (or flexibility) becomes more pronounced with an increase in the fairness weight ρ. Moreover, the fair wage-setting mechanism suggests a close connection between the degree of wage pressure and the degree of wage rigidity.

We can also construct a single flexibility index defined by the quotient of wage and employment elasticity, i.e.

$$\varepsilon_{w_j^* A}/\varepsilon_{n_j^* A} = \xi_j \qquad \text{for} \quad j = 1, 2 \tag{26}$$

In other words the index measures the percentage change in wages relative to the percentage change in employment. The larger the index the more flexible are wages. In the standard model as well as on the threshold of the two specifications of the fairness model the percentage change in wages is 1.75 times the percentage change in employment.[20]

In order to get an idea of the magnitude of the union fair wage effect discussed above table 3 shows the percentage deviation of the flexibility index obtained in the fairness model from that of the standard model for both model specifications.

The upper part of the table contains the results for the first specification in which output per worker is used as fairness reference. The lower part of the table reports the results for the second specification in which profit per worker is used

[20] The shock is a 1% decrease in A. We parameterized the model as follows: $\alpha = 0.7$, $A = 1$, $b = 0.2$. For the standard model and the threshold of the fairness model we used $\kappa = 0.8$, $v_1 = 0.448$ and $v_2 = 1.2727$.

TABLE 3 Relative deviation from the flexibility index of the standard model

		ρ	0.1	0.3	0.5	0.7
Specification 1 $IR = vY/n$	$\kappa = 0.8$	Case 1($v = 0.4928$)	-2,26	-8,41	-18,5	-38,28
		Case 2($v = 0.4032$)	2,32	9,27	23,26	66,27
	$v = 0.448$	Case 1($\kappa = 0.72$)	-4,7	-17,11	-36,4	-71,74
		Case 2($\kappa = 0.88$)	4,68	19,77	55,74	262,26
Specification 2 $IR = v\Pi/n$	$\kappa = 0.8$	Case 1($v = 1.4$)	-2,26	-8,41	-18,5	-38,28
		Case 2($v = 1.1455$)	2,32	9,27	23,26	66,27
	$v = 1.2727$	Case 1($\kappa = 0.72$)	-5,05	-18,32	-38,75	-75,76
		Case 2($\kappa = 0.88$)	5,61	24,12	71,39	479,45

Numbers shown in this table denote the percentage deviation of the flexibility index in the fairness model from that of the standard model. The flexibility index is defined in eq. (26). The model is parameterized with $\alpha = 0.7$, $A = 1$, $b = 0.2$ and a 1% shock in A.

as fairness reference. For both specifications, cases 1 and 2 are first obtained by changes in the size of the fairness reference v and second by changes in the degree of competition in the goods market κ. The parameter changes are calculated as a 10% increase or decrease from the threshold value that leads to the solution of the standard model. For both model specifications table 3 shows that in case 1 with a higher v or lower κ more rigid wages in comparison to the standard model result, whereas in case 2 wages are more flexible. If the fairness parameter ρ is small, implying that there is not much weight on the internal reference, the fair wage mechanism only leads to relatively small percentage deviations from the flexibility index for the standard model. However if the fairness parameter is large and fairness is important the deviations from the standard model are large.

2.5 Conclusions

The inclusion of fairness considerations leads to a different wage-setting behavior in unionized labor markets in comparison to that predicted by standard labor union models. In our theoretical model unions not only take the outside option of union members into account, but also base their wage-setting decisions on firm internal factors such as productivity or profits per worker. The predictions of the model are driven by the fact that fairness considerations change the trade-off between wages and employment for each labor union. Using the standard model as benchmark two cases can be distinguished depending on the size of the internal reference compared to external earnings possibilities.

If the fairness reference is relatively high compared to the outside option, marginal utility of employment is relatively low. In that case, each union is willing to give up more employment for an increase in wages, leading to higher wages and lower employment compared to the standard model. If the fairness reference is relatively low, the opposite results are obtained. As wages and employment differ from the respective levels of the standard model, an increase in the fairness parameter (i.e. the fairness weight) amplifies these deviations. These results hold for the single union as well as on the aggregate level. The intuition behind these results is straightforward. Unions which care about the performance of the firm tend to exert wage pressure if the firms' earnings situation allows it, i.e. if the firms' productivity and profitability is high. If the firms' earnings situation is bad, having low productivity and profits per worker, unions are willing to commit to wage moderation.

Fairness considerations change the shape of the aggregate wage-setting curve. In the standard model the wage-setting curve is upward sloping in real wage–employment space. In contrast, in the fairness model the wage-setting curve follows a U–shaped pattern. For very high values of the fairness parameter it is even possible that the wage-setting curve is negatively sloped over the whole range of admissible employment rates.

Given the different possible shapes of the wage-setting curve it can be shown that the economy reacts in different ways to shocks. In the standard model an adverse technology shock only shifts the labor demand curve downwards, leading to a reduction in wages and employment. If fairness considerations play a role, the wage–setting curve shifts downwards as well. The reaction of employment and wages depends on the two cases identified in the paper. If the fairness reference is relatively high, the decline in employment is stronger and the reduction in wages is smaller than in the standard model. In this scenario the inclusion of fairness considerations leads to real wage rigidity, which increases with the fairness weight. However, fairness considerations do not necessarily imply rigid wages. If the fairness reference is relatively low, a stronger wage reduction and a less pronounced decline in employment compared to the standard model is observed. Again this effect is the stronger the higher the fairness weight.

In short, the fair wage-setting mechanism nests both, higher wage pressure and increased wage moderation in comparison to the standard model. Moreover, it establishes a connection between the degree of wage pressure and the degree of wage rigidity.

2.A Appendix

2.A.1 Labor unions' preferences and utility functions

From an empirical point of view the question about labor unions' preferences is still unsettled.[21] In the theoretical literature, a widely used specification of labor union's preferences is the expected utility function:

$$U_i = \left(\frac{N_i}{M_i}\right) u(w_i) + \left(\frac{M_i - N_i}{M_i}\right) u(\overline{w}), \tag{27}$$

where M_i denotes the number of union members which is (usually) considered to be exogenous, and $N_i < M_i$. Behind this formulation lies the idea that union members are (ex ante) homogenous and that the firm randomly selects union members for the workplaces available. In this case, every union member has a chance of N_i/M_i of getting a job and a chance of $(M_i - N_i)/N_i$ of not being employed in the firm under consideration. Usually, it is assumed that in the latter case the worker will be unemployed, hence $\overline{w}$ is then interpreted as denoting unemployment benefits. With exogenously given membership, eq. (27) is equivalent to

$$U_i = N_i u(w_i) + (M_i - N_i) u(\overline{w}) \tag{28}$$

This so-called utilitarian formulation of labor union preferences reflects the idea that the labor union treats all members identically and that the union's utility simply is the sum of its members' utilities. Finally, since from the union's point of view, M_i and $\overline{w}$ are exogenously given, the following transformation still reflects the same preferences:

$$U_i = N_i[u(w_i) - u(\overline{w})]. \tag{29}$$

If risk-neutral workers are assumed, eq. (29) leads to eq. (1) in the main text.

The problem with the specifications (27) and (28) is that they are inconsistent when dealing with firm-level labor unions in a general equilibrium framework. The reason is that both specifications assume that workers who are not employed in firm *i* may still remain union members of the respective union *i*. However, this is in conflict with the view that a worker who is not employed in firm *i* has some chance to obtain a job elsewhere in the economy at a different firm *j*. In a static general equilibrium model this is taken into account by assuming that $\overline{w}$ consists of a weighted average of unemployment benefits and the average wage obtained elsewhere in the economy.[22] If a worker who has been dismissed by firm *i* gets a job at a different firm *j*, the worker should become a member of union *j* instead

21 Surveys and discussions of these issues are, for instance, found in Oswald (1985), Pencavel (1991) and Booth (1995).

22 This assumption in a static model should be understood as an approximation to the results obtained within an intertemporal general equilibrium model of firm-level trade unions, as in Beissinger and Egger (2004). In the steady state of such a dynamic model, $\overline{w}$ turns out to be a weighted average of unemployment benefits and average wages, where the weights depend on the unemployment rate, among others.

of remaining a member of union i.

In the main text it is therefore assumed that only employed workers are union members. Moreover, eq. (1) is taken as a starting point since this equation also is in line with the view that the union only cares about employed workers and maximizes the rent for the employed workers. The rent maximizing labor union is often assumed in general equilibrium models.[23]

2.A.2 Profits per worker as internal reference in the labor union utility function

Using IR_2 defined in eq. (4) as firm-specific internal reference, the labor union utility function in eq. (2) becomes

$$U_i = N_i \cdot \Omega_i \qquad \text{with} \quad \Omega_i \equiv \rho \left[w_i - v \frac{\Pi_i}{N_i} \right] + (1-\rho)\left[w_i - \overline{w} \right], \qquad (30)$$

where profits are defined as $\Pi_i = R(N_i) - w_i N_i$ and $R(N_i)$ denotes the firm's revenues. The marginal rate of substitution between wages and employment becomes

$$\text{MRS} = \frac{\partial U_i/\partial N_i}{\partial U_i/\partial w_i} = \frac{w_i - \overline{w} - \rho \left[\varepsilon_{\Pi N} \cdot v \cdot (\Pi_i/N_i) - \overline{w}) \right]}{N_i(1+\rho v)}, \qquad (31)$$

where $\varepsilon_{\Pi N}$ denotes the elasticity of profits with respect to employment (at given wages). As is evident from eq. (31), both marginal utilities differ from the standard model. Comparing the marginal rate of substitution with that of the standard model in eq. (6) leads to the following case distinctions:

$$\begin{aligned} &\text{MRS} < \text{MRS}^s \quad \text{for} \quad v\left(\varepsilon_{\Pi N} \frac{\Pi_i}{N_i} + w_i - \overline{w} \right) > \overline{w} \qquad \text{case 1} \\ &\text{MRS} > \text{MRS}^s \quad \text{for} \quad v\left(\varepsilon_{\Pi N} \frac{\Pi_i}{N_i} + w_i - \overline{w} \right) < \overline{w} \qquad \text{case 2} \end{aligned}$$

Though this is somewhat different from the case distinctions in section 2.2, it turns out that as soon as maximum profits are taken into account similar results are obtained if IR_2 instead of IR_1 is used as internal reference.

2.A.3 The slope of the aggregate wage-setting curve

The slope of the wage-setting curve in the fairness model with $0 < \rho < 1$ is taken from eq. (14) with $j = 1, 2$ indicating the respective specification of the model and rewritten as

$$\frac{\partial w_j}{\partial n_j} = \frac{\Psi_A \, \rho v \, \lambda_j \, A n_j^{\alpha-1} + \Psi_b \, b}{[\alpha\kappa - (1-\rho)n_j]^2} \quad \text{with} \quad \lambda_1 = \alpha, \; \lambda_2 = \alpha\kappa(1-\alpha\kappa) \qquad (32)$$

[23] See, for example, Manning (1993), Nickell (1999), Beissinger and Busse (2001) and Beissinger and Egger (2004).

with $\Psi_A \equiv (2-\alpha)(1-\rho) - \alpha\kappa(1-\alpha)\frac{1}{n}$ and $\Psi_b \equiv [1-\rho-\alpha\kappa](1-\rho)$. The sign of the slope depends on the sign of the numerator. To determine the sign, two cases must be distinguished.

Case (i): $0 < \rho < 1 - \alpha\kappa$

In this case $\Psi_b > 0$. As has been outlined in Section 2.3.2, the employment rate is restricted to the interval $0 < n_j < \alpha\kappa/(1-\rho)$. Taking the upper limit for n into account, $\Psi_A \geq 0$ for

$$\frac{\alpha\kappa}{(1-\rho)}\frac{(1-\alpha)}{(2-\alpha)} \leq n_j < \frac{\alpha\kappa}{1-\rho} \tag{33}$$

which is sufficient (but not necessary) for $\partial w_j/\partial n_j > 0$. Hence in the range defined by eq. (33) the WS curve certainly is upward sloping. If

$$0 < n_j < \frac{\alpha\kappa}{(1-\rho)}\frac{(1-\alpha)}{(2-\alpha)} \tag{34}$$

then $\Psi_A < 0$, but it may still hold that the slope of the wage-setting curve is positive. However, if $n_j \to 0$ then $\Psi_A \to (-\infty)$. As a consequence, for low n_j the negative value of the first term in the numerator dominates implying $\partial w_j/\partial n_j < 0$. It can be concluded that the U–shaped wage-setting curve reaches an interior minimum at an employment rate $\tilde{n}_j$, with $0 < \tilde{n}_j < \alpha\kappa(1-\alpha)/[(1-\rho)(2-\alpha)]$.

Case (ii): $1 - \alpha\kappa \leq \rho < 1$

In this case $\Psi_b \leq 0$. The wage-setting curve is now defined over the whole range $0 < n_j \leq 1$. If the employment rate is in the range defined by eq. (34) it holds that $\Psi_A < 0$. Notice that in Case (ii) $\alpha\kappa/(1-\rho) \geq 1$. If $\rho > 1 - [\alpha\kappa(1-\alpha)/(2-\alpha)]$, the upper limit for n_j in eq. (34) would be greater than one and must therefore be replaced by one. For such high values of the fairness parameter the wage-setting curve would therefore be downward-sloping over all employment rates in the interval (0,1]. If $1 - \alpha\kappa < \rho < 1 - [\alpha\kappa(1-\alpha)/(2-\alpha)]$, there is a range of employment rates, namely

$$\frac{\alpha\kappa}{(1-\rho)}\frac{(1-\alpha)}{(2-\alpha)} \leq n_j \leq 1, \tag{35}$$

where $\Psi_A > 0$ holds. This is a necessary, but not a sufficient condition for a positively sloped wage-setting curve. However, if $n_j \to 1$ then $\partial w_j/\partial n_j > 0$. In this case there is again an interior minimum at an employment rate $\tilde{n}_j$ implying a U–shaped wage-setting curve.

2.A.4 Parameter restrictions for the general equilibrium

There are two reasons, why further parameter restrictions are necessary. First, it would be rather implausible if the fairness reference would be lower than unemployment benefits. Second, it must be guaranteed that the equilibrium employment rate n lies in the interval $(0,1)$. We first focus on restrictions of v. The different specifications of the model are indicated by $j = 1, 2$.

With regard to the first reason, we assume that $vY/n > b$ respectively $v\Pi/n > b$. With that we are in line with the common notion that "comparison [is] always made upward rather than downward" (Rees, 1993, p. 244). Since we get the highest lower bound of the fairness reference for $\lim_{n \to n_{\max}}$, this "Rees Assumption" (RA) leads to $v > v_j^{\mathrm{RA}}$ with $v_1^{\mathrm{RA}} = (n_{\max})^{1-\alpha} \cdot b/A$ and $v_2^{\mathrm{RA}} = (n_{\max})^{1-\alpha} \cdot b/((1-\alpha\kappa)A)$. For $0 < \rho < 1-\alpha\kappa$ the upper bound for employment is given by $n_{\max} = \alpha\kappa/(1-\rho)$. For $1-\alpha\kappa \leq \rho < 1$ the upper employment threshold is $n_{\max} = 1$.

With regard to the second reason, only in the case $1-\alpha\kappa \leq \rho < 1$ a restriction for v is necessary to guarantee that $n \leq 1$. Since $\partial n^*/\partial v < 0$ (see eq. (19)), a decrease in v leads to an increase in n. Therefore there must be a lower bound $v_{\min}$ leading to $n = 1$. This lower bound is derived from the macroeconomic equilibrium.

Solving the implicit equilibrium employment rate at $\lim_{n \to 1}$ for v, we get the restriction $v > v_j^{min}$ with $v_1^{min} = (\alpha\kappa - (1-\rho))\kappa/\rho$ and $v_2^{min} = (\alpha\kappa - (1-\rho))/(\rho(1-\alpha\kappa))$, not only assuring that $n^* < 1$ but also $w^* > b$. Notice that in the case $1-\alpha\kappa \leq \rho < 1$ we therefore have two lower bounds v^{RA} and $v_{\min}$. Always the larger of the two is binding.

In addition to the lower bound an upper bound for $v < v_j^{max}$ with $v_1^{max} = \alpha\kappa^2/\rho$ and $v_2^{max} = \alpha\kappa/(\rho(1-\alpha\kappa))$ exists for $\lim_{n \to 0}$. Again this is derived from the equilibrium employment rate. Moreover, we assume in the first specification, that v can not be larger than 1. It is impossible that wages are larger than average productivity. In that case the lower of the two upper bounds for v is binding. Taken together these limits denote the range of all possible $\rho - v$ combinations generating an employment rate between zero and one ($0 < n^* < 1$).

2.A.5 Case distinctions on the aggregate level

Eq. (18) can be obtained from eq. (16) by taking the following steps. Labor demand can be used to write the internal reference as a function of the wage. The wage-setting curve from eq. (13) can also be rewritten taking labor demand from eq. (15) into account for the internal reference which yields:

$$w_j = \frac{(1-\rho)(1-n_j)}{\alpha\kappa - (1-\rho)n_j - \rho v \frac{\lambda_j}{\alpha\kappa}} b \qquad \text{for} \quad j = 1, 2 \tag{36}$$

Plugging this expression in the internal reference which is written as a function of wages in eq. (16) and simplifying leads ultimately to eq. (18). The expression in curly brackets in that equation denotes the reduced form case distinction on the aggregate level.

2.A.5.1 Specification 1

In specification 1, the expression in curly brackets in eq. (18) reads as follows.

$$v\frac{1}{\kappa} - \alpha\kappa \tag{37}$$

If the expression is positive we are in case 1 and if it is negative we are in case 2. We can obtain the different cases by varying one of the parameters holding the others constant. We first focus on the size of the internal reference (v) and then on the price setting power of firms (κ).

In order to obtain the different cases a threshold $\tilde{v}$ must exist with max $\{v^{min}, v^{RA}\} < \tilde{v} < \min\{v^{max}, 1\}$ which sets equation (37) equal to 0. This is true for all parameter ranges since $\tilde{v} = \alpha\kappa^2$. The cases prevail on the aggregate level. They can be rewritten in the following short notation:

$$\begin{array}{ccccccl} \min\{v^{max},1\} & > & v & > & \tilde{v} & & \text{case 1} \\ \tilde{v} & > & v & > & \max\{v^{min}, v^{RA}\} & & \text{case 2} \end{array} \tag{38}$$

Since the standard model is unaffected by changes in v we can directly conclude that $w_{case1} > w^s > w_{case_2}$ and $n_{case1} < n^s < n_{case_2}$. Derivation of equilibrium wages and employment proves this conclusion as shown in section 2.3.3.

With regard to κ a threshold $\tilde{\kappa}$ must exist with $0 < \tilde{\kappa} < 1$ which sets equation (37) equal to 0. Given the restrictions for v this is true since $\tilde{\kappa} = \sqrt{v/\alpha}$. Again the cases prevail on the aggregate level. They can be rewritten in the following short notation:

$$\begin{array}{cccccl} 0 & < & \kappa & < & \tilde{\kappa} & \text{case 1} \\ \tilde{\kappa} & < & \kappa & < & 1 & \text{case 2} \end{array} \tag{39}$$

In contrast to v changes in κ also affect the results of the standard model, which are ambiguous for equilibrium wages. We can conclude $n_{case1} < n_s < n_{case_2}$ but not so for wages.

2.A.5.2 Specification 2

In specification 2, the expression in curly brackets in eq. (18) reads as follows.

$$v(1 - \alpha\kappa) - \alpha\kappa \tag{40}$$

Similarly to the discussion above we obtain the different cases by varying one of the parameters holding the others constant. The threshold value for v is given by $\tilde{v} = \alpha\kappa/(1 - \alpha\kappa)$ which fulfills $\max\{v^{min}, v^{RA}\} < \tilde{v} < v^{max}$. With regard to κ, the threshold $\tilde{\kappa} = v/(\alpha(1 + v))$ fulfills $0 < \tilde{\kappa} < 1$. One again obtains the parameter ranges in eqs. (38) and (39), the only difference being that v is no longer restricted to be smaller than one.

2.A.6 Derivation of the wage flexibility index

Using the inverse labor demand equation (15) and the wage-setting equation (13), equilibrium employment n_j^* is determined by the following equation:

$$\alpha\kappa A(n_j^*)^{\alpha-1} = \frac{\rho v \lambda_j A(n_j^*)^{\alpha-1} + (1-\rho)(1-n_j^*)b}{\alpha\kappa - (1-\rho)n_j^*}$$

with $j = 1, 2$ and $\lambda_1 \equiv \alpha$ for the first, and $\lambda_2 \equiv \alpha\kappa(1-\alpha\kappa)$ for the second specification. Totally differentiating this equation, one finally arrives at the following expression for the elasticity of equilibrium employment with regard to technology:

$$\frac{\partial n_j^*}{\partial A}\frac{A}{n_j^*} = \frac{1}{1-\alpha+\xi_j} > 0$$

with

$$\xi_j \equiv \frac{n_j^*}{1-n_j^*}\frac{1-\alpha\kappa\phi_j}{\alpha\kappa\phi_j - n_j^*}, \quad \text{and} \quad \phi_j \equiv \frac{1-\rho\frac{v}{\delta_j}}{1-\rho}, \quad \text{with } \delta_1 \equiv \alpha\kappa^2, \text{ and } \delta_2 \equiv \frac{\alpha\kappa}{1-\alpha\kappa}.$$

Using the inverse labor demand equation, the elasticity of wages with regard to technology is

$$\frac{\partial w_j^*}{\partial A}\frac{A}{w_j^*} = 1-(1-\alpha)\frac{\partial n_j^*}{\partial A}\frac{A}{n_j^*} = \frac{\xi_j}{1-\alpha+\xi_j} > 0$$

Combining the two elasticities leads to the measure of wage rigidity as given in eq. (26):

$$\frac{\partial w_j^*/\partial A}{\partial n_j^*/\partial A}\frac{n_j^*}{w_j^*} = \xi_j \qquad \text{with} \quad j = 1, 2$$

2.A.7 Convexity of WS

In order to show that the wage-setting curve is U–shaped we prove that the second derivative of the wage-setting equation is positive over the whole support $0 < n < n_{\max}$. We first consider the case with $0 < \rho < 1-\alpha\kappa$ in which $n_{\max} = [\alpha\kappa/(1-\rho)] < 1$. Then we analyze the case $1-\alpha\kappa \leq \rho < 1$ in which $n_{\max} = 1$.

The second derivative of the wage-setting equation is:

$$\begin{aligned}\frac{\partial^2 w}{\partial n^2} = \frac{v(1-\alpha\kappa)An^{\alpha-1}}{(\alpha\kappa-(1-\rho)n)^3}\Big[&(\alpha\kappa-(1-\rho)n)^2(2-\alpha)(1-\alpha)\rho\alpha\kappa\frac{1}{n^2}\\ &-2(1-\rho)(\alpha\kappa-(1-\rho)n)(1-\alpha)\rho\alpha\kappa\frac{1}{n}+2(1-\rho)^2\rho\alpha\kappa\\ &+2(1-\rho)^2(1-\rho-\alpha\kappa)\frac{b}{v(1-\alpha\kappa)An^{\alpha-1}}\Big]\end{aligned} \tag{41}$$

In order to determine the sign of the derivation only the expression in edged brackets needs to be considered. The term in front is positive for all parameter values.

We first assume, that $0 < \rho < 1-\alpha\kappa$. From this it follows, that the last term in eq. (41) is positive, i.e.

$$2(1-\rho)^2(1-\rho-\alpha\kappa)\frac{b}{v(1-\alpha\kappa)An^{\alpha-1}} > 0$$

We therefore focus on the sign of the first three terms in brackets:

$$\begin{aligned}(\alpha\kappa-(1-\rho)n)^2(2-\alpha)(1-\alpha)\rho\alpha\kappa\frac{1}{n^2}-2(1-\rho)(\alpha\kappa-(1-\rho)n)(1-\alpha)\rho\alpha\kappa\frac{1}{n}\\ +2(1-\rho)^2\rho\alpha\kappa\end{aligned}$$

$$\begin{aligned}=\rho\alpha\kappa\frac{1}{n^2}\Big\{&[(\alpha\kappa-(1-\rho)n)(1-\alpha)-(1-\rho)n]^2\\ &+(1-\rho)^2n^2+(\alpha\kappa-(1-\rho)n)^2(1-\alpha)\Big\} > 0\end{aligned}$$

As a consequence, if $0 < \rho < 1-\alpha\kappa$,

$$\frac{\partial^2 w}{\partial n^2} > 0 \qquad \text{for all } n \quad \text{with} \quad 0 < n < \frac{\alpha\kappa}{(1-\rho)} < 1$$

Now we consider the case $1-\alpha\kappa \le \rho < 1$ in which $n_{\max} = 1$. In this case $\max\{v^{RA}, v^{min}\}$ starts to be binding. The edged brackets of eq. (41) reads as:

$$(\alpha\kappa-(1-\rho)n)^2(2-\alpha)(1-\alpha)\rho\alpha\kappa\frac{1}{n^2}-2(1-\rho)(\alpha\kappa-(1-\rho)n)(1-\alpha)\rho\alpha\kappa\frac{1}{n}$$
$$+2(1-\rho)^2\rho\alpha\kappa+\underbrace{2(1-\rho)^2\underbrace{(1-\rho-\alpha\kappa)}_{<0}\underbrace{\frac{b}{v(1-\alpha\kappa)An^{\alpha-1}}}_{\text{at most close to 1}}}_{\text{is smallest (most negative) for } v^{RA}}$$

In order to have the last term in the equation above as large as possible in absolute values, we need to choose v as small as possible, which is v^{RA}. Therefore rewrite sufficiently as follows:

$$(\alpha\kappa-(1-\rho)n)^2(2-\alpha)(1-\alpha)\rho\alpha\kappa\frac{1}{n^2}-2(1-\rho)(\alpha\kappa-(1-\rho)n)(1-\alpha)\rho\alpha\kappa\frac{1}{n}$$
$$+2(1-\rho)^2\rho\alpha\kappa-2(1-\rho)^2(\alpha\kappa-(1-\rho))$$

Which we can again rewrite as:

$$(\alpha\kappa-(1-\rho)n)(1-\alpha)\rho\alpha\kappa\frac{1}{n}$$
$$\left[\frac{\alpha\kappa-(1-\rho)n}{n}(2-\alpha)+2(1-\rho)^2\frac{n}{(\alpha\kappa-(1-\rho)n)(1-\alpha)}-2(1-\rho)\right.$$
$$\left.-2(1-\rho)^2\frac{(\alpha\kappa-(1-\rho))}{\rho\alpha\kappa}\frac{n}{(\alpha\kappa-(1-\rho)n)(1-\alpha)}\right]$$

In order to determine the sign only the expressions in edged brackets need to be considered. We rewrite this expression with $\frac{(\alpha\kappa-(1-\rho)n)(1-\alpha)}{n}=2(1-\rho)x$ and therefore capture the following. With $0<x\leq 1$ we suppose $\frac{(\alpha\kappa-(1-\rho)n)(1-\alpha)}{n}\geq 2(1-\rho)$, and with $x>1$ we suppose $\frac{(\alpha\kappa-(1-\rho)n)(1-\alpha)}{n}<2(1-\rho)$.

$$\frac{2(1-\rho)x}{1-\alpha}+2(1-\rho)x+\frac{2(1-\rho)^2}{2(1-\rho)x}-2(1-\rho)-\frac{2(1-\rho)^2}{2(1-\rho)x}\frac{\alpha\kappa-(1-\rho)}{\rho\alpha\kappa}$$

Simplifying the expression yields:

$$\frac{(1-\rho)}{\rho\alpha\kappa}\frac{1}{x}\left[2x\left(\frac{2-\alpha}{1-\alpha}x-1\right)\rho\alpha\kappa+(1-\alpha\kappa)(1-\rho)\right] \tag{42}$$

First order derivative of the (relevant) term in brackets is:

$$2\frac{\rho\alpha\kappa}{1-\alpha}\left[(2-\alpha)x-(1-\alpha)+(2-\alpha)x\right]=0 \quad \Rightarrow \quad x^*=\frac{1-\alpha}{2(2-\alpha)}$$

Second order derivative:

$$2\frac{\rho\alpha\kappa}{1-\alpha}2(2-\alpha) > 0 \quad \rightarrow \quad \text{is a minimum}$$

Therefore this solution of x gives the minimum value which we can use sufficiently. If the expression is positive at x^* is is positive for all other $x > 0$ as well. We therefore plug x^* in eq (42) which yields (more precisely we only plug it in the terms in brackets since these determine the sign) after simplifying:

$$(1-\alpha\kappa)(1-\rho) - \frac{1-\alpha}{2(2-\alpha)}\rho\alpha\kappa \tag{43}$$

Eq. (43) can be rewritten sufficiently as (by choosing $\kappa \rightarrow 1$):

$$(1-\alpha)(1-\rho) - \frac{1-\alpha}{2(2-\alpha)}\rho\alpha \tag{44}$$

This can be further simplified to:

$$(1-\alpha)\left[1-\rho\underbrace{\left(1-\frac{\alpha}{2(2-\alpha)}\right)}_{\text{is at most 1 for } \alpha\rightarrow 0}\right] > 0 \tag{45}$$

Where it is ultimately possible to see that the expression is positive. Remember, this expression was derived from eq. (42), which we now showed is positive at its minimum (x^*) and therefore positive for all $x > 0$. This proves that $\frac{\partial^2 w}{\partial n^2} > 0$ in case of having $1 - \alpha\kappa \leq \rho < 1$. Thus the second derivative of the WS curve was proved to be positive over the whole support. The WS is convex.

2.A.8 Multiple equilibria

The following 3 steps exclude the existence of multiple equilibria. First, both curves are strictly convex in $n \in (0,1)$. Second, to the left hand side ($n \rightarrow 0$) the value of WS is lower than the value of LD and to the right hand side ($n \rightarrow n^{max}$ resp. 1) the value of WS is higher than the value of LD. Third, the slope of the WS is always larger than the slope of the LD in $n \in (0,1)$. In the following we provide a more detailed look at steps two and three. Checking the left hand side for both curves yields:

$$\lim_{n\rightarrow 0} w^{LD} = \alpha\kappa A \overbrace{n^{\alpha-1}}^{+\infty}$$

$$\lim_{n\to 0} w^{WS} = \frac{\rho v\alpha\kappa(1-\alpha\kappa)A\overbrace{n^{\alpha-1}}^{+\infty}+(1-\rho)(1-n)b}{\alpha\kappa}$$

The highest possible values for w^{WS} are achieved for $\rho \to 1$, which makes it approaching the values of the LD curve from underneath. Consider, that $\lim_{\rho\to 1} v^{max} = v^{min} = \tilde{v}$. Replacing v by $\tilde{v} = \alpha\kappa/(1-\alpha\kappa)$ then gives the same limit for the value of the WS than for LD. We thus showed that $\lim_{n\to 0} w^{WS} < \lim_{n\to 0} w^{LD}$.

Concerning the right hand side we get:

$$\lim_{n\to 1} w^{LD} = \alpha\kappa A$$

For the WS curve, having $n^{max} = \frac{\alpha\kappa}{1-\rho}$ binding ($\alpha\kappa \leq 1-\rho$):

$$\lim_{n\to n^{max}} w^{WS} = \frac{\rho v\alpha\kappa(1-\alpha\kappa)An^{max\,\alpha-1} + (1-\rho)(1-n^{max})b}{\alpha\kappa-(1-\rho)n^{max}} = +\infty$$

In case of $\alpha\kappa > 1-\rho$, considering the limit of case 1 ($v = \alpha\kappa/(\rho(1-\alpha\kappa))$) we get:

$$\lim_{n\to 1} w^{WS} = \alpha\kappa A \underbrace{\frac{\alpha\kappa}{\alpha\kappa-(1-\rho)}}_{>1} > \alpha\kappa A$$

Considering the limit of case 3 ($v = (\alpha\kappa-(1-\rho))/(\rho(1-\alpha\kappa))$), the value of WS is approaching the value of LD from above:

$$\lim_{n\to 1} w^{WS} = \alpha\kappa A$$

It is therefore proved that $\lim_{n\to 1} w^{WS} > \lim_{n\to 1} w^{LD}$, as well as for $\lim_{n\to n^{max}} w^{WS}$.

Ultimately we provide the proof for step three. The slope of the WS curve is always bigger than the one from the LD curve in $n \in (0,1)$. Subtracting the slopes in the order mentioned and rearranging we get a positive difference:

$$\underbrace{\frac{(1-\alpha)\frac{1}{n}\alpha\kappa A n^{\alpha-1}}{(\alpha\kappa-(1-\rho)n)(1-\alpha\kappa)}}_{>0}\underbrace{\left[\frac{\alpha\kappa-(1-\rho)n}{1-\alpha\kappa}-\rho v\right]}_{\geq 0}$$

$$+\underbrace{\frac{1-\rho}{(\alpha\kappa-(1-\rho)n)^2}}_{>0}\underbrace{\left[\rho v\alpha\kappa(1-\alpha\kappa)A n^{\alpha-1}+(1-\rho-\alpha\kappa)b\right]}_{>0}>0$$

The first edged bracket is smallest (approaches zero) for $\lim_{\rho\to 1}$ which in turn implies $v \to \tilde{v}$. Rewriting the expression yields:

$$\underbrace{\frac{\alpha\kappa-\overbrace{(1-\rho)}^{\to 0}n}{1-\alpha\kappa}}_{\frac{\alpha\kappa}{1-\alpha\kappa}}-\underbrace{\overbrace{\rho}^{\to 1}\overbrace{v}^{\to\tilde{v}}}_{\to\frac{\alpha\kappa}{1-\alpha\kappa}}=0$$

Choosing $v \to v^{max}$ makes the first edged bracket approach zero, too. Remember, that v^{max} leads to $n \to 0$.

$$\underbrace{\frac{\alpha\kappa-(1-\rho)\overbrace{n}^{\to 0}}{1-\alpha\kappa}}_{\frac{\alpha\kappa}{1-\alpha\kappa}}-\underbrace{\rho v}_{\to\frac{\alpha\kappa}{1-\alpha\kappa}}=0$$

Otherwise the expression is positive. The second edged bracket is positive, which can be proved by RA (Rees Assumption), which implies $v(1-\alpha\kappa)An^{\alpha-1} > b$. The expression can be rewritten sufficiently as follows:

$$(1-\rho)(1-\alpha\kappa)b > 0$$

With $\frac{\partial w^{WS}}{\partial n} > \frac{\partial w^{LD}}{\partial n}$ as a third step, we proved that there is a unique equilibrium. Evidently RA is a necessary ingredient for assuring the uniqueness of equilibrium.

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3 DO INTERNAL REFERENCES LEAD TO WAGE RIGIDITY?

Abstract*

This paper analyzes three prominent models of internal references and their impact on wage rigidity (Danthine and Kurmann, 2007, 2010; Koskela and Schöb, 2009). These studies find that internal references unambiguously increase wage rigidity. Only Danthine and Kurmann (2010) identify an ambiguous effect in case of a technology shock. In contrast to that literature, the present study provides analytical proofs and calibration results of the models of Danthine and Kurmann (2007) and Koskela and Schöb (2009) which show that the effect of internal references on wage rigidity is ambiguous. This holds regardless of whether real or monetary shocks are considered. Furthermore, this paper provides a well-founded modification of the Danthine and Kurmann (2010) model which shows that the impulse response of wages is ambiguous also after a monetary shock. The intuition for this result is similar in all models: As internal and external reference are modeled as weighted average, an increase in the weight on the internal reference implies a simultaneous decrease in the weight on the outside option. Therefore, the effect of the internal reference *relative* to the external reference determines whether wage rigidity increases or decreases.

Keywords: Wage Rigidity, Internal References, External References, Reciprocity, Fairness, Efficiency Wages

3.1 Introduction

Based on abundant empirical and experimental evidence on fairness and reciprocity (Fehr et al., 2009; Falk et al., 2008; Bewley, 2007; Bruni et al., 2008; Wilson and Dixon, 2008), theoretical modeling by Danthine and Kurmann (DK) (2006,

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2007, 2010) and Koskela and Schöb (KS) (2009) show that internal references can lead to a substantial increase in wage rigidity. These studies find that the effect on wage rigidity is unambiguous, in case of both, technology (KS, 2009; DK, 2007) and monetary shocks (DK, 2007; 2010). Only DK (2010) find an ambiguous effect in case of a technology shock. All three models are at the core of the theoretical literature on internal references and wage rigidity. As such they set the standard of how we understand internal references and their connection to wage rigidity.

Given these contradictory results in DK (2010), DK (2007) and KS (2009), this study analyzes the potentially ambiguous effect of internal references on wage rigidity in these models. The study provides calibration and parametrization results and analytical proofs which show that the effect is ambiguous in DK (2007) and KS (2009). In fact it is ambiguous in case of both, technology as well as monetary shocks. Furthermore the study reveals that the unambiguity in case of a monetary shock in DK (2010) is not robust to a slight change of the references, which mainly consists of the inclusion of unemployment benefits into the external reference respectively outside option. Analyzing the model's wage dynamics through impulse response functions shows that the internal reference can also increase wage volatility. Thus the effect is equally ambiguous.

As a consequence, contrary to the findings of the literature, there is a common pattern that internal references do not unambiguously imply wage rigidity. The intuition for this result is similar in all three models. The internal reference forms a weighted average with the outside option. Thus, an increase of the weight on the internal reference implies a simultaneous decrease in the weight on the outside option. Consequently it is not sufficient to focus only on the effect the internal reference has on wage rigidity. What matters is the effect of the internal reference relative to the external reference. If the effect is relatively stronger, wage rigidity increases. If the effect is relatively weaker, wage rigidity decreases.

Section 3.2 discusses the DK (2007) model and analyzes the equilibrium wage elasticity after real and monetary shock respectively. Section 3.3 presents the DK (2010) model and discusses wage dynamics in case of a technology shock. A modification of the original model is introduced with focus on unemployment benefits, and wage dynamics analyzed after a monetary shock. Section 3.4 reviews the KS (2009) model and analyzes the equilibrium wage elasticity after a technology shock. The last section concludes. A full description and derivation of all three models is found in the appendix.

3.2 The DK (2007) model revisited

3.2.1 Basic features of the model

The DK (2007) model is very innovative and introduces an internal reference into reciprocal preferences of workers. It is a static general equilibrium and efficiency wage model where production depends on effort and is subject to decreasing returns to labor. The authors analyze how wages react to technology and monetary shocks. Simulation results are provided which show that the internal reference unambiguously increases wage rigidity.

It can be shown that the author's eloquent micro-foundation of reciprocal preferences results in a modified Summers (1988) effort function.[1]

$$e = \left(\frac{\lambda}{\theta}\right)^{\frac{1}{\theta-1}} \left(ln(w) - \varphi_1 \nu ln\left(\frac{y}{n}\right) - \varphi_2 ln(\omega)\right)^{\frac{1}{\theta-1}} \qquad \text{with} \quad \theta > 1,\ \lambda > 0 \quad (46)$$

λ measures the importance of reciprocity considerations and θ the disutility of effort. The second term on the right hand side denotes the rent associated with employment. Wages (w) are compared to expected earnings outside the firm ($\omega = \bar{w}^{\bar{n}}\bar{b}^{1-\bar{n}}$) with b denoting unemployment benefits and n the employment rate. The labor force is normalized to one. The outside option is also referred to as external reference (ER). Furthermore, wages are compared to an internal reference (IR) given by the log output (y) per worker times $\nu < 1$. Since ν is exogenously given it directly determines the size of the IR and consequently referred to as such. With two references there are two weights which determine the respective importance of each reference. φ_1 measures the weight on the IR and φ_2 the weight on the ER. As $\varphi_1 + \varphi_2 = 1$, the total rent is given by a weighted average of internal and external reference. Therefore the weight on the ER can be rewritten as $\varphi_2 = 1 - \varphi_1$ with $0 \leq \varphi_1 \leq 1$.

The equilibrium of the model is given by the wage-setting curve (eq. (13), p. 868):

$$ln(w) = \frac{\frac{1-\varphi_1\nu}{\theta-1} + \varphi_1 \nu ln\left(y/n\right) + (1-\varphi_1)(1-n)ln(b)}{1-(1-\varphi_1)n} \quad (47)$$

Labor demand as given by eq. (15), p. 869:

$$ln(w) = ln\left(\frac{\psi\alpha}{1-\varphi_1\nu(1-\alpha)}\right) + ln\left(\frac{y}{n}\right) \quad (48)$$

Optimal effort is given by a function of parameters (see eq. (14) in DK (2007)).

$$e = \left(\frac{\lambda(1-\varphi_1\nu)}{\theta(\theta-1)}\right)^{\frac{1}{\theta-1}} \quad (49)$$

The main feature of the model is found in the wage-setting curve from eq. (47). If $\varphi_1 = 0$, employment matters only through the outside option. Wages increase with employment because it is easier to find a job elsewhere. If $\varphi_1 > 0$, there is an additional mechanism to employment. Higher employment leads to lower average productivity dampening wages through the IR. This mechanism provides the intuition for wage rigidity. If the economy is hit by an adverse shock, output

[1] This paper discusses the so-called "constant effort model" of the DK (2007) article. Results remain qualitatively unchanged for the model with variable effort. Please refer to appendix 3.A.1 for a detailed illustration of the model and the derivation of the main equations.

and employment decreases. The decrease in employment attenuates the decrease in output per worker, which in turn prevents a decrease in wages through the IR. DK (2007) analyze two kinds of shocks, a technology shock in A (total factor productivity) and a monetary shock in $M = y$ and, based on the above intuition, conclude that ”with more weight on the internal component of the wage reference, wages are more rigid, hours are more volatile” (p.873). The following section reviews the comparative statics of these shocks at different levels of φ_1, the weight on the IR, and shows that DK's conclusion is incorrect.

3.2.2 Wage rigidity

Following DK (2007) two kinds of shocks are considered, a technology shock which affects A at flexible prices and a monetary shock which directly affects output $M = y$ at fixed prices. More precisely DK provide simulation results of the effect of a -1% change in A respectively $M = y$ on wages and employment at $\varphi_1 = 0$ (zero weight on the IR) compared to $\varphi_1 = 1$ (all weight on the IR). The result of DK, in analytical terms, can be summarized as follows:

$$\left.\frac{\partial w^*}{\partial \chi}\right|_{\varphi_1=0} > \left.\frac{\partial w^*}{\partial \chi}\right|_{\varphi_1=1} \quad \Leftrightarrow \quad |\varepsilon_{w^*\chi}|_{\varphi_1=0} > |\varepsilon_{w^*\chi}|_{\varphi_1=1} \quad \text{with} \quad \chi = A, y \tag{50}$$

It states that the reaction of the equilibrium wage due to a 1% decrease in technology respectively output is smaller if the weight on the IR is high ($\varphi_1 = 1$); implying wage rigidity. As φ_1 can vary between the two extremes zero and unity, DK conclude that the degree of wage rigidity increases with φ_1 (see citation above). In analytical terms this conclusion can be represented as follows.

$$\frac{\partial \frac{\partial w^*}{\partial \chi}}{\partial \varphi_1} < 0 \quad \text{respectively} \quad \frac{\partial |\varepsilon_{w^*\chi}|}{\partial \varphi_1} < 0 \quad \text{with} \quad \chi = A, y \tag{51}$$

In absolute values the elasticity of the equilibrium wage with regard to a change in technology respectively output decreases in φ_1, the weight on the IR. In presence of a negative shock this implies that the elasticity approaches zero from below. The following two subsections analyze this result separately for the technology as well as the monetary shock.

3.2.2.1 Technology shock

The elasticity of equilibrium employment and wages with regard to a technology shock in A is given by equations (52) and (53).[2]

$$|\varepsilon_{n^*A}| = \frac{1}{1 - \alpha + \frac{(1-\varphi_1)n^*}{1-(1-\varphi_1)n^*-\varphi_1 \nu}\left(ln(w^*) - ln(b)\right)} \tag{52}$$

[2] Please see appendix 3.A.2.1 for the derivation of the respective elasticities.

$$|\varepsilon_{w^*A}| = \frac{\frac{(1-\varphi_1)n^*}{1-(1-\varphi_1)n^*-\varphi_1\nu}\left(ln(w^*)-ln(b)\right)}{1-\alpha+\frac{(1-\varphi_1)n^*}{1-(1-\varphi_1)n^*-\varphi_1\nu}\left(ln(w^*)-ln(b)\right)} \tag{53}$$

The IR leads to higher wage rigidity if the wage elasticity decreases in φ_1. It can be shown that if ε_{n^*A} increases (decreases) ε_{w^*A} decreases (increases). It is, therefore, sufficient to analyze one elasticity. Deriving the employment elasticity with regard to φ_1 yields

$$\frac{\partial|\varepsilon_{n^*A}|}{\partial\varphi_1} = \frac{{\varepsilon_{n^*A}}^2}{1-(1-\varphi_1)n^*-\varphi_1\nu}\left[\frac{n^*(1-\nu)}{1-(1-\varphi_1)n^*-\varphi_1\nu}\left(ln(w^*)-ln(b)\right)\right.$$
$$\left.-\frac{1-\varphi_1\nu}{1-(1-\varphi_1)n^*-\varphi_1\nu}\left(ln(w^*)-ln(b)\right)\frac{\partial n^*}{\partial\varphi_1}-\frac{(1-\varphi_1)n^*}{w^*}\frac{\partial w^*}{\partial\varphi_1}\right] \lesseqgtr 0 \tag{54}$$

Equation (54) considers how the employment elasticity changes when the weight on the IR increases. The expression in square brackets determines the sign of the change in the employment elasticity. The first term measures the direct effect of φ_1. It is positive and increases the employment reaction and thus wage rigidity. However, there are also indirect effects through equilibrium wages and employment. Appendix 3.A.3 shows that the indirect effects make the sign of eq. (54) ambiguous.

This issue is explored further by calibrating the model and calculating the equilibrium wage elasticity. Table 4 illustrates the wage elasticity (see eq. (53)) at different levels of φ_1 and ν. Note, that the calibration follows DK (2007) (see table 1, figure 1 and text on p. 870-871) in order to ensure straightforward comparison. Like the authors, unemployment benefits are modeled as replacement ratio with $b = \rho \cdot w$. In particular the following holds, $\alpha = 0.66$, $\psi = 0.9$, $A = 1$, $\triangle A = -1\%$, $\theta \approx 5.81$, $\lambda = 5 \cdot 10^6$, $\rho = 0.5$, which leads to an employment rate of $n = 0.7$ when rent-sharing is absent ($\varphi_1 = 0$, first column).

TABLE 4 Wage elasticity after real shock

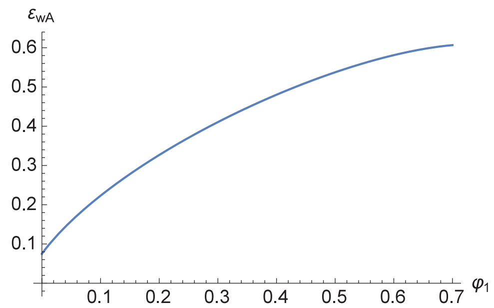
ν \ φ_1	0	0.1	0.2	0.3	0.4
0.25	0.8249	0.8514	0.8726		
0.5	0.8249	0.8277	0.8311	0.8346	0.8372
0.75	0.8249	0.8004	0.7766	0.7540	0.7311

The elasticities are calculated as a percentage change in absolute values, i.e. the numbers correspond directly to eq. (53). Calibration follows DK (2007) and is as follows, $\alpha = 0.66$, $\psi = 0.9$, $\theta \approx 5.81$, $\lambda = 5 \cdot 10^6$, $\rho = 0.5$ $A = 1.0$ and $\triangle A = -1\%$ which implies an employment rate of $n = 0.7$ in the first column ($\varphi_1 = 0$). In the shaded area the internal reference leads to a lower degree of wage rigidity. An empty cell implies that there is no solution to the equations system on $0 < n < 1$.

The employment elasticity reported in the second column is similar over all different levels of ν because the IR does not enter the wage-setting equation at $\varphi_1 = 0$. It shows that a 1% decrease in technology leads to a 0.8249% decrease in wages. According to DK (2007) the elasticity is supposed to decrease in φ_1 which implies an ever smaller reaction in wages as the weight on the IR increases. This actually holds at $\nu = 0.75$ in the third row where the elasticity decreases to 0.7331% in column 5. However this does not hold at $\nu = 0.5$, respectively $\nu = 0.25$. In fact the opposite is true in rows one and two: the wage elasticity increases in φ_1. In row 2 column 5 the elasticity increased to 0.8372%. Therefore the shaded cells in the table indicate where the IR leads to an increase in wage volatility and a lower employment reaction.

In order to illustrate this result more impressively the wage elasticity from eq. (53) is parameterized with $\alpha = 0.66$, $\psi = 0.9$, $A = 1$, $\theta = 2.5$, $\lambda = 500$, $\rho = 0.5$ and $\nu = 0.5$ and depicted in figure 2. It clearly shows that the wage elasticity

FIGURE 2 Wage elasticity after real shock as a function of φ_1



Parametrization: $\alpha = 0.66$, $\psi = 0.9$, $A = 1$, $\theta = 2.5$, $\lambda = 500$, $\rho = 0.5$ and $\nu = 0.5$.

increases in φ_1 which implies that the wage reaction increases as more weight is put on the IR. Evidently, increasing the weight on the IR does not imply an increase in the degree of wage rigidity.

The intuition for the ambiguous effect of the IR on wage rigidity is as follows. First, there is a direct effect of an increase in φ_1 on both references: The IR makes employment enter negatively in the wage equation. After a shock a decrease in employment leads c.p. to a higher IR and thus attenuates the wage reaction. Simultaneously a decrease in employment decreases the ER and thus strengthens the wage reaction. Taken together, an increase in φ_1 directly increases the degree of wage rigidity by giving more weight to the IR (attenuation) and reducing weight on the ER (reinforcement). This is at the core of DKs explanation: wages are rigid because a decrease in employment has an attenuating effect on wages through the IR. However, as shown in eq. (54), there is also a second, respectively indirect, effect which works opposite ways if equilibrium employment increases in φ_1. The following holds for an increase in employment: the smaller is the IR and the smaller is it's attenuating effect. On the other hand, the higher is the ER and the higher is wage rigidity. As such an increase of the weight on the IR comprises two opposite effects in each reference. To conclude, as internal and external reference enter the effort function and ultimately the wage-setting curve as a weighted average, the (net) effect of the IR *relative* to the ER matters for the overall degree of wage rigidity. If the effect of the ER is small in comparison to the internal, adding weight to the latter leads to an overall increase in wage rigidity. This is the scenario described by the authors. On the other hand, it is possible that the effect of the IR is small compared to the ER which implies that adding weight to the first leads to a decrease in wage rigidity.

3.2.2.2 Monetary shock

Equilibrium employment and wage elasticity with respect to the monetary shock in $M = y$ are given by the following two equations.[3] Note that the monetary shock implies a direct decrease in output which is not micro-founded. This follows DK (2007) in order to ensure direct comparability of the effect of the IR on wage rigidity.

$$|\varepsilon_{n^*y}| = \frac{1}{\alpha} \tag{55}$$

$$|\varepsilon_{w^*y}| = \frac{\varphi_1 \nu(\alpha - 1) + (1 - \varphi_1)n^* \left(ln(w^*) - ln(b)\right)}{\alpha(1 - (1 - \varphi_1)n^*)} \tag{56}$$

The IR has no effect on the employment elasticity. The wage elasticity reacts ambiguously. Derivation of the latter, given by eq. (56), with regard to the weight on the IR (φ_1) yields

$$\begin{aligned} \frac{\partial|\varepsilon_{w^*y}|}{\partial\varphi_1} = \frac{1}{\alpha(1-(1-\varphi_1)n^*)^2}\Big[&- (\nu(1-\alpha)(1-n^*) + n^* \left(ln(w^*) - ln(b)\right)) \\ &+ \left(\varphi_1\nu(\alpha-1) + ln(w^*) - ln(b)\right)(1-\varphi_1)\frac{\partial n^*}{\partial\varphi_1} \\ &+ (1-(1-\varphi_1)n^*)(1-\varphi_1)\frac{n^*}{w^*}\frac{\partial w^*}{\partial\varphi_1} \Big] \lesseqgtr 0 \end{aligned} \tag{57}$$

Equation (57) considers how the wage elasticity changes when the weight on the IR increases. The expression in square brackets determines whether the wage elasticity increases or decreases. The first term measures the direct effect of φ_1. It is negative and decreases the wage elasticity (i.e. increases wage rigidity). The two following terms denote the indirect effect through wages and employment. Similar to above the indirect effects make the sign of eq. (57) ambiguous.

Calibrating the model and the equilibrium wage elasticity confirms the analytical results. Table 5 reports the wage elasticity from eq. (56) at different levels of φ_1 and ν. The calibration is similar to section 3.2.2.1, i.e. follows DK (2007) with the monetary shock given by $\triangle y = -1\%$.

Similar to above the size of ν has no impact on the wage elasticity as the IR does not enter the wage equation, see column 1. In contrast to the technology

[3] Please see appendix 3.A.2.2 for the derivation of the respective elasticities.

TABLE 5 Wage elasticity after monetary shock

ν \ φ_1	0	0.1	0.2	0.3	0.4
0.25	2.4493	2.6661	2.7954		
0.5	2.4493	2.0425	1.7093	1.4256	1.1752
0.75	2.4493	1.5783	1.0540	0.7032	0.4510

The elasticities are calculated as a percentage change in absolute values, i.e. the numbers correspond directly to eq. (56). Calibration follows DK (2007) and is as follows, $\alpha = 0.66$, $\psi = 0.9$, $\theta \approx 5.81$, $\lambda = 5 \cdot 10^6$, $\rho = 0.5$ $A = 1.0$ and $\triangle y = -1\%$ which implies an employment rate of $n = 0.7$ in the first column ($\varphi_1 = 0$). In the shaded area the internal reference leads to a lower degree of wage rigidity. An empty cell implies that there is no solution to the equations system on $0 < n < 1$.

shock wages decrease much stronger, by almost 2.5%. At higher levels of ν, in row 2 but especially in row 3, the wage elasticity decreases substantially as the weight on the IR increases. This corresponds to the conclusion drawn by DK (2007). However at lower levels of ν, in row 1, the wage elasticity actually increases in φ_1. The shaded area indicates where the IR does not lead to wage rigidity.

The intuition for the ambiguous effect on wage rigidity is the same as the one provided in the previous section. Not the absolute but relative effect of the IR matters. Depending on the effect of the IR relative to the ER, an increase in the weight on the internal reference increases or decreases the overall degree of wage rigidity.

3.3 The DK (2010) model revisited

3.3.1 Basic features of the model

DK (2010) expand the idea of wage-setting under reciprocity into a DSGE framework. Apart from including households, retailers, financial sector and monetary policy, several features regarding the labor market are modified. Besides effort and employment also capital and utilization enter the production function. It exhibits decreasing returns to labor. A large part of the model parameters are estimated by VAR. The impact of technology and monetary shocks on wage dynamics are analyzed by impulse response functions. The authors find an ambiguous effect of the IR on wage rigidity in case of a technology shock and an unambiguous effect in case of a monetary shock.

This section presents the basic features of the model with a focus on the labor market.[4] It can be shown that the provision of effort is governed by a mod-

[4] For the ease of exposition this paper discusses the model version with constant effort.

ified Summers (1988) effort function.

$$e_t = (\alpha\lambda)^{\frac{1}{\theta+1-\alpha}} \left(ln(w_t) - \varphi_1 ln\left(\psi_t \frac{y_t}{n_t}\right) - \varphi_2 ln(\omega_t) - \varphi_3 ln(\bar{w}_{t-1}) \right)^{\frac{1}{\theta+1-\alpha}}$$
$$\text{with} \quad \theta \geq 1,\ \lambda > 0 \qquad (58)$$

Similarly to above λ measures how important reciprocity considerations are and θ the disutility of effort. In general, notation is similar to section 3.2 however with subscript t indicating the time period. The different functional form of parameters λ and θ stems from a different formulation of household preferences, see appendix 3.A.4 for details. The second term on the right hand side denotes the rent associated with employment. In contrast to eq. (46) wages (w_t) are not only compared to an internal (IR) and an external reference (ER) but in addition to a third reference which is given by last period's average wage level. The third reference is referred to as wage entitlement.[5] In presence of three wage references there are three respective weights. φ_1 measures the weight on the IR, φ_2 on the ER, and φ_3 on the entitlement reference. It holds that $\varphi_1 + \varphi_2 + \varphi_3 = 1$ which implies that the references are given by a weighted average. Similarly to section 3.2 the impact of the IR on wage rigidity is analyzed by an increase in φ_1 implying a simultaneous decrease in φ_2. This implies that the weight on the ER is given by $\varphi_2 = 1 - \varphi_1 - \varphi_3$ (see DK (2010), p. 843).

Effort is provided if wages exceed the weighted average of the references. Note that the IR is directly given by revenue per worker. This implies that if all weight is on the IR, wages would need to exceed revenue per employee in order to illicit positive effort. Obviously this is not possible which means that the model is not defined for $\varphi_1 = 1$. Although workers tend to choose reference points which favor higher wages (Babcock and Loewenstein, 1997) it is unlikely they base wage expectations on a reference which is impossible to reach. Finally an important difference to eq. (46) is given by the definition of the ER: $\omega_t = \bar{n}_t \bar{w}_t$. This does not denote expected earnings outside the firm. It only comprises the probability of finding a job elsewhere times wages. The complementary event, becoming unemployed and receiving unemployment benefits, is neglected. Both issues will be addressed in section 3.3.2.2.

The equilibrium conditions regarding the labor market of the model are given by the following three equations. The wage-setting curve is given by (see eq. (21), p. 842):

$$ln(w_t) = \frac{\frac{1-\varphi_1}{\theta+1-\alpha} + \varphi_1 ln\left(\psi_t y_t / n_t\right) + (1 - \varphi_1 - \varphi_3) ln(n_t) + \varphi_3 ln(w_{t-1})}{\varphi_1 + \varphi_3} \qquad (59)$$

Please refer to appendix 3.A.4 for the derivation of the model's main equations.

5 DK consider also past own wages in the entitlement reference which renders effort dynamic. However, as the authors derive their main results based on constant effort, and thus with the entitlement reference given only by the past aggregate wage level, this paper follows that approach.

Labor demand is given by (see eq. (18), p. 842):

$$ln(w_t) = ln\left(\frac{\psi_t \alpha}{1-(1-\alpha)\varphi_1}\right) + ln\,(y_t/n_t) \tag{60}$$

Optimal effort in turn is given by a function of parameters (see p. 843):

$$e_t = e^* = \left(\frac{\alpha\lambda(1-\varphi_1)}{\theta+1-\alpha}\right)^{\frac{1}{\theta+1-\alpha}} \tag{61}$$

The similarity to eqs. (47)-(49) is obvious. In analogy to section 3.2 the main feature of the model is found in the IR of the wage-setting curve given by eq. (59). φ_1 determines how employment impacts on wages. At low levels of φ_1, employment matters only through the outside option, however at higher levels there is also a direct effect through the IR. Higher employment then also has a dampening effect on wages as average productivity decreases.

DK (2010) focus on two kinds of shocks, a neutral real shock which affects the growth rate of technology A_t and a monetary shock which affects the growth rule of money M_t. Based on the wage-setting equation, DK conclude that the impact of the IR on wage rigidity is ambiguous in case of a real shock but the IR unambiguously increases wage rigidity in case of a monetary shock. The following section reviews the analysis of these shocks and shows that the authors conclusion is not robust to minor changes of the reference points. In case of both shocks the effect of the IR is ambiguous.

3.3.2 Wage rigidity

The impact of the internal reference on wage rigidity is analyzed based on the wage dynamics of the model. Abstracting from physical capital and ignoring constants, wage dynamics are given by (see eq. (25) in DK (2010)):

$$\hat{w}_t = \frac{1}{\varphi_1+\varphi_3}\left(\varphi_1\alpha\hat{a}_t + (1-(2-\alpha)\varphi_1-\varphi_3)\hat{n}_t + \varphi_3\hat{w}_{t-1}\right) \tag{62}$$

Hatted variables denote the percentage deviation from the steady state. In order to analyze the impact of the IR on wage rigidity, DK consider an increase in the weight on the IR (φ_1), which simultaneously implies a decrease in the weight on the outside option. This corresponds to the analysis of wage rigidity in DK (2007) as discussed in more detail in section 3.2.2 above. The real shock affects the growth rate of technology $\mu_{A,t} = A_t/A_{t-1}$ and is given by:

$$\hat{\mu}_{A,t} = \rho_{\mu_A}\hat{\mu}_{A,t-1} + \varepsilon_{\mu_A,t} \quad \text{with} \quad \varepsilon_{\mu_A,t}\, iid\left(0, \sigma^2_{\varepsilon_{\mu_A}}\right) \tag{63}$$

$\hat{\mu}_{A,t}$ denotes the percentage deviation from its steady state value and $\varepsilon_{\mu_A,t}$ is an i.i.d. shock affecting technology. In case of that shock $\hat{a}_t \neq 0$ in eq. (62). The monetary shock affects the money growth rule of the central bank ($\mu_{M,t} = M_t/M_{t-1}$)

and is given by:

$$\hat{\mu}_{M,t} = \rho_{\mu_M}\hat{\mu}_{M^*,t-1} + \varepsilon_{\mu_M,t} + \phi_A\hat{\mu}_{A,t} \quad \text{with} \quad \varepsilon_{\mu_M,t}\, iid\left(0, \sigma^2_{\varepsilon_{\mu_M}}\right) \tag{64}$$

Similar to above $\hat{\mu}_{M,t}$ denotes the percentage deviation from μ_M and $\varepsilon_{\mu_M,t}$ represents an i.i.d. shock to money growth. ϕ_A allows for the accommodation of the technology shock in monetary policy. Note that $\hat{a}_t = 0$ in case of the monetary shock. Each of the two following subsections analyzes one shock respectively.

3.3.2.1 Technology shock

After a technology shock it holds that $\hat{a}_t > 0$. Based on eq. (62), the authors point out that an increase in φ_1 has an ambiguous effect on the wage response. It increases the impact of technology but decreases the impact of employment. Thus, an increased weight on the IR may result in either higher or lower wage rigidity. Rewriting the wage dynamics as done in eq. (65) reveals that also another interpretation of this result is possible.

$$\hat{w}_t = \frac{1}{\varphi_1 + \varphi_3}\left(\varphi_1(\alpha\hat{a}_t - (1-\alpha)\hat{n}_t) + \varphi_2\hat{n}_t + \varphi_3\hat{w}_1\right) \tag{65}$$

The expression in brackets determines whether the wage response increases or decreases. The first term in that bracket denotes the impact of the internal reference (with weight φ_1) and the second term the impact of the outside option (with weight $\varphi_2 = 1 - \varphi_1 - \varphi_3$) on the wage response. Obviously, the first can outweigh the second or vice versa. Putting more weight on the IR thus leads to an ambiguous effect because the impact of the internal reference on the wage response can be smaller or larger than the impact of the outside option. As IR and ER form a weighted average (as φ_1 increases, φ_2 decreases), not the absolute, but relative effect of the IR is relevant for the reaction of the wage response. With one difference this intuition corresponds to the DK (2007) model, provided in section 3.2.2. Here solely the direct effect of a change in φ_1 (neglecting the indirect/ general equilibrium effect) is enough to make the wage response ambiguous.

3.3.2.2 Monetary shock

Under a monetary shock with $\hat{a}_t = 0$ the effect of employment determines the wage response. According to eq. (62), an increase in the weight on the IR unambiguously increases the degree of wage rigidity. Despite the weighted average of the two references an unambiguous effect arises. In fact, the effect of the ER on the wage response is positive, while the effect of the IR is now negative. Thus, the effect of the IR relative to the ER always leads to an increase in wage rigidity. However, as shown below, this result is not very robust.

As pointed out above it is impossible for wages to exceed the IR and the ER lacks the complementary event of becoming unemployed. The first item can be addressed by defining the IR to be a function of revenue per worker:

IR $= (\psi_t y_t / n_t)^\nu$ with $0 < \nu < 1$. The second can be resolved by including unemployment benefits into the outside option: $\omega_t = \bar{w}_t^{\bar{n}_t} \bar{b}_t^{1-\bar{n}_t}$. Thus the outside option is defined as a geometric mean of finding a job elsewhere and earning $\bar{w}_t$ times its probability $\bar{n}_t$ and staying unemployed and receiving benefits $\bar{b}_t$ times the counter-probability $1 - \bar{n}_t$. Considering these changes reveals that the wage response is also ambiguous after the monetary growth shock.

Let's assume that unemployment benefits are given by a replacement ratio $\bar{b}_t = \rho \bar{w}_{t-1}$. A certain share of the wage earned before becoming unemployed is paid as benefit. As such the outside option is very close to actual labor market institutions. Finally the wage equation is given by:[6]

$$ln(w_t) = \frac{\frac{1-\varphi_1 \nu}{\theta+1-\alpha} + \varphi_1 \nu ln\left(\psi_t \frac{y_t}{n_t}\right) + (1-\varphi_1-\varphi_3)(1-n_t) ln\left(\rho w_{t-1}\right) + \varphi_3 ln(w_{t-1})}{1-(1-\varphi_1-\varphi_3)n_t} \tag{66}$$

Note that past periods wages enter wage-setting twice. Firstly they enter as entitlement reference for workers who remain employed in the same firm and secondly they enter in form of unemployment benefits for those workers who lost their jobs in the current period. The IR is similar to above however now it is possible for wages to be higher than the IR which ensures positive effort. Log-linearization, dropping constants and abstracting from physical capital leads to the following wage dynamics.

$$\hat{w}_t = \frac{\varphi_1 \nu(\alpha \hat{a}_t - (1-\alpha)\hat{n}_t) + (1-\varphi_1-\varphi_3)((1-n)\hat{w}_{t-1} - n ln(\rho)\hat{n}_t) + \varphi_3 \hat{w}_{t-1}}{1-(1-\varphi_1-\varphi_3)n} \tag{67}$$

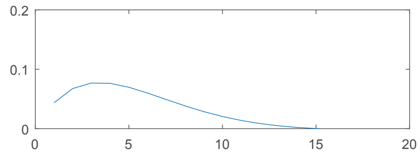
With $\hat{a}_t = 0$, the impact of the IR enters negatively into the wage response. However, in contrast to the original model, the outside option makes wage dynamics depend on the steady state employment rate n. When steady state employment increases in φ_1, then an increase in φ_1 can lead to a larger positive impact of the external reference on the wage response. This can outweigh the negative effect of the IR and thus makes the impact of an increase in φ_1 on the wage response ambiguous.

Figure 3 displays the impulse response functions of real wages in the full model due to a monetary policy shock as described by eq. (64) at different levels of φ_1. With few exceptions the quantitative evaluation of the model follows the calibration and baseline estimates of DK (2010) and is described in more detail in appendix 3.A.5.3. Regarding internal and external reference it is assumed that $\nu = 0.5$ and $\rho = 0.3$, which implies a replacement ratio of 30 %.

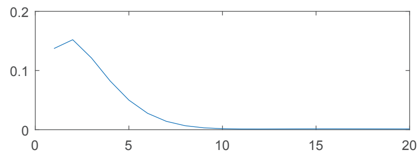
Note how the wage response increases with rent-sharing - the exact opposite reaction as described by DK (2010). At $\varphi_1 = 0.25$ the response more than doubles compared to zero weight on the IR. The hump-shaped course of the wage response is due to the fact that unemployment benefits are given by a replacement ratio of past wages. At low levels of φ_1, i.e. a high weight on the ER, this produces a very sluggish wage response. This effect looses strength with the increase in φ_1.

[6] See appendix 3.A.4 and 3.A.5 for the full description of the model.

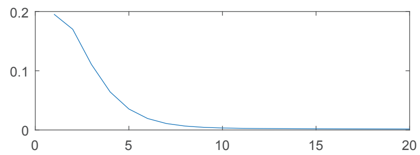
FIGURE 3 Wage reaction after monetary policy shock



(a) $\varphi_1 = 0.0$



(b) $\varphi_1 = 0.15$



(c) $\varphi_1 = 0.25$

For most parameters calibration follows DK (2010) and is described in more detail in appendix 3.A.5.3. Parameters: $\alpha = 0.75$, $\beta = 0.99$, $\theta_p = 10$, $\delta = 0.025$, $\mu_M = 1$, $\kappa_p = 0.6$, $\sigma_u = 1$, $\omega_p = 0.0$, $\rho_{\mu_M} = 0.55$, $\sigma_{\varepsilon_{\mu_M}} = 0.159$, $\lambda = 1000$, $\theta = 1.0$, $A = 1$, $\rho = 0.3$, $\nu = 0.5$ and $\varphi_3 = 0.25$.

As such, a simple and well-founded modification of the original model reveals that internal references can have an ambiguous effect on wage rigidity also in case of a monetary shock. The intuition is similar to DK (2007). First, an increase in φ_1 directly increases the negative effect of the IR and decreases the positive effect of the ER on the wage response. Second, an increase in φ_1 gives also rise to an indirect general equilibrium effect. If steady state employment increases and the employment reaction ($\hat{n}_t$) decreases in φ_1 then the negative effect of the IR decreases and the positive effect of the ER increases. As such an increase in the weight on the IR comprises two opposite effects in each reference. As IR and ER form a weighted average (keeping φ_3 constant), the relative (net) effect of the IR matters for the reaction of the wage response.

An unambiguous effect arises in the original model: Increasing φ_1 directly increases the dampening effect of the IR on the wage response and decreases the positive effect of the ER. The indirect effect remains small and does not matter. However, considering the full outside option makes the indirect effect more pronounced. Increasing φ_1 directly increases the dampening effect of the IR on the wage response but now also increases the positive effect of the ER (as steady state employment increases in φ_1). Thus taken together, the relative effect is ambiguous, which ultimately matters for the wage response.

3.4 The KS (2009) model revisited

3.4.1 Basic features of the model

The KS (2009) model develops on DK (2006) and includes an IR into the Akerlof (1982) effort function, see eq. (2) p. 82. As such the authors are the first to nest an Akerlof (1982) effort function with IR in a static general equilibrium model. Production is as in DK (2007) with decreasing returns to labor. The effect of the IR on wage rigidity is analyzed by exogenous labor demand shocks. Simulation results are provided which show that wages become more rigid the more important the IR.

The effort function is given as follows.[7]

$$e = -a_0 + a_1 \left(\left(\frac{w}{y/n} \right)^{\varphi_1} \left(\frac{w}{\omega} \right)^{\varphi_2} \right)^{\gamma} \quad \text{with } 0 < \gamma < 1,\ a_0, a_1 > 0 \tag{68}$$

a_0, a_1 and γ are positive constants. The outside option is given by expected earnings ($\omega = \bar{w}^{\bar{n}} \bar{b}^{1-\bar{n}}$). Output ($y$) per worker ($n$) is used as IR and the rent associated with employment is a weighted average of internal and external wage reference with weights φ_1 and $\varphi_2 = 1 - \varphi_1$. It holds that $0 \leq \varphi_1 < 1$. The equilibrium is given by the wage-setting curve from eq. (5) p. 83:

$$ln(w) = \frac{\frac{1}{\gamma} ln \left(\frac{a_0}{a_1(1-\gamma(1-\varphi_1))} \right) + \varphi_1 ln\,(y/n) + (1-\varphi_1)(1-n) lnb}{1-(1-\varphi_1)n} \tag{69}$$

Labor demand, given in eq. (3) p. 82:

$$ln(w) = ln \left(\frac{\alpha}{1-\varphi_1(1-\alpha)} \right) + ln \left(\frac{y}{n} \right) \tag{70}$$

Optimal effort is constant, given by eq. (4) in the paper:

$$e = \frac{\gamma(1-\varphi_1)}{1-\gamma(1-\varphi_1)} a_0 \tag{71}$$

The intuition on the effect of employment on wages is similar to DK (2007). The authors conclude that "the more important the internal reference relative to the external view becomes, the more rigid wages react to exogenous labor demand shocks" (p. 84).

7 Please see appendix 3.A.6 for a more detailed derivation of the model.

3.4.2 Wage rigidity

An adverse change in A represents an exogenous labor demand shock. The elasticities of equilibrium employment and wages are given as follows.[8]

$$|\varepsilon_{n^*A}| = \frac{1}{1-\alpha+\frac{n^*}{1-n^*}\left(ln(w^*)-ln(b)\right)} \tag{72}$$

$$|\varepsilon_{w^*A}| = \frac{\frac{n^*}{1-n^*}\left(ln(w^*)-ln(b)\right)}{1-\alpha+\frac{n^*}{1-n^*}\left(ln(w^*)-ln(b)\right)} \tag{73}$$

It can be shown that it is sufficient to focus on just one elasticity. Deriving the employment elasticity with regard to φ_1 gives

$$\frac{\partial|\varepsilon_{n^*A}|}{\partial\varphi_1} = -\frac{{\varepsilon_{n^*A}}^2}{1-n^*}\left[\frac{ln(w^*)-ln(b)}{1-n^*}\frac{\partial n^*}{\partial\varphi_1}+\frac{n^*}{w^*}\frac{\partial w^*}{\partial\varphi_1}\right] \lesseqgtr 0 \tag{74}$$

In contrast to DK (2007), there is no direct effect of φ_1. As shown in appendix 3.A.7, the reaction of equilibrium wages and employment with regard to φ_1 is ambiguous. An increase in the weight of the IR does not necessarily lead to higher wage rigidity. The authors do not derive this result since they consider shocks which shift labor demand along the wage-setting curve, see eq. (6) respectively (9) p. 84. However a change in A not only shifts labor demand but also shifts wage-setting due to the IR. In fact the internal reference contains all variables which can be found in labor demand. As such a shock which shifts labor demand necessarily also shifts the wage-setting curve.

TABLE 6 Wage elasticity after technology shock

φ_1	0	0.1	0.2	0.3	0.4	0.5	0.6
ε_{w^*A}	0.8872	0.8846	0.8838	0.8864	0.8956	0.9196	0.9838

The elasticities are calculated as a percentage change in absolute values. This corresponds directly to eq. (73). Parametrization is as follows, $\alpha = 0.7$, $\gamma = 0.1$, $a_0 = 100$, $a_1 = 105$, $b = 1.0$, $A = 1.0$ and $\triangle A = -1\%$. For $\varphi_1 = 0.4$ benefits b imply a replacement ratio of 0.31 and an equilibrium employment rate of 0.69. The average replacement ratio is 0.29. In the shaded area the internal reference leads to a lower degree of wage rigidity.

Parameterizing the model and calculating equilibrium wage elasticities confirms the analytical results. Table 6 shows the wage elasticity at different levels of φ_1. In the shaded area the IR leads to an increase in wage volatility. This happens at the core of the model, e.g. at $\varphi_1 = 0.4$ the equilibrium employment rate is 0.69

8 The derivation of both elasticities is similar to appendix 3.A.2.1. In contrast to DK (2007) a replacement ratio of $b = \rho w$ changes the working mechanism of the model entirely. It then holds that $\varepsilon_{n^*A} = 0$ and $\varepsilon_{w^*A} = 1$. As such the IR, respectively an increase in φ_1, has no effect at all on the degree of wage rigidity.

with a replacement ratio of 0.31. Similar to sections 3.2 and 3.3 the intuition lies in the fact that IR and ER are both sources of wage rigidity which are traded off. The difference to DK (2007), (2010) however is that only the indirect general equilibrium effect drives the results. When employment decreases in φ_1 the attenuating effect of the IR gets stronger and the effect of the ER on wage rigidity decreases. In table 6 this happens at lower levels of φ_1 (columns 2-4). When employment increases in φ_1 the attenuating effect of the IR decreases and the effect of the ER increases. In table 6 this happens at higher levels of φ_1 (columns 5-7).

To conclude, as the references form a weighted average, the effect of the IR relative to the ER decides on whether the wage elasticity increases or decreases. In fact, KS (2009) find that wage rigidity falls with an increase in the replacement ratio (see table 1, p. 85), which implies that the effect of the IR relative to the ER decreases. However the authors miss to identify that this mechanism can ultimately turn the sign of the effect on wage rigidity.

3.5 Conclusions

Theoretical research on internal references and wage rigidity, with the exception of the analysis of a technology shock in DK (2010), find that internal references lead unambiguously to a higher degree of wage rigidity. The core of this research is formed by the prominent models of Danthine and Kurmann (2007), (2010) and Koskela and Schöb (2009). This study analyzes these models and provides evidence that internal references do not unambiguously imply wage rigidity. This holds regardless of whether real or monetary shocks are considered and is in sharp contrast to the findings of the literature.

In the aforementioned models, internal references form a weighted average with the outside option. Increasing the weight on the internal reference thus implies a simultaneous decrease in the weight on the outside option. Both references affect the wage level and the wage response after shocks. Consequently, it is not sufficient to focus only on the effect of the internal reference on the degree of wage rigidity. What matters is the effect of the internal reference relative to the external reference. This ultimately explains the ambiguous effect on wage rigidity in all three articles.

Either a more careful formulation of internal references is required, for instance dropping the assumption of references as weighted average, or a more precise analysis of the exact conditions under which internal references lead to wage rigidity. While the second avenue would build on theoretical modeling and perhaps empirical analysis, the first would greatly benefit from further experimental evidence on how different references are related to each other. Furthermore, a more comprehensive analysis of internal references, which also focuses on the level of wages and employment, is needed. Internal references are a promising candidate to link rent-sharing and wage rigidity.

Besides the formulation of internal references a closer look at the production technology is warranted. All three models discussed in this paper assume production functions which exhibit decreasing returns to labor. Since the form of the production function directly impacts on the internal reference, it matters for the wage reaction after a shock. However the labor share can vary between industries and different types of firms have different types of production functions and some might even be subject to increasing returns over a certain range of production. Consequently the analysis of the impact of production technology on wage rigidity potentially presents an interesting avenue for future research.

3.A Appendix

3.A.1 Illustration of the DK (2007) model

Workers' preferences are assumed to consist of two components:

$$U = u(c,e) + \lambda s(w,e) \tag{75}$$

The first component implies direct utility from consumption c and direct disutility from effort e which takes the following form: $u(c,e) = ln(c) - e^{\theta}$, with $\theta > 1$. The second component captures the workers' tendency to reciprocate, where $\lambda > 0$ measures the relative importance of reciprocity considerations. Following Rabin (1993) $s(w,e)$ is defined as the product of the gifts of the worker and the firm:

$$s(w,e) = d(e,\cdot)g(w,\cdot) \tag{76}$$

In the constant-effort version of the model, the gift of the worker is directly measured in terms of effort: $d(e,\cdot) = e - e_r$ where effort is provided above a certain reference effort level e_r. The gift of the firm is measured as the difference in utility between the wage paid to an internal as well as external reference wage.

$$g(w,\cdot) = ln(w) - \varphi_1 ln\left((y/n)^{\nu}\right) - (1-\varphi_1)ln\left(\overline{w}^{\overline{n}} b^{1-\overline{n}}\right) \tag{77}$$

The (firm) internal reference (IR) is given by a function of the product per worker $\nu ln(y/n)$. The external reference (ER), respectively the outside option of the worker is given by the wage if hired by another firm ($\overline{w}$) with the probability of finding a job ($\overline{n}$) and the consumption of unemployment benefits (b) if no job is found with probability ($1-\overline{n}$). $0 \leq \varphi_1 \leq 1$ measures the weight put on the IR.

Plugging the respective gifts of the worker and the firm as well as the (dis-)utility derived from effort and consumption ($u(c,e)$) into the workers' preferences given in eq. (75), maximizing with respect to effort e and rearranging ultimately leads to the effort function shown in eq. (46).

As firms can not observe effort directly but are aware of the worker's reciprocal preferences the effort function is taken into consideration when deciding on wages and employment. The firm's goods demand is of the Blanchard-Kyotaki type where ψ measures firm's price setting power. The production function is subject to decreasing returns to labor and given by $f(e,n) = y = A(en)^{\alpha}$ with $\alpha < 1$. The firm's maximization problem is thus given by:

$$\max_{w,n} \quad \psi f(e,n) - wn \tag{78}$$

The first order conditions are given as follows.

$$w = \psi \left(f_n + f_e \frac{\partial e}{\partial n} \right) \tag{79}$$

$$n = \psi f_e \frac{\partial e}{\partial w} \tag{80}$$

Combining the two first order conditions leads to the so-called Modified Solow Condition which reads as:

$$\varepsilon_{e,w} - \varepsilon_{e,n} = 1 \tag{81}$$

Eq. (80) can be rewritten by taking into account that $f_n = Ae^{\alpha}n^{\alpha-1}\alpha = f_e e/n$:

$$w = \psi \left(\varepsilon_{e,n} + 1\right) f_n \tag{82}$$

Rearranging eq. (46) and applying the implicit function theorem allows to derive the following expressions for the respective elasticities:

$$\varepsilon_{e,w} = \frac{1}{(\theta - 1)\frac{\theta}{\lambda}e^{\theta-1} + \varphi_1 \nu \alpha} \tag{83}$$

$$\varepsilon_{e,n} = \frac{-\varphi_1 \nu (\alpha - 1)}{(\theta - 1)\frac{\theta}{\lambda}e^{\theta-1} + \varphi_1 \nu \alpha} \tag{84}$$

Plugging the explicit elasticities into the Modified Solow Condition from eq. (81) leads to the following expression for effort:

$$\frac{\theta}{\lambda}e^{\theta-1} = \frac{1 - \varphi_1 \nu}{\theta - 1} \tag{85}$$

Through rearranging optimal effort can then be written as given in eq. (49).

Combining the effort function from eq. (46) and the Modified Solow Condition from eq. (81) and considering the explicit expressions for the elasticities derived above wage-setting can be written as follows:

$$lnw = \frac{1 - \varphi_1 \nu}{\theta - 1} + \varphi_1 \nu ln \left(\frac{y}{n}\right) + (1 - \varphi_1) \left(\overline{w}^{\overline{n}} b^{1-\overline{n}}\right) \tag{86}$$

Aggregating the model by considering $\overline{w} = w$ and $\overline{n} = n$ and rearranging the wage-setting curve can be written as given in eq. (47).

Plugging the explicit expression of the elasticity of effort with regard to employment from eq. (84) into the modified first order condition from eq. (82) and taking into account that $f_n = Ae^{\alpha} n^{\alpha-1}\alpha = \alpha y/n$ labor demand can be written as follows:

$$w = \psi \left(\frac{1}{1+\varphi_1 \nu(\alpha-1)} \right) \alpha \frac{y}{n} \tag{87}$$

Rearranging eq. (87) leads to the labor demand equation as depicted in eq. (48).

3.A.2 DK (2007): Derivation of elasticity of employment and wages

3.A.2.1 with regard to A

Implicit equilibrium employment is given by:

$$\Phi = \frac{\frac{1-\varphi_1\nu}{\theta-1} + \varphi_1 \nu ln\left(Ae^{\alpha} n^{*\alpha-1}\right) + (1-\varphi_1)(1-n^*)lnb}{1-(1-\varphi_1)n^*} \\ -ln\left(\frac{\psi\alpha}{1-\varphi_1\nu(1-\alpha)}\right) - ln\left(Ae^{\alpha}n^{*\alpha-1}\right) \tag{88}$$

Implicitly differentiating eq. (88) with regard to A and n^*, re-substituting and rearranging leads to the following two expressions:

$$\Phi_A = -\frac{1-(1-\varphi_1)n^* - \varphi_1\nu}{1-(1-\varphi_1)n^*}\frac{1}{A} \tag{89}$$

$$\Phi_{n^*} = \frac{(1-\alpha)(1-(1-\varphi_1)n^*-\varphi_1\nu) + (1-\varphi_1)n^*(lnw^*-lnb)}{1-(1-\varphi_1)n^*}\frac{1}{n^*} \tag{90}$$

The reaction of equilibrium employment due to an exogenous change in A is thus given by $\partial n^*/\partial A = -\Phi_A/\Phi_{n^*}$ and the respective employment elasticity depicted in eq. (52) is obtained through $\partial n^*/\partial A \cdot A/n^* = -\Phi_A/\Phi_{n^*} \cdot A/n^* \equiv \varepsilon_{n^*A}$.

Equilibrium wages are obtained by plugging in equilibrium employment in the wage-setting curve:

$$lnw^* = \frac{\frac{1-\varphi_1\nu}{\theta-1} + \varphi_1\nu ln\left(Ae^{\alpha}n^{*\alpha-1}\right) + (1-\varphi_1)(1-n^*)lnb}{1-(1-\varphi_1)n^*} \tag{91}$$

By considering $n^*(A)$, re-substitution and rearranging, the derivation of eq. (91) with regard to A can be written as follows.

$$\frac{\partial w^*}{\partial A} = w^* \cdot \frac{\varphi_1\nu\frac{1}{A} + \left((1-\varphi_1)(lnw-lnb) - \varphi_1\nu(1-\alpha)\frac{1}{n^*}\right)\frac{\partial n^*}{\partial A}}{1-(1-\varphi_1)n^*} \tag{92}$$

By plugging $\partial n^*/\partial A$ into equation (92) an explicit expression of the reaction of equilibrium wages to a change in A can be obtained. The respective elasticity $\varepsilon_{w^*A} \equiv \partial w^*/\partial A \cdot A/w^*$ is ultimately given by eq. (53).

3.A.2.2 with regard to $M = y$

The monetary shock implies a direct decrease in output which leads through the production function to a decrease in employment. Differentiating the inverse production function $n = y^{1/\alpha}A^{-1/\alpha}e^{-1}$ with regard to y and resubstituting leads to:

$$\frac{\partial n^*}{\partial y} = \frac{1}{\alpha}\frac{n}{y} \tag{93}$$

The elasticity of employment with regard to a exogenous change in $M = y$ is thus obtained by $\partial n^*/\partial y \cdot y/n^* \equiv \varepsilon_{n^*y}$ as given in eq. (55).

As shown above the equilibrium wage is given by eq. (91). Deriving this equation with regard to $M = y$ and considering the inverse production function $n^*(y)$ and resubstituting leads to the following reaction of wages:

$$\frac{\partial w^*}{\partial y} = \frac{\varphi_1\nu(\alpha-1) + (1-\varphi_1)n(lnw - lnb)}{\alpha(1-(1-\varphi_1)n)}\frac{w}{y} \tag{94}$$

Similarly to above the elasticity of wages with regard to a exogenous change in $M = y$ is thus obtained by $\partial w^*/\partial y \cdot y/w^* \equiv \varepsilon_{w^*y}$ as given in eq. (56).

3.A.3 DK (2007): Reaction of w^* and n^* with regard to φ_1

Derivation of equilibrium employment with regard to φ_1 gives

$$\begin{aligned}
\frac{\partial n^*}{\partial \varphi_1} = & \frac{(1-(1-\varphi_1)n^*-\varphi_1\nu)^{-1}}{(1-(1-\varphi_1)n^*-\varphi_1\nu)(1-\alpha)\frac{1}{n^*} + (1-\varphi_1)\left(ln(w^*)-ln(b)\right)} \\
& \left[\frac{\nu(1-\alpha)(1-(1-\varphi_1)n^*-\varphi_1\nu)(1-(1-\varphi_1)n^*)}{1-\varphi_1\nu(1-\alpha)}\right. \\
& -\frac{\alpha\nu(1-(1-\varphi_1)n^*-\varphi_1\nu)^2}{(\theta-1)(1-\varphi_1\nu)} + \frac{n^*(1-\nu)}{\theta-1} \\
& \left. +(1-n^*)\nu ln\left(\frac{\psi\alpha}{1-\varphi_1\nu(1-\alpha)}\right) + (1-n^*)(1-\nu)ln(b)\right] \gtrless 0
\end{aligned} \tag{95}$$

The fraction in the first line is positive. The expression in square brackets determines the sign of the derivation. Depending on the parameters in this expression it can be positive or negative. An increase in the weight on the internal reference can lead to lower or higher employment. The same holds for the effect on wages:

$$\frac{\partial w^*}{\partial \varphi_1} = w^* \left(\frac{\nu(1-\alpha)}{1-\varphi_1\nu(1-\alpha)} - \frac{\nu\alpha}{(1-\varphi_1\nu)(\theta-1)} - (1-\alpha)\frac{1}{n^*}\frac{\partial n^*}{\partial \varphi_1} \right) \gtrless 0 \qquad (96)$$

3.A.4 Illustration of the DK (2010) model

Households' optimization problem is given by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ ln(c_t - \zeta c_{t-1}) + n_t \left[ln(1-H) - \frac{1}{\theta+1} e_t^{\theta+1} + \lambda s(e_t, \cdot) \right] \right\} \qquad (97)$$

subject to

$$\frac{M_{t+1}}{P_t} = r_t \left[\frac{M_t}{P_t} - q_t + (\mu_{M,t} - 1)\frac{\bar{M}_t}{P_t} \right] + q_t + w_t n_t + r_t^k k_t + d_t - (1+\eta(v_t))c_t - i_t (98)$$

and

$$k_{t+1} = (1-\delta(u_t))k_t + v_t f(i_t, i_{t-1}) \qquad (99)$$

Households' preferences correspond to eq. (75) with several differences. Utility depends on current (c_t) as well as previous period's consumption (c_{t-1}), with $\zeta \geq 0$ being an external habit parameter. H denotes the fixed number of hours of a work shift. Households thus provide a lottery which chooses fraction n_t for work and and $1 - n_t$ remain unemployed. See Rogerson (1988), and Hansen (1985) for details. Besides less free time employment is associated with the disutility of effort (e_t) and the utility of reciprocating a gift $s(e_t, \cdot)$, where $\lambda > 0$ measures the importance of that consideration. This setup directly corresponds to DK (2007).

Regarding the constraints, r_t denotes the interest rate, M_t the money stock, P_t price level, q_t real cash holdings and $(\mu_{M,t} - 1)\frac{\bar{M}_t}{P_t}$ the lump sum transfer of the central bank after monetary shock. r_t^k denotes the renal rate of capital k_t, d_t dividends, i_t investments and $\eta(v_t)$ the transaction costs of consumption with $v_t = c_t/q_t$. Capital depreciation is a function of capital utilization $\delta(u_t)$; v_t an exogenous investment-specific technology parameter and f a function which translates investment into capital. $v_t f(i_t, i_{t-1})$ thus refers to capital installed at the end of period t.

Similarly to eq. (76) the reciprocity component in the utility function is given by the product of the two gifts: $s(e_t, \cdot) = d(e_t, \cdot)g(w_t, \cdot)$. The gift of the worker is given by $d(e_t, \cdot) = e_t^\alpha - e_r^\alpha$, were e_r denotes a reference effort level which is assumed to be zero. The firm's gift is given by the difference in utility between the wage paid and three reference points.

$$g(w_t, \cdot) = ln(w_t) - \varphi_1 ln\left(\psi_t y_t / n_t\right) - (\varphi_2) ln\left(\omega_t\right) - \varphi_3 ln(\bar{w}_{t-1}) \qquad (100)$$

The first reference is the IR, given by revenue per worker, the second is given by the outside option and the third by past average wages reflecting wage entitlement. Note that in DK (2010) it holds that $\omega_t = n_t w_t$. This implies that the fact, that a worker may end up unemployed, is neglected. Solving the household's maximization problem with regard to effort e_t and rearranging leads to the effort function as depicted in eq. (58).

Three different types of firms are included in the model, intermediate goods producer, retailers and financial intermediary.[9] The intermediate goods firms employ labor and capital to produce good y_t. Retailers purchase y_t in a competitive market and produce by linear transformation a final differentiated good $y_t(z)$. The financial intermediary gives loans to the intermediate goods firms to cover the wage bill. These loans are funded by household deposits.

The intermediate goods producer's production function is given by $y_t = f(e_t, n_t, u_t, k_t) = (A_t e_t n_t)^{\alpha} (u_t k_t)^{1-\alpha}$ with $\alpha < 1$. A_t denotes technology with growth rate $\mu_{A,t}$, which is subject to an exogenous shock, see eq. (63). The intermediate goods producer's problem is given by:

$$E_0 \sum_{j=0}^{\infty} \beta^j \left[\psi_{t+j} y_{t+j} - r_{t+j} w_{t+j} n_{t+j} - r^k_{t+j} k_{t+j} \right] \tag{101}$$

Note that firms need to borrow the wage bill from financial intermediary which implies that labor costs are multiplied with interest rate r_{t+j} in period $t+j$. The first order conditions with respect to n_t and e_t are given as follows.

$$r_t w_t = \psi_t \left(f_{n_t} + f_{e_t} \frac{\partial e_t}{\partial n_t} \right) \tag{102}$$

$$r_t n_t = \psi_t f_{e_t} \frac{\partial e_t}{\partial w_t} \tag{103}$$

Combining these two first order conditions leads to a dynamic version of the Modified Solow Condition, see eq. (81):

$$\varepsilon_{e_t, w_t} - \varepsilon_{e_t, n_t} = 1 \tag{104}$$

Eq. (103) can be rewritten by taking into account that $f_{n_t} = f_{e_t} e_t / n_t$:

$$r_t w_t = \psi_t \left(\varepsilon_{e_t, n_t} + 1 \right) f_{n_t} \tag{105}$$

Rearranging eq. (58) and implicitly differentiating allows to derive the fol-

[9] As the focus of this paper is on the wage rigidity implications of the IR, this appendix provides a detailed derivation of the equations governing the labor market. A short overview over the other optimality conditions is given at the end of this appendix.

lowing expressions for the respective elasticities:

$$\varepsilon_{e_t,w_t} = \frac{\alpha\lambda}{(\theta+1-\alpha)e_t^{\theta+1-\alpha} + \varphi_1\lambda\alpha^2} \tag{106}$$

$$\varepsilon_{e_t,n_t} = \frac{\alpha\lambda(1-\alpha)\varphi_1}{(\theta+1-\alpha)e_t^{\theta+1-\alpha} + \varphi_1\lambda\alpha^2} \tag{107}$$

Plugging the explicit elasticities into the Modified Solow Condition from eq. (104) leads to the following expression for effort:

$$e_t^{\theta+1-\alpha} = \frac{\alpha\lambda(1-\varphi_1)}{\theta+1-\alpha} \tag{108}$$

Therefore optimal effort is constant and can then be written as given in eq. (61). Combining the effort function from eq. (58) and the Modified Solow Condition from eq. (104) and considering the explicit expressions for the elasticities derived above, wage-setting can be written as follows:

$$ln(w_t) = \frac{1-\varphi_1}{\theta+1-\alpha} + \varphi_1 ln\left(\psi_t\frac{y_t}{n_t}\right) + (1-\varphi_1-\varphi_3)(\omega_t) + \varphi_3 ln(w_{t-1}) \tag{109}$$

Aggregating the model by setting $\omega_t = n_t w_t$ and considering the production function the wage-setting curve can be written as given in eq. (59). Plugging ε_{e_t,n_t} from eq. (107) into the modified first order condition from eq. (105) and taking into account that $f_{n_t} = \alpha y_t / n_t$ labor demand can be written as follows:

$$r_t w_t = \psi_t \left(\frac{1}{1-\varphi_1(1-\alpha)}\right)\alpha\frac{y_t}{n_t} \tag{110}$$

Considering the production function, the result from eq. (113) below and taking logs in eq. (110) leads to the labor demand equation as depicted in eq. (60).

In order to simplify the analysis the following assumptions are made: zero investment adjustment costs ($f(i_t, i_{t-1}) = i_t$), no habit formation ($\zeta = 0$) and no transaction costs of cash holdings ($\eta = 0$, implying $q_t = c_t$). Since the focus is on the neutral technology shock as well as the monetary shock, (as in section 3.2.2), the investment specific shock is neglected ($v_t = 1$). This leads to the following capital accumulation and household equilibrium conditions:

$$k_{t+1} = (1-\delta(u_t))k_t + i_t \tag{111}$$

$$\frac{1}{c_t} = \beta E_t\left[\frac{1}{c_{t+1}}\left(r_{t+1}^k + 1 - \delta(u_{t+1})\right)\right] \tag{112}$$

$$r_t = 1 \tag{113}$$

Similarly to the derivation of labor demand, optimal utilization and capital demand can be obtained. Solving the firm's problem in eq. (101) with regard to k_t and deriving an explicit expression for the elasticity of effort with regard to capital, leads to the following demand for capital:

$$r_t^k = \frac{(1-\alpha)(1-\varphi_1)}{1-(1-\alpha)\varphi_1}\psi_t \frac{y_t}{k_t} \tag{114}$$

Similarly optimal utilization is given by:

$$\delta'(u_t)k_t = \frac{(1-\alpha)(1-\varphi_1)}{1-(1-\alpha)\varphi_1}\psi_t \frac{y_t}{u_t} \quad \rightarrow \quad \delta'(u_t)u_t = r_t^k \tag{115}$$

The aggregate price index is given as follows, with $\pi_{t-1} \equiv P_{t-1}/P_{t-2}$ i.e. last period's inflation and $\bar{\pi}$ denoting average inflation:

$$P_t^{1-\theta_p} = (1-\kappa_p)P_t^{1-\theta_p} + \kappa_p \left(\pi_{t-1}^{\omega_p}\bar{\pi}^{1-\omega_p}P_{t-1}\right)^{1-\theta_p} \tag{116}$$

Based on Calvo (1983), DK propose that any retailer has a probability of $1-\kappa_p$ to reoptimize its price. With the counter-probability κ_p the retailer can only update its price from last period by a weighted average of past and average inflation. θ_p denotes the elasticity of substitution across goods. The optimal price of the retailer is given by:

$$P_{t,t}(z) = \frac{\theta_p}{\theta_p - 1}\frac{\sum_{j=0}^{\infty}(\beta\kappa_p)^j E_t\left[\Lambda_{t+j}\left(\Pi_{k=1}^{j}\left(\pi_{t+k-1}^{\omega_p}\bar{\pi}^{1-\omega_p}\right)^{-\theta_p}\right)P_{t+j}^{\theta_p}y_{t+j}\psi_{t+j}\right]}{\sum_{j=0}^{\infty}(\beta\kappa_p)^j E_t\left[\Lambda_{t+j}\left(\Pi_{k=1}^{j}\left(\pi_{t+k-1}^{\omega_p}\bar{\pi}^{1-\omega_p}\right)^{1-\theta_p}\right)P_{t+j}^{\theta_p-1}y_{t+j}\right]} \tag{117}$$

The loan market is assumed to be in equilibrium (with $m_t \equiv M_t/P_t$), and the nominal growth rate of money $\mu_{M,t}$ is linked to m_t as follows:

$$w_t n_t = \mu_{M,t} m_t - q_t \tag{118}$$

$$\mu_{M,t} = \frac{M_t}{M_{t-1}} = \frac{P_t m_t}{P_{t-1}m_{t-1}} = \pi_t \frac{m_t}{m_{t-1}} \tag{119}$$

Finally national income is given as follows, with X_t denoting the fixed costs of retailers (following DK fixed costs are defined as $X_t = A_t$):

$$y_t = c_t + i_t + \phi X_t \tag{120}$$

Equations (111) to (120) together with the labor market conditions from the main text, the monetary policy rule and the production function of the intermediate goods producers fully describe the general equilibrium dynamics of the model.

3.A.4.1 Steady state

This section summarizes the steady state equations of the model. Regarding the labor market the steady state is given as follows:

Optimal effort (as effort is constant its steady state value is identical to eq. (61)).

$$e = \left(\frac{\alpha\lambda(1-\varphi_1)}{\theta+1-\alpha} \right)^{\frac{1}{\theta+1-\alpha}} \tag{121}$$

Wage setting:

$$\varphi_1 ln(w) = \frac{1-\varphi_1}{\theta+1-\alpha} + \varphi_1 ln\left(\psi\frac{y}{n}\right) + (1-\varphi_1-\varphi_3)ln(n) \tag{122}$$

Labor demand:

$$ln(w) = ln\frac{\psi\alpha}{1-(1-\alpha)\varphi_1} + ln\left(\frac{y}{n}\right) \tag{123}$$

The household optimality conditions are given by:

$$\frac{i}{k} = \delta \tag{124}$$

$$r^k = \frac{1}{\beta} - (1-\delta) \tag{125}$$

$$r = 1 \tag{126}$$

Capital demand and optimal utilization are given as follows:

$$r^k = \frac{(1-\alpha)(1-\varphi_1)}{1-(1-\alpha)\varphi_1}\psi\frac{y}{k} \tag{127}$$

$$\delta'(u)u = r^k \tag{128}$$

Following Altig et al. (2011) it is imposed that $u = 1$ which allows to treat δ and σ_u (see eq. (141)) as parameters.

The relative price of intermediate goods simplifies to:

$$\psi = \frac{\theta_p - 1}{\theta_p} \tag{129}$$

With zero transaction costs of cash holdings it holds that:

$$q = c \tag{130}$$

The loan market equilibrium is given by:

$$wn = \mu_M m - q \tag{131}$$

Fixed costs of retailers are set such that dividends are zero. This implies that $\phi/y = 1 - \psi = 1/\theta_p$. Therefore the national income identity can be written as:

$$\frac{c}{y} = 1 - \frac{i}{y} - \frac{1}{\theta_p}A \tag{132}$$

Finally the intermediate goods producers' production function is given as follows.

$$y = (Aen)^{\alpha}(uk)^{1-\alpha} \tag{133}$$

3.A.4.2 System of log-linearized equations

This section summarizes the log-linearized equations of the model. Hatted variables are defined as percentage-deviations from the steady state described above. Note that for the ease of exposition log-linearization is done around the steady state described above and not around the balanced growth path as done by DK.

Labor market:

$$\hat{e}_t = 0 \tag{134}$$

$$(\varphi_1 + \varphi_3)\hat{w}_t = \varphi_1\left(\hat{\psi}_t + \hat{y}_t - \hat{n}_t\right) + (1 - \varphi_1 - \varphi_3)\hat{n}_t + \varphi_3\hat{w}_{t-1} \tag{135}$$

$$\hat{w}_t = \hat{\psi}_t + \hat{y}_t - \hat{n}_t \tag{136}$$

Capital accumulation and household optimality conditions:

$$\hat{k}_{t+1} = (1 - \delta(u))\left(\hat{k}_t - \delta'(u)u\hat{u}_t\right) + \frac{i}{k}\hat{i}_t \tag{137}$$

$$-\hat{c}_t = \beta E_t\left[r^k\hat{r}^k_{t+1} - \left(r^k + (1 - \delta(u))\right)\hat{c}_{t+1} - (1 - \delta(u))\delta'(u)u\hat{u}_{t+1}\right] \tag{138}$$

$$\hat{r}_t = 0 \tag{139}$$

Capital demand and optimal utilization:

$$\hat{r}^k_t = \hat{\psi}_t + \hat{y}_t - \hat{k}_t \tag{140}$$

$$(1 + \sigma_u)\,\hat{u}_t = \hat{r}^k_t \quad \text{with} \quad \sigma_u \equiv \frac{\delta''(u)u}{\delta'(u)} \tag{141}$$

Price setting:

$$\left(1+\omega_p\beta\right)\hat{\pi}_t=\beta E_t\left[\hat{\pi}_{t+1}\right]+\omega_p\hat{\pi}_{t-1}+\frac{(1-\kappa_p)(1-\beta\kappa_p)}{\kappa_p}\hat{\psi}_t \tag{142}$$

Cash holdings (zero transaction costs), loan market and nominal money growth:

$$\hat{q}_t=\hat{c}_t \tag{143}$$

$$\hat{w}_t+\hat{n}_t=\frac{\mu_M m\left(\hat{\mu}_{M,t}+\hat{m}_t\right)-q\hat{q}_t}{\mu_M m-q} \tag{144}$$

$$\hat{\mu}_{M,t}=\hat{\pi}_t+\hat{m}_t-\hat{m}_{t-1} \tag{145}$$

National income:

$$\hat{y}_t=\frac{c}{y}\hat{c}_t+\frac{i}{y}\hat{i}_t+\frac{A}{\theta_p}\hat{a}_t \tag{146}$$

Production function:

$$\hat{y}_t=\alpha\left(\hat{a}_t+\hat{n}_t\right)+(1-\alpha)\left(\hat{u}_t+\hat{k}_t\right) \tag{147}$$

Monetary shock as given by eq. (64).

3.A.5 Modified DK (2010) model

This appendix contains the model based on the modified internal and external reference (see section 3.3.2.2): IR $=(\psi_t y_t/n_t)^{\nu}$, and $\omega_t=w_t^{n_t}(\rho w_{t-1})^{1-n_t}$. The derivation of the equilibrium conditions is practically identical to appendix 3.A.4 which is why only those equations which differ from above are presented.

3.A.5.1 Steady state

Optimal effort:

$$e=\left(\frac{\alpha\lambda(1-\varphi_1\nu)}{\theta+1-\alpha}\right)^{\frac{1}{\theta+1-\alpha}} \tag{148}$$

Wage setting:

$$ln(w)=\frac{1-\varphi_1\nu}{(\theta+1-\alpha)\varphi_1}+\nu ln\left(\psi\frac{y}{n}\right)+\frac{1-\varphi_1-\varphi_3}{\varphi_1}(1-n)ln(\rho) \tag{149}$$

Labor demand:

$$ln(w) = ln\frac{\psi\alpha}{1-(1-\alpha)\varphi_1\nu} + ln\left(\frac{y}{n}\right) \tag{150}$$

Capital demand and optimal utilization::

$$r^k = \frac{(1-\alpha)(1-\varphi_1\nu)}{1-(1-\alpha)\varphi_1}\psi\frac{y}{k} \tag{151}$$

$$\delta'(u)u = r^k \tag{152}$$

3.A.5.2 System of log-linearized equations

All log-linearized equations are identical to appendix 3.A.4.2 with the exception of wage-setting (with $\varphi_2 = 1 - \varphi_1 - \varphi_3$):

$$\hat{w}_t = \frac{1}{1-\varphi_2 n}\left(\varphi_1\nu\left(\hat{\psi}_t + \hat{y}_t - \hat{n}_t\right) + \varphi_2((1-n)\hat{w}_{t-1} - nln(\rho)\hat{n}_t) + \varphi_3\hat{w}_{t-1}\right) \tag{153}$$

3.A.5.3 Calibration of model parameters

In large parts the calibration of the model follows DK (2010). The values of α, β, θ_p and δ are taken from table (1), p. 846. μ_M, the growth rate of money, is set to unity in order to allow a sensible log-linearization around the steady state. Estimates for the following parameters are taken directly from table (2), p. 847: σ_u, ω_p, ρ_{μ_M} and $\sigma_{\varepsilon_{\mu_M}}$. κ_p is set such that an average price rigidity of 2.5 periods results which is similar to DK (2010) and Bils and Klenow (2004). DK do not offer calibrated values or estimates for λ and θ as they do not affect model dynamics in the original model. They are parameterized such to allow a clear analysis of wage dynamics. As log-linearization takes place around the steady state an not the balance growth path as in DK (2010), A is set to unity.

3.A.6 Illustration of the KS (2009) model

KS assume perfect competition on the goods market and a production function with decreasing returns to labor $f(e,n) = y = A(en)^\alpha$ with $\alpha < 1$. Effort is not observable but the firm knows about worker's preferences which is why the effort function is taken into account when setting wages and employment. The firm's maximization problem reads as:

$$\max_{w,n} \quad f(e,n) - wn \tag{154}$$

As such the solution to this problem is very similar to appendix 3.A.1. The first order conditions yield the Modified Solow Condition and implicit differentiation of the effort function given in eq. (68) allows to derive the elasticity of effort with respect to wages and employment:

$$\varepsilon_{e,w} = \frac{\gamma a_1 \left(\frac{w}{(y/n)^{\varphi_1}\omega^{1-\varphi_1}}\right)^{\gamma}}{e + \varphi_1 \alpha \gamma a_1 \left(\frac{w}{(y/n)^{\varphi_1}\omega^{1-\varphi_1}}\right)^{\gamma}} \tag{155}$$

$$\varepsilon_{e,n} = \frac{\gamma \varphi_1 (1-\alpha) a_1 \left(\frac{w}{(y/n)^{\varphi_1}\omega^{1-\varphi_1}}\right)^{\gamma}}{e + \varphi_1 \alpha \gamma a_1 \left(\frac{w}{(y/n)^{\varphi_1}\omega^{1-\varphi_1}}\right)^{\gamma}} \tag{156}$$

Plugging both elasticities in the Modified Solow Condition yields the following expression for effort:

$$e = (1-\varphi_1)\gamma a_1 \left(\frac{w}{(y/n)^{\varphi_1}\,\omega^{1-\varphi_1}}\right)^{\gamma} \tag{157}$$

Considering this expression in the initial effort function from eq. (68) and simplifying leads to optimal effort as denoted by eq. (71). The derivation of wage-setting and labor demand is again similar to appendix 3.A.1.

3.A.7 KS (2009): Reaction of w^* and n^* with regard to φ_1

Derivation of equilibrium employment and wages is given by

$$\begin{aligned}\frac{\partial n^*}{\partial \varphi_1} = &\frac{(1-\varphi_1)^{-2}}{(1-\alpha)\frac{1-n^*}{n^*} + (ln(w^*) - ln(b))}\left[\frac{(1-\alpha)(1-\varphi_1)(1-(1-\varphi_1)n^*)}{1-\varphi_1(1-\alpha)}\right. \\ &+ \frac{(1-\varphi_1)(1-\alpha(1-n^*))}{1-\gamma(1-\varphi_1)} + ln\left(\frac{\alpha}{1-(1-\alpha)\varphi_1}\right) \\ &\left.-\frac{1}{\gamma} ln\left(\frac{a_0}{a_1(1-\gamma(1-\varphi_1))}\right)\right] \lesseqgtr 0\end{aligned} \tag{158}$$

$$\frac{\partial w^*}{\partial \varphi_1} = w^* \left(\frac{1-\alpha}{1-(1-\alpha)\varphi_1} - \frac{\alpha}{(1-\varphi_1)(1-\gamma(1-\varphi_1))} - (1-\alpha)\frac{1}{n^*}\frac{\partial n^*}{\partial \varphi_1}\right) \lesseqgtr 0 \tag{159}$$

In eq. (158) the denominator is positive. The expression in square brackets determines the sign. It can be positive or negative depending on the parameters in brackets. Note that in contrast to above the level of unemployment benefits b does not decide on the sign of the derivation any more.

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4 WAGE EFFECTS OF FIRM SIZE: EVIDENCE FROM LINKED EMPLOYER-EMPLOYEE PANEL

Abstract[*]
This study explores the relationship between wages and firm size using large registered data and different identification strategies. We find that the effect of firm size on wages is negligible when worker and firm characteristics are accounted for. The findings are robust across identification strategies and numerous covariates. The findings are also consistent with the view that coordinated wage-setting systems narrow wage distributions.

Keywords: Wages, firm size, premium, panel data, fixed effects

4.1 Introduction

Empirical and theoretical research on the relationship between wages and firm size has provided two main conclusions. First, wage differentials between small and large firms are substantial and pervasive, and, second, the firm-size wage premium arises from the labour market, the product market, or both. Typically, doubling the firm size increases wages by 4–6 per cent. Controls for certain worker characteristics (such as human capital) and firm characteristics (such as rent sharing) tend to halve the effect to 2–3 per cent.[1]

This study contributes to the literature in two novel ways. First, large and representative data allow us to identify the firm-size wage effect from different

1 See e.g. Albaek et al. (1998), Arai (2003), Barth and Dale-Olsen (2011), Brown and Medoff (1989), Ferrer and Lluis (2008), Green et al. (1996), Groshen (1991), Idson and Oi (1999), Kruse (1992), Lallemand et al. (2007), and Troske (1999). Table 1 in chapter 1.2 provides an overview over that literature.

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samples with varying identification assumptions: job stayers with a changing firm size, workers moving between firms of different sizes, and the job moves of displaced workers. Second, matched register data provide a rich set of observable covariates on workers and firms, of which some have not been controlled for in previous studies. In addition to conventional controls for human capital and firm characteristics, we control for the existence of profit-sharing schemes, capital intensity, skill group size, compensation for working conditions, effort-related differences in pay, and tightness in the local labour market. Finally this paper is among very few to estimate the firm size-wage effect for Finland.

4.2 Matched data and model

We exploit a 20% sample of private sector wage earners in Finland.[2] The panel data span the 2003–2010 period and include information on $283,757$ individuals working in $18,570$ firms. The number of unique combinations of workers and firms (job spells) is $384,041$, and the total number of observations is $1,162,325$. We also employ two subsamples: the first consists of workers changing firms over the investigation period. This sample includes $79,984$ different individuals working in $13,832$ different firms, with a total of $419,770$ wage observations. The second subsample consists of job moves due to firm closures. In this sample, the total number of observations is $11,138$, from $2,211$ individuals in $1,612$ different firms. In these subsamples, the number of unique worker-firm combinations varies from $5,338$ to $178,408$.

The overall quality of the data is worth noting: firm size is measured as a continuous variable; worker wages are measured on an hourly basis; and the often poorly measured firm heterogeneity can be controlled for by using a number of firm characteristics. Figures 4 and 5 provide two snapshots of the relationship between firm size and wages. Figure 4 describes the average development in wages over the estimation period by four size categories (micro, small, medium and large firms). The mean wage differential between the categories reveals a stable pattern. Figure 5, in turn, describes the variation in hourly wages in firms of different sizes. Fitted values show a very small but positive relation. To prevent identification, we have excluded all firms with more than $10,000$ workers. In our estimations, we use a continuous measure (log number of workers in a firm) as the main explanatory variable. The dependent variable is the worker's (log) hourly wage.

We use the linear three-way error-component model (see, e.g. Andrews et al. (2006) and write the standard Mincerian wage equation as follows:

$$w_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + \mathbf{w}_{j(i,t)t}\gamma + \phi_i + \psi_{j(i,t)} + \varepsilon_{it} \tag{160}$$

where workers ($i = 1, ..., N$) are observed once per period ($t = 1, ..., T$) in

[2] See appendices 4.A.1 and 4.A.2 for data and definitions.

a firm ($j = 1, ..., J$). Because workers can move from one firm to another over time, the function $j(i,t)$ maps worker i to firm j at time t. w_{it} denotes the dependent variable (log wages), and ε_{it} denotes a stochastic error term. x_{it} and $w_{j(i,t)t}$ are vectors of time-variant observables for workers and firms, whereas ϕ_i and ψ_j capture corresponding time-invariant unobservables.

FIGURE 4 The development of mean hourly wages from 2003-2010 in four firm size categories.

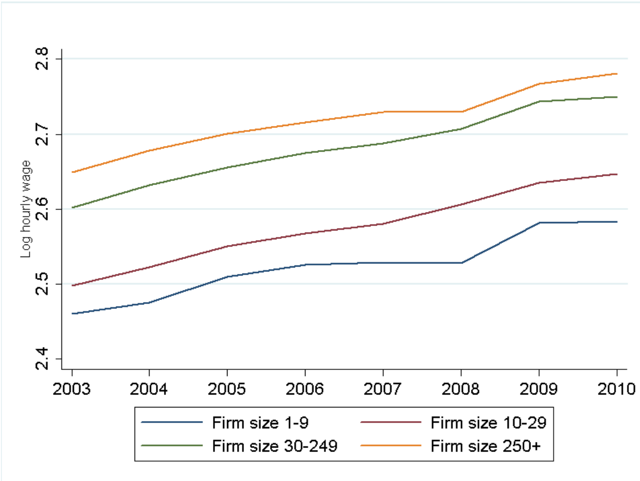
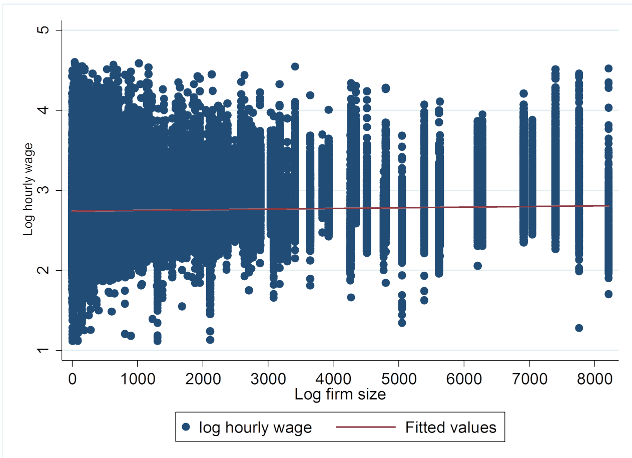


FIGURE 5 Log hourly wages by firm size in 2010.



4.3 Results

4.3.1 Benchmark estimates

The estimates in table 7 provide our benchmark. The OLS estimate without observable controls (column 1) indicates that the firm-size wage premium is rather small in quantitative terms but statistically significant: doubling the firm size relates to a wage increase of 1.9 per cent. Controlling for worker characteristics (column 2) reduces the estimate to 1.4 per cent. The inclusion of observable firm characteristics (column 3) reduces the effect to 0.7 per cent. The premium further decreases to 0.3 per cent when we add individual fixed effects (column 4). This finding implies that unobserved worker heterogeneity (quality, effort) and firm size are positively correlated. The premium similarly decreases to 0.5 per cent (and loses significance) when we add firm fixed effects (column 5). This finding indicates that unobserved firm heterogeneity (productivity) and firm size are positively correlated. The use of the spell specification (column 6), which combines both effects, increases the estimate to 0.8 per cent. The comparison of the point estimate to those in columns (4) and (5) is not straightforward because, in the spell and firm fixed effects specification, the firm-size effect is identified only by changes in firm size; that is, it does not utilize variation that arises from workers switching firms.

TABLE 7 Estimates of the Firm-Size Wage Effect. The Dependent Variable is Log Hourly Wages. Full Panel (1, 162, 325 observations).

	(1)	(2)	(3)	(4)	(5)	(6)
Log firm size	0.019**	0.014**	0.007**	0.003**	0.005	0.008**
	(0.0002)	(0.0002)	(0.0002)	(0.0004)	(0.004)	(0.0025)
Controls						
*Worker characteristics	-	yes	yes	yes	yes	yes
*Firm characteristics	-	-	yes	yes	yes	yes
*Worker fixed effects	-	-	-	yes	-	yes
*Firm fixed effects	-	-	-	-	yes	yes
R^2 Adj.	0.01	0.57	0.60	0.91	0.70	0.93

Notes: All specifications include time dummies. Worker controls include age, age squared, gender, occupation, tenure, tenure squared, level and field of education, and form of employment. Firm controls include industry, region, and export status. ** (*) denotes statistical significance at the 0.01 (0.05) level. Standard errors are clustered for workers in columns 1-4, and for firms in columns 5 and 6.

The results in table 7 offer two robust conclusions. First, the firm-size wage premium is statistically significant but modest, as the pure firm-size effect is small when compared with earlier estimates from other European countries. See e.g.

Lallemand et al. (2007) who report a premium of $0.6 - 6.8$ % for Denmark, Belgium, Italy, Ireland and Spain. As such, the finding is consistent with the view that coordinated wage-setting systems, such as those in Finland, tend to narrow wage distributions (see, e.g. Wallerstein, 1999).[3] Although the firm-size premium is only one component of firm level variation in wages, all observed as well as unobserved components are controlled for in the spell fixed effects estimation. With an estimated premium of 0.8 % it still ranges at the lower end compared to other European countries. Our results also corroborate the findings of Lallemand et al. (2007) who report a negative association between coordination and the premium.

Second, the results imply that the relative importance of observed firm and worker heterogeneity for the firm-size wage effect is substantial. Individual heterogeneity accounts for approximately 40 per cent, and firm heterogeneity accounts for 60 per cent of the estimated decline in the firm-size wage premium.[4] Unobserved worker heterogeneity captured via fixed effects plays a significant role, decreasing the estimate from 0.7 to 0.3 per cent. The findings can be compared with, for example, those of Brown and Medoff (1989) and Scoppa (2014), who show that the firm-size wage differential is reduced by up to 45–50 per cent when worker fixed effects are used, or those of Brunello and Colussi (1998), who report that the firm-size wage premium completely disappears after controlling for observed worker characteristics and selection. Winter-Ebmer and Zweimüller (1999), in turn, conclude that approximately 50 per cent of the firm-size wage premium is due to worker heterogeneity but that it cannot be explained by firm heterogeneity. Similarly, Abowd et al. (1999) find that individual heterogeneity explains approximately 75 per cent of the firm-size wage effect but that the role of firm heterogeneity is negligible.

4.3.2 Firm-size premium and exogenous job moves

The firm size is not exogenously given because a firm's growth may well depend on the quality of its labour; see, e.g., Foster et al. (2008). Thus, it is important to explore the firm-size effect using a model in which the identification is based on workers moving between firms of different sizes. The approach has its drawbacks. First, if job moves are not exogenous, there might be self-selection among workers. For example, low-quality and low-paid workers move to small firms with low profits, and high-quality and high-paid workers move to large firms with high profits (Abowd et al., 1999). This suggests an upward bias of the estimate. Second, the identification of exogenous job moves is difficult. For example, the use of firm closures as an indicator is problematic because the firm identi-

[3] We estimated the model (specification 6) using dummies for four firm size categories, i.e., micro (1-9 employees), small (10-29 employees), medium (30-249 employees), and large (over 250 employees). The results were consistent with the continuous measure as medium and large firms obtained a modest but statistically significant premium over micro and small firms. For medium firms the premium was one percentage points and for large firms two percentage points.

[4] The effect of firm heterogeneity is even stronger if we first control for firm observables only. In fact it directly reduces the estimate to 0.003 (0.0002).

fier bears the potential of measurement error if, for example, a change in firm identifiers may also result from ownership changes. Third, the joint estimation of fixed worker and firm effects becomes cumbersome (Abowd et al., 1999; Barth and Dale-Olsen, 2011).

The results from the models using observations of all workers that switch jobs (table 8) and displaced (exogenous) job movers (table 9) provide similar results. The identification of the firm-size effect is based on changes between post-move (t) and pre-move wages ($t-1$) in firms of different sizes. Uncontrolled OLS estimates indicate a premium that varies from 1.1 per cent (table 8, column 1) to 1.5 per cent (table 9, column 1). The inclusion of observable worker characteristics decreases the estimates to 1.0 and 1.2 per cent, respectively. As in the case of the full panel, observable firm controls lower the estimates further to 0.2 (table 8) and 0.6 per cent (table 9). The FE models by workers (column 4) or by firms (column 5) yield similar estimates. In table 8, the premium estimates are close to zero (0.1 and -0.2 per cent) and are statistically significant (column 4) or insignificant (column 5). The difference in point estimates between table 7 and 8 stems from the fact that voluntary movers tend to make wage gains regardless from the size of the firm to which they move. In table 9, the FE estimates show more variation, from 0.5 per cent (column 4) to -1.1 per cent (column 5). The standard errors are also larger, especially for the firm fixed effects.[5] The difference in point estimates between table 8 and 9 can be motivated as follows. Sorting of workers (endogeneity bias) would suggest a stronger upward bias in case of voluntary moves which should lead to higher estimates in table 8 compared to 9. However, many other factors beyond wages (or specifically the firm-size wage premium) can induce a voluntary move. Therefore self-selection is much more prominent for a voluntary compared to an involuntary move (Solon, 1988). Displaced workers are under pressure to accept the next job offer. This reduces the possibility to self-select into a firm with specific characteristics (not captured by the observable firm controls).[6] In sum, the results confirm the findings of the full panel: observed worker and firm characteristics are important in explaining the firm-size wage premium. Furthermore, the possible biases arising from endogenous job moves appear to be modest.

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5 Note that, in case of firm fixed effects, identification stems only from changes in firm size of those companies from (and to) which workers moved.

6 We also estimated worker fixed effects, separately for workers who switch from a micro/small to a medium/large firm and vice versa. The estimate is positive (2 respectively 8 per cent) yet not significant.

TABLE 8 Estimates of the Firm-Size Wage Effect. The Dependent Variable is Log Hourly Wages. All Movers (193, 645 observations)*.

	(1)	(2)	(3)	(4)	(5)
Log firm size	0.011**	0.010**	0.002**	0.001**	-0.002
	(0.0005)	(0.0003)	(0.0003)	(0.0004)	(0.004)
Controls					
*Worker characteristics	-	yes	yes	yes	yes
*Firm characteristics	-	-	yes	yes	yes
*Worker fixed effects	-	-	-	yes	-
*Firm fixed effects	-	-	-	-	yes
R^2 Adj.	0.01	0.59	0.62	0.85	0.71

Notes: See Table 7. *Sample consists of observations prior to (t-1) and after (t) job move. In specification 5, where the firm effect is captured by a firm dummy at time t, the number of observations is 249, 453.

TABLE 9 Estimates of the Firm-Size Wage Effect. The Dependent Variable is Log Hourly Wages. Displaced Movers (5,674 observations)*.

	(1)	(2)	(3)	(4)	(5)
Log firm size	0.015**	0.012**	0.006**	0.005*	-0.011
	(0.002)	(0.002)	(0.002)	(0.003)	(0.014)
Controls					
*Worker characteristics	-	yes	yes	yes	yes
*Firm characteristics	-	-	yes	yes	yes
*Worker fixed effects	-	-	-	yes	-
*Firm fixed effects	-	-	-	-	yes
R^2 Adj.	0.01	0.50	0.53	0.75	0.73

Notes: See Table 7. *In specification 5, where the firm effect is captured by a firm dummy at time t, the number of observations is 6, 102.

4.3.3 Robustness

We explore the robustness of the results further by augmenting the model (full panel with worker fixed effects) with additional covariates; see table 4 for the results and the data appendix for definitions. First, we exploit variations in the data, i.e., whether wage bargaining is centralized (coordinated at the national level) or decentralized (conducted at the industry level) and whether a firm has a profit-sharing scheme (Wallerstein, 1999; Long and Fang, Long and Fang 2012). Thus far, institutionalized profit sharing has not been controlled for by previous studies using linked data. These extensions (dummies and interactions) allow us to evaluate the effects of profit sharing on wages and the firm-size wage premium through the effect of the bargaining mode. Typically, centrally coordinated agreements provide less room for local negotiations regarding firm- or industry-specific benefits or pay increases (Asplund, 2007). Second, following Barth and Dale-Olsen (2011), we add skill group size as a covariate. This addition is in line with the dynamic monopsony approach (Manning, 2003(, which postulates that increased demand for one particular worker category implies higher wages for that group but does not increase wages for other worker categories in the firm. Third, to control for labour market frictions and difficulties in the job-to-job search process (Manning, 2011) we augment the model with a well-measured proxy of local labour market tightness, namely, local unemployment measured by the travel to work area and weighted by municipality-level unemployment rates. Fourth, following Arai (2003), we control for the capital intensity of firms. The variable is important, as capital intensity may signal higher product market rents stemming from high barriers to entry due to high fixed costs and, in the presence of unions, may indicate rent extraction and thus higher wages. Fifth, we add dummies that identify compensating differentials that arise from differences in irregular working hours, compensation for on-call and urgent work, or increased compensation based on location and workplace conditions (Lallemand et al., 2007). Finally, we account for effort-related differences in pay across workers, i.e., if a worker's wage contains a performance-based component (Idson and Oi, 1999).

The covariates increase the precision of the analysis, and they are in line with previous empirical studies. First, profit sharing at the company level increases wages and, as expected, decreases the firm-size wage premium even further. Second, the effect of the skill group size on wages is positive, though only when bargaining over wages is centralized. Third, tightness in the local labour market affects wages, and wages are more responsive to labour market conditions under decentralized wage bargaining. Fourth, higher capital intensity implies a modest increase in wages, and the effect is stronger when bargaining over wages is centralized.[7] Most importantly, the inclusion of additional measures to capture heterogeneity across workers and firms corroborates the main conclusions: the firm-size effect on wages remains modest, even negligible.

[7] See Pehkonen et al. (2016) for more detailed results.

TABLE 10 Robustness. The Dependent Variable is Log Hourly Wages. Full Panel (1, 162, 325 observations).

	(1)	(2)	(3)	(4)	(5)
Log firm size	0.001**	0.003**	0.002**	0.001**	0.001*
	(0.0003)	(0.0006)	(0.0006)	(0.0003)	(0.0003)
Controls					
*Profit sharing	yes	yes	yes	yes	yes
*Bargaining mode	yes	yes	yes	yes	yes
*Skill group size	yes	yes	yes	yes	yes
*Local tightness	yes	-	-	-	yes
*Capital intensity	-	yes	-	-	yes
*Wage provisions	-	-	yes	-	yes
*Effort pay	-	-	-	yes	yes
Worker fixed effects	yes	yes	yes	yes	yes
R^2 Adj.	0.91	0.91	0.91	0.91	0.91

Notes: See Table 7 and Appendix 4.A.2 for definitions.

4.4 Conclusions

Our analysis provides two main conclusions. First, the firm-size wage effect is statistically significant but modest when we account for worker and firm characteristics. Individual heterogeneity accounts for approximately 40 per cent, and firm heterogeneity accounts for 60 per cent of the estimated decline in the firm-size wage premium. This finding is robust across alternative identification strategies and for a large number of controls. The inclusion of covariates that describe profit sharing, bargaining modes, labour market tightness and working conditions further decreases the firm-size effect on wages. Thus, our study is among the few that can explain the commonly detected firm-size wage premium. Second, our empirical findings are consistent with the view that countries with coordinated wage setting tend to have narrower wage distributions.

4.A Appendix

4.A.1 Data overview

TABLE 11 Matched Employer-Employee Data for Finland, 2003–2010.

Sample	Workers N	Firms J	Spells J	Rows N*
Full panel	283,757	18,570	384,041	1,162,325
All movers	79,984	13,832	178,408	419,770
Displaced movers	2,211	1,612	5,338	11,138

4.A.2 Variable definitions

Wages: Total monthly earnings include supplements based on location and workplace conditions; performance-based pay components for salaried employees; wage earner performance-based earnings; taxation values for fringe benefits; earnings for extra and overtime work; eventual compensation for on-call or urgent work; other irregularly paid supplements; and pay for working hours not worked. Firm size: the number of employees.

Worker characteristics:
Age and age squared (Age, Age^2): age.
Tenure and tenure squared: years of employment in the firm.
Occupation: 25 categories, ISCO 2-digit classification.
Education: 9 categories, ISCED 1997 classification.
Field of Education: 9 categories (General Education; Teacher Education and Educational Science; Humanities and Arts; Social Sciences and Business; Natural Sciences; Technology; Agriculture and Forestry; Health and Welfare; Services; Other).
Form of employment: dummy (full time = 1, part time = 0).

Firm characteristics:
Regions: 18 regions, NUTS2 classification.
Industry: 12 categories, NACE 1-digit classification.
Firm's export status: dummy (exports = 1).
Firm's legal status: dummy (limited company = 1).
Firm's ownership: dummy (public majority = 1).

Additional controls:
Profit-sharing scheme: dummy (yes = 1).
Skill group size in firm: 81 groups (9 education levels and 9 education fields). Local tightness: unemployment rate measured by the travel to work area (82 areas)

and weighted by municipality-level unemployment rates (445 municipalities).
Capital intensity: physical capital (in euros) per worker (number of employees) in a firm. Wage provisions: dummy (worker has received overtime pay; additional compensation based on location and workplace conditions; on-call compensation = 1, otherwise 0).
Effort-based pay: dummy (worker has received performance-based pay component = 1, otherwise 0).
Degree of centralization in bargaining: dummy (centralized =1, otherwise 0).

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5 PROFIT SHARING THE FIRM-SIZE WAGE PREMIUM

Abstract*

This study analyzes the relationships among wages, firm size, and profit sharing schemes. We develop a simple theoretical model and explore the relationship empirically using high-quality panel data. The theoretical model shows that the firm-size wage premium decreases in the presence of profit sharing. The empirical results based on rich matched employee-employer data for private sector wage earners in Finland show that the firm-size wage premium is modest, and it becomes negligible when we account for profit sharing and covariates describing assortative matching and monopsony behavior. The analysis suggests that profit sharing schemes embody effects of firm-specific unobservables that raise productivity, support rent sharing, and boost wages.

Keywords: Wages, firm size, profit sharing, wage bargaining, assortative matching, monopsony behavior, unbalanced panel

5.1 Introduction

Empirical research indicates that wage differentials between small and large firms are substantial and pervasive and that the firm-size wage premium arises from either the labor market or the product market. The most frequently cited reasons for the firm-size wage premium relate to differences in labor quality and working conditions across firms. Large firms hire greater numbers of qualified workers because of their greater capital intensity and capital-skill complementarity, and the wage premium reflects a compensation differential (see, e.g. Brown and Medoff, 1989; Kruse, 1992). Wage efficiency, labor turnover, and dynamic monopsony explanations fall into the same category. Larger firms face higher monitoring and recruiting costs, and to discourage shirking and increase job stability, they pro-

* This chapter is joint work with Jaakko Pehkonen, Sampo Pehkonen and Mika Maliranta.

vide higher wages. In essence, these explanations reflect labor market frictions and sorting, with heterogeneous labor being sorted into heterogeneous firms, see e.g. Barth and Dale-Olsen (2011) for a review of recent empirical research.

The second set of explanations is rooted in the profit sharing literature. The firm-size wage premium may reflect large firms' greater market power in the product market and, thus, greater earnings per worker. Some firms might be large because their superior technology makes them efficient and allows them to capture market shares from other, less efficient firms and may benefit from lower prices of non-labor inputs and, thus, higher earnings per worker (see, e.g. Bagger et al., 2010; Foster et al., 2008). The excess profits can be shared ex post between the firm and workers represented by a strong union, a group of workers, or by individual workers.

The earlier literature shows large firms are more likely to use profit sharing than the smaller ones (see, e.g. Andrews et al., 2010; Kruse et al., 2010). The literature also lists several reasons for this behavior. Larger firms may be more eager to substitute fixed pay components by variable pay if they face more financial volatility than smaller firms (see, e.g. Kruse, 1992, 1996). These firms may have a greater need to attract and retain trained labor, as well as enhance employees' efforts and motivation to fulfill diversified organizational goals (see, e.g. Strauss, 1990). In short, larger firms may enjoy greater market power in the product market, which allows them to pay higher wages; at the same time, they may have incentives to do so.

This study contributes to the literature on the firm-size wage premium in two ways. First, we sketch a theoretical model that focuses on the relationship between profit sharing and the firm-size wage premium. The model follows the literature beginning with Weitzman (1984, 1987) and assumes that total pay is made up of two components, a base wage and a profit share, which may both contribute to the wage differential. Considering varying degrees of profit sharing, the model shows that the firm-size wage premium decreases as the profit sharing component increases. This implies that the effect of profit sharing may be attributed to the firm-size wage premium if it is not controlled for in the estimation.

Second, we use large panel data from Finland, a country with strong trade unions and a long history of wage bargaining, to explore the relationship empirically. In particular, we apply a novel approach that identifies firms that use profit sharing schemes and workers who participate in such schemes. As such, the study contributes to the recent literature focusing on wages and profit sharing, including Arai and Heyman (2009), Andrews et al. (2010), Long and Fang (2012), Rusinek and Rycx (2013) and Card et al. (2014), and from a more general perspective, it extends the multi-country analyses of Lallemand et al. (2007) and Albaek et al. (1998), who examine firm-size wage premiums in five European countries (Belgium, Denmark, Ireland, Italy, and Spain) and four Nordic countries (Denmark, Finland, Norway, and Sweden), respectively.

Our empirical analysis is based on rich matched employee-employer data for private sector wage earners containing longitudinal information on $283,757$

individuals working in 18, 570 different firms. The data span the 2003–10 period and provide 1, 162, 325 wage observations and several useful covariates for regression analysis. In particular, we control for dynamic monopsony behavior and labor market frictions (see, e.g. Manning, 2003, 2011). We also control for assortative matching (see, e.g. Abowd et al., 1999). For example, heterogeneity across workers and firms can be accounted for by education (9-category ISCED classification), occupation (25-category ISCO classification), form of employment (full- or part-time), firm capita-labor intensity and firm export status. The approach is in line with Melitz's (2003) theoretical arguments on quality differences between exporting (large firms) and non-exporting firms (small firms), as well as with the subsequent empirical findings of Yeaple (2005) and Wagner (2012). Labor market frictions are accounted for in the spirit of the dynamic monopsony behavior. We follow Barth and Dale-Olsen (2011), who show that the unexplained firm-size wage effect reflects labor market frictions and difficulties in the job-to-job search process stemming from variations in skill group size between firms of different sizes.

The empirical analysis treats the adoption of profit sharing scheme as exogenous. This constitutes a potential source of estimation bias if both base wages and profit sharing scheme adoption are both driven by common unobserved factors. Although it is quite likely that wages and profit shares are driven jointly, e.g. by demand-side shocks, the existence of a profit sharing scheme in a firm is less likely to be driven or determined by such temporary shocks (including demand-side shocks) that affect wages. However, we aim to alleviate possible endogeneity problems by using a rich set of firm and worker characteristics and fixed effects. Furthermore, in the spell specification, where the profit sharing indicator becomes a part of the firm fixed effect, we measure the impact of profit sharing on wages using a worker-level indicator, controlling for several worker and firm observables simultaneously. Implicitly, we assume that the adoption of a profit sharing scheme is associated with overall firm quality and that the effects can be captured by observable covariates, such as firm export status (Melitz, 2003) and capital-labor ratio (Foster et al., 2008) conditional on the firm's industry (Kruse, 1996).

The empirical section of the study begins by reporting a modest but statistically significant effect of firm size on base wages after accounting for several sources of individual and firm heterogeneity and worker and firm fixed effects. The results from the subsequent analysis of profit sharing indicate that there is no firm-size wage premium. The results also imply that employees in firms with profit sharing schemes earn higher base wages. In sum, the findings accord with the notion that larger firms are more likely to use profit sharing schemes, to employ more proficient labor and thus to pay higher wages.

5.2 The firm-size wage premium – a simple model of profit sharing

This section studies how profit sharing affects the firm-size wage premium from a theoretical point of view. We utilize a standard wage-setting/price-setting framework with incomplete competition on the goods and labor markets. We assume firm heterogeneity to be rooted in the product market, where small firms are not able to charge the same prices as large firms. Recent empirical evidence that product prices increase with firm size motivates this assumption (see Kugler and Verhoogen, 2012; Johnson, 2012; Manova and Zhang, 2012).[1] In other words, large firms are assumed to have more price-setting power compared to small firms.[2]

Moreover, we assume that firms commit themselves to profit sharing before union wage-setting. This timing structure is common in the literature (see, e.g. Holmlund, 1990; Koskela and Stenbacka, 2012), and it may result in certain policy benefits for firms, such as tax exemptions (see Cahuc and Dormont, 1997; Pendleton et al., 2001). In essence, the structure implies that after wage bargaining, the total pay of the worker is composed of a (negotiated) base wage and a profit share, where the base wage is set with the expectation of profit sharing.

We assume that there are two types of firms. Large firms face lower product market competition (κ_b), whereas small firms face tougher market competition (κ_s), with subscripts b and s denoting large and small firms, respectively.[3] The price-setting power $0 < \kappa < 1$ is defined as $\kappa \equiv (\eta - 1)/\eta$ with $\eta > 1$ being the good's demand elasticity from a Blanchard-Kiyotaki demand function.

Following the structure of the Finnish labor market,[4] where union density is over 70 % and bargaining coverage is over 80 %, we assume that bargaining over base wages is the basic mechanism through which unions enable the transfer of rents to workers. In both large and small firms, wages are negotiated separately with a rent-maximizing union. In the case of bargaining with a large firm, the union's utility function is given by eq. (161).

$$U_{ib} = N_{ib}\Omega_{ib} \tag{161}$$

The union's utility is the number of workers in firm $i \in [0,1]$, N_{ib}, multi-

1 A large part of the literature also focuses on differences in product quality, where large firms tend to produce qualitatively superior products. It is also common in the competition and antitrust literature to expect that larger firms realize higher margins; see Davis and Garcés (2010).

2 It can be argued that firms also differ in respects other than price-setting power. If we assume that firm productivity is a second source of heterogeneity, our results remain qualitatively unchanged.

3 In an open economy where large firms tend to export, this assumption would need further adjustment, such as higher price-setting power for larger firms to be limited to their home markets, for instance. Although this is an interesting avenue, we are not able to pursue it in this paper.

4 See Findicator (2015) and ICTWSS-Database (2015).

plied by the rent of each worker when that worker is employed in that firm Ω_{ib}. Assuming risk-neutral workers, the rent is given by

$$\Omega_{ib} = w_{ib} - \overline{w} + \mu \frac{\Pi_{ib}}{N_{ib}} \tag{162}$$

w_{ib} denotes the wage in the large firm, $\overline{w}$ denotes the outside option, and $\mu\Pi_{ib}/N_{ib}$ denotes the share of profits that the firm is committed to paying each worker.[5] Following Bhaskar (1990) and Holden and Driscoll (2003), the union is concerned about the relative pay of w_{ib} over the wage of outside workers $\overline{w}$ and relies on the firm's commitment to profit sharing.

Bargaining takes place via Nash bargaining between the single firm and the union.

$$\max_{w_{ib}} U_{ib}^{1-\gamma}[(1-\mu)\Pi_{ib}]^{\gamma} \tag{163}$$

γ denotes the bargaining power of the firm. We assume zero rent and zero profits as status quo payments.[6] Replacing subscript b with s in equations (161) to (163) provides the same setup for a union facing a small firm.

Firm behavior is similar in both types of firms ($j = b, s$). They face a production function with diminishing marginal returns to labor and a productivity parameter: $Y_{ij} = AN_{ij}^{\alpha}$, with $0 < \alpha < 1$. They maximize profits by setting prices as a markup on labor costs. Aggregation is achieved by setting relative prices to unity and acknowledging the continuum of firms $i \in [0, 1]$ in the economy: $w_{ij} = w_j$, and $N_{ij} = Jn_j$ with $j = b, s$ on the labor demand side. n_j is the share of workers (among all workers including unemployed) who work for firm j. J indicates the number of different firm types in the economy; in this case, two. Together with production, see below, this ensures decreasing returns to labor on the aggregate level over both types of firms.

Overall production is given by $Y = A(n_b + n_s)^{\alpha}$, and the outside option takes the form $\overline{w} = n_b r_b + n_s r_s + (1-n)b$ where the total pay of the worker is given by $r_j = w_j + \mu\Pi_j/N_j$ with $j = b, s$. Workers have the opportunity to find a job at a large firm or a small firm or to receive unemployment benefits. The worker shares denote the respective probabilities.

5 Profit sharing is a pay variable and a group incentive related to firm performance. As such, the size of μ is likely to be determined by tradeoffs among potential tax exemptions, productivity effects, costs and agency problems (e.g., shirking). The rules of profit sharing are set and known in advance (see Estrin et al., 1997). In the basic version of the model, discussed in this section, we assume μ to be exogenously given and set by the firm unilaterally. The results are qualitatively the same when the profit share is bargained over (see Appendix 5.A.1 for details).

6 Instead of a rent-maximizing union, it is possible to assume a utilitarian union with $U_{ib} = N_{ib}(w_{ib} + \mu\Pi_{ib}/N_{ib}) + (L - N_{ib})\overline{w}$, where L denotes the total labor force and the following status quo payments: $U_{ib}^0 = L\overline{w}$ and $\Pi_{ib}^0 = 0$ as above. However, we prefer the specification with the rent-maximizing union because the utilitarian one is inconsistent when dealing with firm-level labor unions in the general equilibrium.

The general equilibrium is given by equations (164) to (167). Labor demand of large and small firms, respectively, is written as

$$w_j = \alpha\kappa_j A\left(2n_j\right)^{\alpha\kappa_j - 1} n^{\alpha(1-\kappa_j)} \quad \text{with} \quad j = b, s \tag{164}$$

and the labor demand condition (165) ensures that the share of workers in small firms plus the share of workers in large firms gives total employment.

$$n_s + n_b = n \tag{165}$$

Assuming all bargaining power to be on side of the union $\gamma = 0$ yields the simplest solution for the base wage and total pay in both firms:

$$w_b = -\mu\frac{\Pi_b}{n_b} + \frac{n_s r_s + (1-n)b}{\alpha\kappa_b - n_b} \text{ and } w_s = -\mu\frac{\Pi_s}{n_s} + \frac{n_b r_b + (1-n)b}{\alpha\kappa_s - n_s} \tag{166}$$

$$r_b = \frac{n_s r_s + (1-n)b}{\alpha\kappa_b - n_b} \text{ and } r_s = \frac{n_b r_b + (1-n)b}{\alpha\kappa_s - n_s} \tag{167}$$

In contrast to a model with firm homogeneity, base wages and total pay are set as a markup not only on unemployment benefits but also on the pay of the other firm type. The model thus captures the idea from the outside option, which comprises the likelihood of finding a job not only in another firm of the same type but also in another type of firm. A positive profit share μ decreases base wages in eq. (166) because unions anticipate the share to be paid when bargaining over wages. To ensure positive base wages and total pay, there is an upper limit on employment, which is given by $n_j < \alpha\kappa_j$ for $j = b, s$.

Total pay, as denoted in eq. (167), is composed of a base wage component, as given in eq. (166), and a profit share component, $\mu\Pi/n$. The relative premium of total pay between different types of firms is given by

$$p \equiv \frac{r_b - r_s}{r_s} = \frac{\kappa_s - \kappa_b}{\kappa_b} \tag{168}$$

Obviously, the size of the premium rests only upon the different degrees of price-setting power. Because total pay is made up of two pay components, the base wage and profit share, both contribute to the total premium. To distinguish between the components, we divide eq. (168) into a base wage premium that stems from firm-size effects and a profit sharing premium. The firm-size wage premium (base wage premium) is given by

$$f \equiv \frac{w_b - w_s}{w_s} = \frac{(1-\mu)\alpha(\kappa_s - \kappa_b)}{\alpha\kappa_b + \mu(1-\alpha\kappa_b)} \tag{169}$$

The profit sharing premium is given by

$$s = \frac{\mu(\kappa_s - \kappa_b)}{\kappa_b(\alpha\kappa_b + \mu(1-\alpha\kappa_b))} \tag{170}$$

Considering eq. (169) first, the base wage premium can be interpreted as firm-size wage effect because large firms face lower product market competition, which unions are able to transform into higher base wages. In the case of $\mu = 0$, meaning without any profit sharing, the base wage premium is identical to the premium in total pay. Only firm size accounts for the pay premium.

Eq. (170) shows that firms committing to profit sharing leads to another wage differential between large and small firms. As the price-setting power of the firm increases, the profit and, therefore, the profit share transferred to the workers increase. In the case of $\mu = 1$, when all profits of the firm are redistributed to the workers, the profit sharing premium is identical to the premium on total pay. Only profit sharing accounts for the pay premium. With $0 < \mu < 1$, the premium in total pay consists of two components: a firm-size (base) wage premium and a profit sharing premium. As such, the intuition of the model is that an increasing size-earnings profile may stem from a flat base wage and an increasing profit share or from an increasing base wage without a profit share.[7] Note that profit sharing leaves the total premium unchanged. In that sense our model can be understood as a generalization of the result of Weitzman (1987) to the firm size-wage premium.

Calibrating the model using $\alpha = 0.7$, $\kappa_b = 0.9$, $\kappa_s = 0.9135$, $b = 0.5$, $A = 5.0$ yields a total pay premium of 1.5 %, which is consistent with our estimates reported in section 5.3 (Table 16). With $\alpha = 0.7$, we fit the labor share of several European countries, and the values for unemployment benefits and the productivity parameter ultimately lead to an employment rate of 60 %. We follow the theoretical literature in setting $\kappa_b = 0.9$. This implies product demand elasticity for large firms of minus 10 %. The estimate is compatible with the data from the Swedish Establishment Survey (1991) wherein over one-half of firms expect the decrease in demand to be stronger than the price increase.[8] We also fit the empirical finding that the share of workers employed by large firms is smaller than the

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7 A similar result could be obtained if the firm-size premium arose from the labor market. Considering a typical dynamic monopsony model, wages rise with firm size because the monopsonist faces an upward sloping supply curve. The greater the monopsony power, the stronger the firm-size relationship and the higher the profits (Green et al. 1996). Introducing profit sharing into such a setting may produce the same results as in our model. The firm-size wage effect might stem from monopsony (base) wage setting or from total remuneration through profit sharing, where larger firms share more of their profits. We are grateful to an anonymous referee for highlighting this similarity.

8 We are grateful to Michael Tåhlin for providing the data.

share employed by small firms.

Table 12 shows the decomposition of the premium of total pay under different degrees of profit sharing. The first column presents the pay premium in the absence of profit sharing. As shown in eqs. (168)-(170), the pay premium stems entirely from the firm-size wage effect. Columns two to five show that an increase in profit sharing simultaneously increases profit sharing premium and decreases the firm-size wage premium. If one-quarter of profits are shared, 34.67 % of the total pay premium is explained by profit sharing. As more profits are shared, the firm-size wage effect becomes less relevant to the point at which it does not have any impact on the wage premium, that is, when all profits are redistributed to the employees.[9]

TABLE 12 Firm-size wage premium under different degrees of profit sharing between firms and workers.

	(1)	(2)	(3)	(4)	(5)
Workers' share of profits (μ)	0.00	0.25	0.50	0.75	1.00
Firm-size premium	1.50	0.98	0.58	0.26	0.00
Profit sharing premium	0.00	0.52	0.92	1.24	1.50
Total pay premium	1.50	1.50	1.50	1.50	1.50
Premium explained by (in %)					
Firm size	100.00	65.33	38.67	17.33	0.00
Profit sharing	0.00	34.67	61.33	82.67	100.00

Notes: The model is calibrated with $\alpha = 0.7$, $\kappa_b = 0.9$, $\kappa_s = 0.9135$, $b = 0.5$, $A = 5.0$.

5.3 Data, methods and preliminary findings of the firm-size wage premium

5.3.1 The employee-employer panel, 2003–2010

This study exploits matched employee-employer data from the registers of Statistics Finland, using a 20 % unbalanced sample of private sector wage earners containing longitudinal information on $283,757$ individuals working in $18,570$ differ-

[9] With $0 < \gamma < 1$, this pattern is exactly identical as long as the profit share is smaller than the union's bargaining power. If $\mu > \gamma$, the firm-size wage effect becomes negative, but it is compensated by an even larger profit sharing premium.

ent firms.[10] The total number of unique combinations of workers and firms (job spells) in the data is 384, 041, and the total number of observations is 1, 162, 325.

Table 13 tabulates summary (ratio) statistics for a selection of variables. Firms are divided into four size groups, measured by the numbers of employees, following the classification of Statistics Finland: micro (1-9 employees), small (10-29 employees), medium-sized (30-249 employees), and large (over 250 employees). Firm size is measured as a continuous variable, and worker wages contain all fixed pay components plus performance and overtime pay. The data record employees' age, gender, place of residence, level and field of education, occupation, and job tenure. Recorded employer characteristics include industry, region, form of ownership, export status, and capital input, as well as an indicator of the existence of a profit sharing scheme; see appendix 5.A.2 for definitions.

The first observation is that differences between large and micro firms are substantial and broadly consistent with observations from other countries; see the estimates in column 1. The wage ratio in the largest and smallest size categories varies from 1.20 (hourly wages) to 1.29 (monthly wages). The firm-size wage ratio is 1.18 for males and 1.13 for females. In addition, the size-wage profile is steeper for males than for females, and males are clearly overrepresented in larger firms (1.43). Similarly, jobs last longer (1.59) and workers have more formal education (1.05) in larger firms than in smaller firms. These numbers are consistent with observations that large firms have fewer part-time workers (0.40) than small firms. Although the average age of workers does not significantly differ between small and large firms (1.02), longer tenures in larger firms indicate that large firms may be older than small firms.[11] Differences in firm size are reflected in differences in the capital-labor ratio (2.34), profits per worker (1.25), and the use of profit sharing schemes (7.67).

The second observation is that the discrepancy profile flattens swiftly when moving from micro firms to small and medium-sized firms. The wage ratio between large and small (medium-sized) firms is now 1.18 (1.02) for both hourly and monthly wages; the firm-size wage ratio decreases to 1.13 (1.05) for males and 1.09 (0.99) for females. In sum, these numbers are consistent with the perception that firm-size wage profiles are flatter in countries with stronger trade unions (see Idson and Oi, 1999 and references therein). Males are still overrepresented in larger firms compared to small firms (1.26) but are not overrepresented in larger firms compared to medium-sized firms (1.01). Jobs still last longer in larger firms in both cases (1.48 and 1.25), but the ratio in the share of university-educated workers drops from 1.05 to 0.94 for medium-sized firms. The relative use of part-time workers varies across firms of different sizes, with the relation

[10] Studies that use panel methods and register-based employer-employee data typically rely on samples of 1-2 % of all wage earners or less; see Barth and Dale-Olsen (2011) and Scoppa (2014). Survey-based data involve smaller samples. Arai's (2003) analysis of Sweden is based on 1, 000 matched worker-firm observations. In Winter-Ebmer and Zweimüller (1999), the sample consists of 2, 600 job changers, whereas Ferrer and Lluis (2008) use panels with a sample of approximate 21, 000 yearly observations.

[11] The possible effect of plant age on wages is then captured by tenure. See Brown and Medoff (1989) and Idson and Oi (1999) for a discussion on plant age and wages.

being u-shaped; micro and small firms use more part-time workers in relation to large firms (0.40 and 0.84), whereas large firms use more part-time workers in relation to medium-sized firms (1.41).

TABLE 13 Illustration of the data; selected variable ratios by firm size

Variables	Large/Micro	Large/Small	Large/Medium
Monthly wages	1.29	1.18	1.02
Hourly wages	1.20	1.14	1.03
Male wages	1.18	1.13	1.05
Female wages	1.13	1.09	0.99
Average age	1.02	1.01	1.00
Male share	1.43	1.26	1.01
Tenure	1.59	1.48	1.25
Part time	0.40	0.84	1.41
Paid by monthly/hour	1.93	1.56	1.04
Education*	1.05	1.05	0.94
Profits/worker	1.25	1.56	1.53
Capital/worker	2.34	1.46	1.12
Bonus scheme	7.67	3.36	1.60

Notes: *Education = the share of tertiary education of the workforce.

Table 14 illustrates the data further by reporting averages of the main variables in the first (2003) and the last years (2010) of the investigation period. The table divides firms into those that use profit sharing and to those that do not. In 2003, firms with a profit sharing scheme accounted for 33.6 % of all firms. In 2010, the corresponding estimate was 32.1 %. The samples are consistent in indicating that firms that use profit sharing are different in many observable characteristics. In essence, they are considerably larger (means of 37.2 employees versus 203.1 employees in 2010), provide higher base wages (means of 15.7 euros versus 17.3 euros in 2010), possess more operating capital (means of 70.3 thousand versus 400.3 thousand in 2010), are more profitable (means of 9.9 thousand euros per employee versus 22.5 thousand in 2010) and are more likely to be engaged in foreign trade (averages of 21.0 % versus 50.0 % in 2010). In addition, employees differ across firms. Workers receiving bonuses are more unlikely be female (53.6 % versus 42.6 %) and are less likely to be part-time workers (17.0 % versus 15.1 %). In addition, they have longer tenures (7.28 years versus 10.67 years) and work longer weeks (34.23 hours versus 35.24 hours).

TABLE 14 Illustration of the data; breakdown of main variables by firms in 2003 and 2010

	Firms with no profit sharing		Firms with profit sharing	
Variables	2003	2010	2003	2010
Monthly wage*	1,971.40	2,337.42	2,388.41	2,707.28
	(5.27)	(5.70)	(3.37)	(4.102)
Hourly wages*	12.92	15.74	15.04	17.32
	(0.029)	(0.034)	(0.019)	(0.023)
Female, percent	0.523	0.536	0.423	0.426
	(0.003)	(0.002)	(0.002)	(0.002)
Tertiary education, percent	0.310	0.409	0.349	0.400
	(0.003)	(0.002)	(0.001)	(0.001)
Worker age, years	40.35	41.45	40.87	41.39
	(0.063)	(0.059)	(0.034)	(0.036)
Tenure, years	7.46	7.28	11.05	10.67
	(0.049)	(0.042)	(0.034)	(0.032)
Working week, hours	34.96	34.23	36.12	35.24
	(0.048)	(0.043)	(0.023)	(0.025)
Part-time, percent	0.162	0.170	0.115	0.151
	(0.002)	(0.002)	(0.001)	(0.001)
Profits per employee, euros	11,075	9,923	12,020	22,470
	(631.75)	(648.76)	(5,582)	(2,222)
Firm size, no. of employees	37.49	37.19	202.77	203.06
	(2.81)	(1.94)	(14.08)	(13.50)
Capital per employee	68,810	70,281	319,064	400,286
	(8,716)	(8,836)	(38,277)	(44,477)
Export/import (domestic=0)	0.20	0.21	0.49	0.50
	(0.01)	(0.01)	(0.01)	(0.01)
Capital region, percent	0.332	0.347	0.382	0.406
	(0.003)	(0.002)	(0.001)	(0.001)
No. of workers	33,692	43,096	107,145	107,702
(per cent in brackets)	(23.9)	(28.5)	(76.1)	(71.5)
No. of firms	5,385	6,007	2,727	2,828
(per cent in brackets)	(66.4)	(67.9)	(33.6)	(32.1)

Notes: Means with standard deviations in brackets. Firm size, profits per employee, and capital per employee and export/import ratio are averaged by firms; others are averages by workers. *Wages are in 2003 Euros.

5.3.2 Preliminary findings: the roles of observables and fixed effects

We tackle unobserved heterogeneities by adopting a commonly used variant of the linear three-way error-component model (see, e.g. Abowd et al., 2008; Andrews et al., 2006, 2008). We write the standard Mincerian wage equation as follows, omitting time dummies:

$$w_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + \mathbf{w}_{j(i,t)t}\gamma + \phi_i + \psi_{j(i,t)} + \varepsilon_{it} \tag{171}$$

where workers ($i = 1, ..., N$) are observed once per period ($t = 1, ..., T$) in a firm ($j = 1, ..., J$). Because workers can move from one firm to another over time, the function $j(i,t)$ maps worker i to firm j at time t. w_{it} denotes the dependent variable (log base wages), and ε_{it} denotes a stochastic error term. $\mathbf{x}_{it}$ and $\mathbf{w}_{j(i,t)t}$ are vectors of time-variant observables for workers and firms, whereas ϕ_i and ψ_j capture the corresponding time-invariant unobservables.

The analysis begins by treating observations as one cross-section and by assuming that each component of the implied error term for the OLS estimator ($\phi_i + \psi_{j(i,t)} + \varepsilon_{it}$) is contemporaneously uncorrelated with the observed covariates. Column (1) in Table 15 provides the benchmark. The estimate without observable controls indicates that the firm-size wage premium is quantitatively relevant and statistically significant: doubling the firm size relates to an increase in wages of 1.9 %. This estimate is of the same magnitude as estimates with observable controls of human capital (see, e.g. Brown and Medoff (1989) for the US and Manning (2003) for the UK).

Table 15 corroborates this basic finding by tabulating results for specifications with covariates for observable worker and firm characteristics (columns 2 and 3), fixed effects for workers (column 4), for firms (column 5) and for both (column 6). The within-i transformation eliminates the unobserved worker component and assumes that the remaining unobserved firm component (ψ_j) is uncorrelated with the observed covariates. The model identifies the firm-size wage effect from job stayers with a changing firm size and job movers between firms of different sizes. The within-j transformation, in turn, eliminates the unobserved firm component and assumes that the remaining unobserved worker component (ϕ_i) is uncorrelated with the observed covariates. The firm-size effect is identified by changes in firm size. Following Andrews et al. (2006), we use the spell specification where unobserved worker and firm heterogeneity is eliminated by differencing within each unique worker-firm spell. In our data, the number of such spells is $384,041$.[12]

Controls for worker characteristics reduce the baseline estimate from 1.9 % to 1.4 % (column 2), and those for observable firm characteristics reduce it further to 0.7 % (column 3). Both factors are important: worker heterogeneity accounts for 40 % and firm heterogeneity accounts for approximately 60 % of the decline in the firm-size wage premium. Unobserved worker heterogeneity captured by

12 We follow Andrews et al. (2006) and assume that two periods of employment with employer H separated by a period with employer S consists of two unique job spells.

fixed effects reduces the estimate from 0.7 % to 0.3 %, suggesting that there might be sorting of more productive workers into larger firms (column 4). The specification that accounts for firm-specific unobservables, presenting, for example, differences in technologies that provide higher rents and require compensating differentials, yield a similar result: there is a slight decline in the estimate from 0.7 % to 0.5 % (column 5), albeit the point estimate is now significant.[13] The result may also reflect the possibility that larger firms provide more insurance to workers, thus flattening the wage firm-size profile (see Guiso et al., 2005).[14] The results of the spell specification (column 6) that incorporates firm and worker effects and thus accounts for the systematic sorting of workers across firms, do not differ from those in column (3): the estimate (0.8 %) suggests that the sum of the unobserved worker and firm components is not correlated with firm size. This indicates that assortative matching, i.e. more productive workers matching with more productive firms, might not be that relevant in our data. Section 5.4.1 sheds more light on this issue.

The findings that the firm-size wage effect is modest and that it can be controlled for by using a rich set of observable worker- and firm-specific controls are consistent with the view that the firm-size wage effect is lower in countries with coordinated wage setting than in countries with non-coordinated wage setting. At the general level, the findings support those of, among others, Teulings and Hartog (1998), who report that overall wage dispersion is inversely related to corporatism. Regarding more recent cross-country evidence, our findings are consistent with those of Lallemand et al. (2007), who report considerable lower firm-size estimates for more corporatist countries (Denmark and Belgium) in relation to non-corporatist countries (the US and France). Our results, in turn, differ from those of Albaek et al. (1998), who report considerable firm-size wage effects for all four Nordic countries, with the firm-size wage elasticity for Finland ranging between 2 % and 3 %. However, their analysis focuses on only one year using a relatively small sample (1985 and 23, 500 full-time workers). In sum, our estimates suggest that although the effect of firm size on wages appears negligible, it exists. Furthermore, the estimates of the firm-size wage premium may be biased due to omitted variables, and the firm-size premium estimates may be biased upward or downward.

13 Clustering by workers provides statistically significant estimate.

14 Consistently with this conjecture, Ilmakunnas and Maliranta (2005) find that plant size has a negative relationship with the worker outflow rate when a host of other factors are controlled for, including plant age, labor productivity, wage level, industry, average tenure of the employees, wage dispersion within plant, and net employment growth in the previous period.

TABLE 15 Base wages and firm size in linked worker-firm panel 2003–2010: the roles of unobservables and fixed effects.

	(1)	(2)	(3)	(4)	(5)	(6)
Log firm size	0.019***	0.014***	0.007***	0.003***	0.005	0.008***
	(0.0002)	(0.0001)	(0.0001)	(0.0004)	(0.004)	(0.0005)
Observables:						
Workers	-	yes	yes	yes	yes	yes
Firms	-	-	yes	yes	yes	yes
Fixed effects:						
Workers	-	-	-	yes	-	-
Firms	-	-	-	-	yes	-
Spells	-	-	-	-	-	yes
Identification	All	All	All	All	Stayers	Stayers
Clustered	No	No	No	Workers	Firms	Workers
R^2	0.01	0.57	0.60	0.91	0.70	0.93
No. of Firms	18,570	18,570	18,570	18,570	18,570	18,570
No. of Workers	283,757	283,757	283,757	283,757	283,757	283,757
No. of Spells	-	-	-	-	-	384,041
No. of Obs.	1,162,325	1,162,325	1,162,325	1,162,325	1,162,325	1,162,325

Notes: All specifications include time dummies. Worker controls include age, age squared, gender, occupation, tenure, tenure squared, level and field of education, and form of employment. Firm controls include industry, region, and export status. *** denotes statistical significance at the 0.01 level.

5.4 Profit sharing and the firm-size wage premium

As noted at the outset, larger firms have the ability to pay more if they have market power in the product market, and thus, they can generate more earnings per worker (see, e.g. Foster et al., 2008; Bagger et al., 2010). Rent sharing may take different modes (through higher fixed pay or through higher variable pay) and different manners (between the firm and a labor union, a group of workers, or by an individual worker). The literature indicates that larger firms may have more incentives to use profit sharing schemes, as well as other modes of variable pay, than smaller firms (see Kruse, 1992; Strauss, 1990; Guiso et al., 2005). The earlier literature has also shown that large firms are more likely than smaller firms to use financial participation schemes and that the use of such schemes may have a bearing on the base wage and on total employee compensation (see Weitzman, 1984; Kruse et al., 2010; Andrews et al., 2010). This, in turn, may lead to the non-random matching of workers and firms (see, e.g. Abowd et al., 1999, 2008;

Prendergast, 1999).

Tables 16 and 17 summarize our findings on the associations among firms' profit sharing schemes, firm size and workers' base wages. Three distinct features of our approach are worth noting. First, we apply an indicator variable that divides firms into those that have adopted and operate profit sharing schemes and those that do not.[15] Second, we examine the roles of assortative matching and dynamic monopsony behavior in explaining the firm-size premium. To do so, we report the results of specifications that include/exclude observables that control for worker and firm quality. Covariates that describe assortative matching consist of measures for labor and firm quality (e.g. worker education, capital intensity of firm) and job characteristics (e.g. urgent work, workplace conditions). Third, we employ two model specifications: spell fixed effects and worker fixed effects with alternative identification strategies. We first report the analysis based on spell fixed effects.

5.4.1 Results of the job spell specification

Our preliminary results (Table 15) show that unobserved fixed effects shape the wage-size relationship, albeit marginally. The inclusion of worker fixed effects reduces the firm-size estimate from 0.7 % to 0.3 %; the inclusion of firm fixed effects, to 0.5 %. The model that incorporated both effects (spell effects) raises the estimate to 0.8 %.[16] We continue the analysis using spell fixed effects because it is important to control for both types of unobservables. Theories of assortative matching, in particular, emphasize the approach: there may be selection of high-wage workers to high-wage firms, or vice versa, or both (see Abowd et al., 1999).

Unfortunately, there is little variation in firm-level profit sharing policy over job spells; typically, firms tend to ratify their remuneration policies for several years. Thus, the firm-level profit dummy becomes a part of the firm fixed effect. Consequently, we use a profit indicator that varies within job spells: a dummy variable that indicates whether a worker has received a profit share in a given year. This approach has shortcomings of its own because the proxy combines two possible effects. First, it captures the impact of firm-level profit sharing on wages that is not eliminated by the spell transformation. Second, it reflects the individual heterogeneity of the recipient if a firm's profit sharing scheme is not inclusive, i.e. it does not cover all of a firm's workers.

Table 16 reports the estimated firm-size wage premium when the base wage is conditioned by a dummy that indicates whether a worker has received a profit share. To address the role of alternative theoretical explanations, we divide the covariates into three groups: (i) basic controls that are included in all specifica-

15 We do not explore whether there is causality running from profit sharing schemes to wages. For such attempts, see Hildreth and Oswald (1997), Guertzgen (2009), Arai and Heyman (2009), and Long and Fang (2012).

16 Andrews et al. (2006) report a similar pattern for the wage-size relationship in the IEB data, although their estimates on firm-size wage premiums are much higher. Their estimates for plant employment are, using sample means, 2.7 % (OLS), 1.7 % (worker fixed), 0 % (firm fixed), and 2.2 (for worker and firm effects).

tions, (ii) covariates that describe assortative matching, and (iii) covariates that describe monopsony behavior. We control directly for labor quality using worker education and the attractiveness of a job (job characteristics) is captured by dummies that measure the form of employment, irregular working hours, urgent work, and workplace conditions. Firm quality is proxied by capital intensity and export status (see Melitz, 2003; Foster et al., 2008).[17] The dynamic monopsony view of wage formation follows Barth and Dale-Olsen (2011), i.e., we assume that increased demand for one particular worker category implies higher wages for that group but not necessarily for other worker categories in the firm. This approach is further conditioned on a measure of local labor market tightness based on workers' travel-to-work area classification (see Maliranta and Nurmi, 2007). These controls assess the robustness of the impact of profit sharing on wages, as the observed effects may be due to group size or local shortages that either increase or decrease base wages.

The results are in line with the preliminary findings reported in table 15. The inclusion of the profit sharing indicators (the individual-level profit share and its interaction with firm size) yields three interesting findings (column 2). First, the estimate on the firm-size premium is unaffected at 0.9 % for doubling of the firm size. Second, the interaction dummy produces a statistically significant estimate (-0.1 %). This implies that an increase in firm size increases base wages less for workers who belong to profit sharing schemes, which is in accordance with our theoretical model. Third, the base wages of workers who receive a profit share are, on average, 0.7 % higher compared with non-receivers.[18] The inclusion of the matching/monopsony covariates (columns 3–5) changes the overall picture of the analysis neither qualitative nor quantitatively: the firm-size wage premium is modest but statistically significant. Furthermore, as in column 2, the specifications indicate that base wages are higher in firms with profit sharing schemes. However, the specifications suggest that the covariates that describe monopsony behavior are positively correlated with the firm-size premium, the estimate decreasing from 0.9 to 0.7 (see column 4). The covariates describing assortative matching, in turn, are correlated with the interaction variable, decreasing the estimate to close to zero (see column 3).

The point estimates for the covariates (not reported here) provide interesting comparisons with recent findings. First, they lend support to the view that base wages are affected by the size of different skill groups within a firm. The estimated coefficient (0.7 %) implies that an increase in the number of workers of the same educational type increases wages at the same rate as the general increase in the number of workers in the firm. The magnitude of the estimate is comparable with Barth and Dale-Olsen (2011), who report estimates for Norway. Second,

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17 Capital intensity may also signal higher product market rents stemming from high barriers to entry attributable to high fixed costs and, in the presence of unions, may lead to rent extraction and thus higher wages (see Arai, 2003).

18 To a certain degree this result corresponds qualitatively with the predictions of our model. Due to the increase in general equilibrium employment, base wages of workers in small firms increase with profit sharing but base wages of workers in large firms decrease. Total pay increases in both types of firms while the total premium in eq. 168 remains unchanged.

pressures in the local labor market are associated with wages. The estimated coefficient (-0.021 %) is in line with previous findings on the wage-unemployment curve; see Nijkamp and Poot (2005) for a survey.[19]

[19] Following Guertzgen (2009) and Rusinek and Rycx (2013), we attempted to examine whether the association between profit sharing and wages varies across the level of bargaining, i.e., centralized versus decentralized (industry-level) bargaining. We find some evidence, based on a rough division of the data into periods of centralized and decentralized bargaining, that centralized wage agreements suppress the impact of profits on wages.

TABLE 16 Hourly wages and firm size: the roles of profit sharing, matching and monopsony controls based on the spell specification

	(1)	(2)	(3)	(4)	(5)
Log firm size	0.009***	0.009***	0.009***	0.007***	0.007***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Profit sharing:					
*Worker indicator	-	0.007***	0.006***	0.007***	0.005***
	-	(0.002)	(0.002)	(0.002)	(0.002)
Size-profit interaction	-	-0.001***	-0.000	-0.001**	-0.000
	-	(0.000)	(0.000)	(0.000)	(0.000)
Matching controls:					
Education & level	-	-	yes	-	yes
Employment form	-	-	yes	-	yes
Job characteristics	-	-	yes	-	yes
Capital intensity	-	-	yes	-	yes
Export status	-	-	yes	-	yes
Monopsony controls:					
Skill group size	-	-	-	yes	yes
Local unemployment	-	-	-	yes	yes
Basic controls	yes	yes	yes	yes	yes
Identification	All	All	All	All	All
F-test for equality	-	188.67	161.82	122.90	95.63
(p-value)$^+$	-	0.000	0.000	0.000	0.000
R^2	0.93	0.93	0.93	0.93	0.93
No. of Obs.	1,162,325	1,162,325	1,011,875	1,162,325	1,011,875

Notes:
Basic controls include worker age, age squared, gender, occupation, tenure, tenure squared, industry, and region.
*** (**) denotes statistical significance at the 0.01 (0.05) level. Standard errors are clustered by workers.
$^+$F-test that the estimates on the firm size variables are jointly zero.

5.4.2 Results of the worker fixed effects specification

The results in Table 16 suggest that the spell specification yields robust estimates of the relationship between base wages and firm size. There are still matters that cause concern. First, the spell fixed effect specification employs an individual-level profit sharing indicator because there is little variation in profit sharing policies within firms over job spells. Second, the identification of the firm-size effect on base wages relies on changes in firm size over a job spell. Thus, the premium estimates may reflect short-term fluctuations related to, e.g. firm size or personnel policies (see, e.g. Card et al., 2014) for a similar discussion on the within-job correlation between wages and profitability.

Table 17 reports the results of specifications wherein we have omitted the unobserved firm component and split the data into workers who stay and workers who switch firms. The approach has two advantages. First, it allows us to identify the effect of firm-level profit sharing schemes on base wages together with the individual effect of profit sharing (column 5). Second, it provides information on possible selection bias related to heterogeneity between job movers and stayers. Columns (1)–(3) report estimates of the firm-size wage effect from the model wherein identification is based on workers who stay at the same firm or switch across firms.[20] Columns (4)–(5), in turn, exploit data on workers who have switched firms. For brevity, we do not report the results by various sets of covariates.

As before, the inclusion of the profit variables leaves (column 1) the firm-size estimate intact (0.4 % for a doubling of firm size), the interaction dummy yields a statistically significant estimate (-0.1 %), and the base wages of workers in firms with profit sharing schemes are higher compared with those in firms without profit sharing (1 %). The inclusion of the matching and monopsony covariates (column 3) decreases the premium estimate to nearly zero in firms without profit sharing schemes, and according to the F-test, there is no firm-size wage premium regardless of profit sharing (p = 0.174). This result remains unchanged when data on job movers alone is used (see columns 4 and 5). Furthermore, column (4) suggests another interesting finding: the base wages of workers in firms that use profit sharing and who do receive a profit share earn an additional premium in their base wages of approximately 1.1 %. In sum, because the model omits firm fixed effects but includes worker-specific unobservables together with various observables on worker and firm characteristics, profit sharing schemes are likely to capture firm-specific unobservables that raise productivity and endorse rent sharing.

[20] The proportion of moves that could be considered exogenous due to firm closures in the data is limited (2,211 out of 78,111 moves in total). Our analysis using this sample provides qualitatively similar but statistically insignificant estimates.

TABLE 17 Hourly wages and firm size: the roles of profit sharing, matching and monopsony controls based on worker fixed effects specification

	(1)	(2)	(3)	(4)	(5)
Log firm size	0.004***	0.004***	0.001*	0.001*	0.001
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Profit sharing:					
*Firm indicator	-	0.010***	0.004*	0.011***	0.009***
	-	(0.002)	(0.002)	(0.003)	(0.001)
Size-profit interaction	-	-0.001***	-0.000	-0.001**	-0.001**
	-	(0.0003)	(0.000)	(0.001)	(0.001)
Profit sharing:					
*Worker indicator	-	-	-	-	0.004***
	-	-	-	-	(0.001)
Matching & monopsony controls	-	-	yes	yes	yes
Basic controls	yes	yes	yes	yes	yes
Identification	All	All	All	Movers	Movers
F-test for equality	-	69.16	1.85	0.01	0.00
(p-value)+	-	0.000	0.174	0.931	0.978
R^2	0.91	0.91	0.91	0.90	0.90
No. of Obs.	1,162,325	1,162,325	1,011,875	377,488	377,488

Notes:
Controls (basic, monopsony, and matching) are listed in tables 15 and 16.
*** (**,*) denotes statistical significance at the 0.01 (0.05, 0.10) level. Standard errors are clustered by workers.
+F-test that the estimates on the firm size variables are jointly zero.

5.5 Conclusions

This study analyzes the impact of firm size, profit sharing and their interaction on wages. As such, it not only links two different and well-established strands of the literature but also provides insights into how the wage effects of firm size and profit sharing are related to each other. To do so, we first analyze a theoretical model with firm size rooted in differences in price-setting power in the product market and, second, explore high-quality panel data on wage earners from the Finnish private sector to empirically study the relationships among firm size, profit sharing, and base wages.

The study contributes to the literature in two ways. First, considering varying degrees of profit sharing, our model shows that the firm-size premium and profit sharing premium are traded off one to one against each other. If a large firm introduces a profit sharing scheme, the differential in total pay compared with small firms remains unchanged, but in this case, profit sharing — not firm size — accounts for the differential. Second, we use firm- and individual-level information on profit sharing programs to examine the relationship empirically. As such, the study contributes to research on the wage-profit relationship that has recently focused on profitability and wages by bargaining structures (Guertzgen, 2009; Rusinek and Rycx, 2013), the effects of the adoption of profit sharing schemes on wages (Long and Fang, 2012), asymmetry in the relationship between profits and wages over firm business cycles (Arai and Heyman, 2009), and the role of sunk capital in rent sharing (Card et al., 2014).

The findings of the empirical analysis are in line with our theoretical profit sharing model. Furthermore, the study shows the importance of labor market frictions (dynamic monopsony behavior) and assortative matching (worker and firm quality), in determining the firm-size wage premium. The main findings can be summarized as follows. First, the study detects a modest but statistically significant effect of firm size on base wages after accounting for individual and firm heterogeneity, including worker and firm fixed effects. Second, the study shows that there is no firm-size wage premium when we control for profit sharing and several covariates that describe assortative matching and monopsony behavior. The results also imply that employees in firms with a profit sharing scheme have higher base wages per se. This finding accords with Andrews et al. (2010) and Long and Fang (2012), who show that workers in establishments which use financial participation schemes, earn more than their counterparts. In sum, our results provide support for the view that large firms are more likely to use profit sharing schemes, employ more proficient labor and pay higher wages. The empirical results are thus consistent with the view that larger firms that enjoy price-setting power in the product market may transfer some of these extra rents to employees in the form of profit sharing.

5.A Appendix

5.A.1 Firm-size wage premium under endogenous profit sharing

Allowing the endogenous determination of the profit share, where unions and firms bargain over the share, leads to qualitatively similar results as the basic model presented in section 5.2. Similar to the basic model with an exogenous profit share, we assume that the profit share is set independent from wages due to potential policy benefits for firms. Following a similar timing structure, we thus assume that unions and firms first bargain over the profit share and, thereafter, bargain independently over wages. Nash bargaining over the profit share is given by the following maximization problem:

$$\max_{\mu_j} U_{ij}^{1-\gamma}[(1-\mu_j)\Pi_{ij}]^{\gamma} \quad \text{with} \quad 0 \leq \mu_j \leq 1 \tag{172}$$

This leads to a profit share that depends on firm and union characteristics:

$$\mu_j = 1 - \gamma - \gamma \frac{N_{ij}}{\Pi_{ij}}(w_{ij} - \overline{w}) \tag{173}$$

As firms and unions are committed to the profit share, they take it as given when bargaining over wages. We are therefore back to equation (163). Solving this equation with regard to wages leads to:

$$w_{ij} = -\mu_j \frac{\Pi_{ij}}{N_{ij}} + \frac{1-\gamma(1-\alpha\kappa_j)}{\alpha\kappa_j}\overline{w} \tag{174}$$

Combining equations (173) and (174), replacing firm profits and employment and rearranging leads to:

$$\mu_j(\gamma) = 1 - \gamma \tag{175}$$

Ultimately the profit share depends solely on the bargaining power of the union. The intuition for this result lies in the fact that bargaining over profit shares and wages takes place independently. Although perfect independence might not prevail in actual bargaining situations, it is very likely that decisions on profit shares and wages are quite disconnected for the following reasons: First, as noted above, to obtain potential policy benefits, the firm has an interest in separating the two bargaining situations, for example, by the timing structure. Second and more importantly, wage negotiations most often take place on a very centralized level with a high degree of coordination, especially in the Finnish labor market context. Profit sharing decisions are, however, firm specific and — if negotiated — handled by parties other than central employer organizations or unions. As such, it is difficult, if not impossible, to anticipate and internalize profit sharing or wage decisions.

Replacing $\mu_j(\gamma)$ in the respective equations in section 5.2 thus yields the general equilibrium under endogenous profit sharing. The relative total pay premium given in eq. (168) remains unchanged, while the base wage premium from eq. (169) reduces to a constant and equals zero. Note that for simplicity, it was assumed in section 5.2 that all the bargaining power is on side of the union, which also implies that the profit share equals unity. The result of a base wage premium of zero remains unchanged when $0 < \gamma < 1$. Therefore, the total premium is explained only by profit sharing. This outcome directly corresponds to the results from column 5 in Table 12. As such, the basic model with exogenous profit sharing nests the augmented model with endogenous profit sharing as a special case where the bargaining power of the union coincides with the size of the profit share.

5.A.2 Data: Variable definitions

Data: Main variable definitions.
- Base wage (BW): Total hourly wages include supplements based on location and workplace conditions; performance-based pay components for salaried employees (based on employer's subjective evaluations); performance-based earnings for wage earners (based on piece rates); taxation values for fringe benefits; earnings for extra and overtime work; eventual compensation for on-call or urgent work; other irregularly paid supplements; and pay for working hours not worked. Hourly earnings do not include one-off items, such as holiday pay.
- Firm size (FS): number of employees.
- Profit sharing scheme in firm (PSF): dummy (yes = 1, otherwise 0).
- Worker receives a profit share (PSW): dummy (yes=1, otherwise 0).
- Skill group size in firm (SGS): 81 groups (9 education levels and 9 education fields).
- Local labor market tightness (LMT): the unemployment rate of each municipality (445) within the travel-to-work area (82 areas) weighted by the employment share of the municipality in the travel-to-work area.
- Capital-labor ratio (CLR): physical capital (in euros) per worker (number of employees) in the firm.
- Job characteristics (JC): dummy (yes=1, otherwise 0) for overtime pay, compensation based on location and workplace conditions, on-call compensation; piece rates.
- Age and age squared (A, A2): years
- Tenure and tenure squared (TE, TE2): years of employment in firm
- Occupation (OCC): 25 categories, ISCO 2-digit classification
- Education (EDU): 9 categories, ISCED 1997 classification
- Field of education (FEDU): 9 categories (General Education; Teacher Education and Educational Science; Humanities and Arts; Social Sciences and Business; Natural Sciences; Technology; Agriculture and Forestry; Health and Welfare; Ser-

vices; Other or Unknown Field)
- Form of employment (FE): dummy (full time = 1, part time = 0)
- Pay mode (PM): dummy (monthly = 1, hourly = 0)
- Regions (RE): 18 regions, NUTS2 classification, excluding Ahvenanmaa
- Industry (IN): 12 categories, NACE 1-digit classification
- Firm's export status (EX): dummy (exports = 1)
- Firm's legal status (LE): dummy (limited company = 1)
- Firm's ownership (FO): dummy (public majority = 1)

5.A.3 Derivation of the model's main equations

As pointed out in the main text the behavior of both types of firms is similar. Small and large firms are assumed to maximize profits:

$$max \quad \Pi_{ij} = p_{ij}Y_{ij} - w_{ij}N_{ij} \tag{176}$$

Firm type is indicated by subscript $j = b, s$ and subscript $i \in [0, 1]$ states that there is a continuum of firms in the economy. Both firm types face a production function with decreasing returns to labor $Y_{ij} = AN_{ij}^{\alpha}$ and a Blanchard-Kiyotaki good's demand function $Y_{ij} = p_{ij}^{\eta}Y$. Profit maximization leads to the following expression of firm-level labor demand:

$$N_{ij}(w_{ij}) = \left[\alpha\kappa_j A^{\kappa_j} Y^{1-\kappa_j} w_{ij}^{-1}\right]^{\frac{1}{1-\alpha\kappa_j}} \tag{177}$$

Turning to worker behavior, the union's utility function is given by eq. (161) with rents as discussed in the main text. Bargaining takes place between the single union and firm. The Nash product can be rewritten as follows:

$$max \quad \left[N_{ij}\left(w_{ij} - \overline{w} + \mu\frac{\Pi_{ij}}{N_{ij}}\right)\right]^{1-\gamma} \left[(1-\mu)\Pi_{ij}\right]^{\gamma} \tag{178}$$

Maximization of the Nash product leads to the firm level base wage which is given by:

$$w_{ij} = -\mu\frac{\Pi_{ij}}{N_{ij}} + \frac{1-\gamma(1-\alpha\kappa_j)}{\alpha\kappa_j}\overline{w} \tag{179}$$

Total remuneration is thus given by:

$$\begin{aligned} r_{ij} &= \mu\frac{\Pi_{ij}}{N_{ij}} + w_{ij} \\ &= \frac{1-\gamma(1-\alpha\kappa_j)}{\alpha\kappa_j}\overline{w} \end{aligned} \tag{180}$$

Aggregating the model as described in the main text, turns firm labor demand as given in eq. (177) into labor demand by each firm type as denoted in eq. (164). As such the amount demanded, n_j, can be interpreted as the share of workers (among all workers) employed at firm type j.[21]

Considering the full outside option of the worker as discussed in the main text, allows to write the base wage of workers in a large firm as follows:[22]

$$w_b = -\mu\frac{\Pi_b}{n_b} + \frac{1-\gamma(1-\alpha\kappa_b)}{\alpha\kappa_b - (1-\gamma(1-\alpha\kappa_b))n_b}(n_s r_s + (1-n)b) \tag{181}$$

The total remuneration of the employees in large firms is given by:

$$r_b = \frac{1-\gamma(1-\alpha\kappa_b)}{\alpha\kappa_b - (1-\gamma(1-\alpha\kappa_b))n_b}(n_s r_s + (1-n)b) \tag{182}$$

Similarly base wage and total pay can be derived for the workers in small firms. Note that for $\gamma = 0$ you obtain the equations in the main text, see. eq. (166) and (167).

[21] Assume for instance that the two types of firms are exactly identical, i.e. $\kappa_s = \kappa_b = \kappa$ which implies that $2n_j = n$. This allows to rewrite aggregate labor demand as follows $w = \alpha\kappa A n^{\alpha-1}$, which exactly equals labor demand in a model without firm heterogeneity.

[22] Note that when aggregating eq. (179) it holds that $N_{ij} = n_j$ as there are no nonlinearities which have to be taken into account. As discussed above for the labor demand side it holds that $N_{ij} = J n_j$.

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6 WAGE REFERENCES, PROFIT SHARING AND WAGE RIGIDITY: EVIDENCE FROM LINKED EMPLOYER-EMPLOYEE DATA

Abstract*

Motivated by theoretical research on fair wage setting where workers choose profits per worker as internal wage reference, this paper provides empirical evidence on the close connection between rent-sharing and wage rigidity. Profit endogeneity is accounted for by instrumentation as well as the self-selection of firms in different categories of profitability. As such this study is the first to account for both: endogeneity within and between different categories of profitability. Worker and firm level heterogeneity is controlled for by fixed effects estimations. Using a large linked employer-employee data set, the effect of profits per worker on wages is estimated for firms in the following categories: positive, increasing, positive & increasing, negative, decreasing and negative & decreasing profits. Profits are shared in the first three categories while there is no downward adjustment of wages in the other three. Given the theoretical evidence on fair wages these results suggest that profits per worker serve as internal wage reference.

Keywords: Internal References, Profit sharing, Wage rigidity, Endogeneity, Instrumental Variables

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6.1 Introduction

Given the macroeconomic consequences and its implications for monetary policy a large empirical literature on downward wage rigidity evolved over the last two decades (Dickens et al., 2007). This literature relates the observed rigidities regularly to fairness considerations of employees (Holden, 2004; Bewley, 2007) based on survey evidence (Bewley, 1999) economic psychology (Kahneman et al., 1986) as well as experimental economics (Fehr and Gächter, 1998).[1] With few exceptions such as Elsby (2009) and Stüber and Beissinger (2012) this literature is concentrated on (missing) downward wage adjustments but leaves wage increases unattended. Moreover the focus is rather on business cycle effects than on worker or firm level characteristics which could explain wage changes, for example through profit sharing.

On the other hand there is a large literature trying to quantify the effect of firm profitability on wages, and thus explain wage increases by employer characteristics. Evidence on that association has been produced using industry-level data (e.g. Dickens and Katz, 1987; Blanchflower et al., 1996), firm level data (Reenen, 1996; Hildreth and Oswald, 1997; more recently Long and Fang, 2012) and, to a fewer extent, linked employer-employee data (Kramarz, 2003; Martins, 2009; Arai and Heyman, 2009; Guertzgen, 2009; Rusinek and Rycx, 2013; Card et al., 2014).[2] Among that literature on profit sharing however there are only few papers which address wage rigidity namely Martins (2009) and Arai and Heyman (2009). They show that the relation between profits per worker and wages is asymmetric. As average profits increase so do wages, but as average profits decrease, there is no downward adjustment of wages. Both studies interpret their findings in light of efficient bargaining and do not relate them to fairness considerations of workers.

The contribution of this paper to the literature is twofold. First, it shows from a theoretical perspective that while efficient bargaining is able to motivate rent sharing, it falls short to motivate wage rigidity. Therefore this paper builds on theoretical research which incorporates fairness considerations along experimental and psychological evidence. In these models fairness is mainly modeled as firm internal reference to which workers compare their wages in order to assess whether the wage paid is fair or not. This research shows, that fairness can not only lead to wage rigidity but also to rent- respectively profit sharing (Danthine and Kurmann, 2006, 2007, 2010; Koskela and Schöb, 2009; Strifler and

1 Wage rigidity is also related to contractual or institutional characteristics of labor markets. Böckerman et al. (2007) provide mixed evidence on the causes of wage rigidity. While wage rigidity is often understood as the unresponsiveness of wages to changes in (un)employment this paper follows Arai and Heyman (2009) and Martins (2009) and focuses on the responsiveness of wages towards changes in profitability. However there is a close connection between these understandings as firm profitability decreases during recessions and so does employment.

2 Some recent papers using linked data relate rent-sharing directly to wage dispersion. As such profit-sharing can be seen as a firm-level driver of labor market inequality, see e.g. Barth et al. (2016), Card et al. (2016).

Beissinger, 2016). As such the empirical analysis of this paper is motivated by a feature which, from a theoretical perspective, suggests a close connection between profit sharing and wage rigidity.

Second, while this paper belongs to a small group of studies which are (partly) able to solve the problem of profit endogeneity (see e.g. Abowd and Lemieux, 1993; Estevao and Tevlin, 2003; Martins, 2009; Arai and Heyman, 2009; Card et al., 2014), this paper is the first to consistently estimate the effect of profits per worker on wages over different profitability categories where firms are likely subject to self-selection. In other words, two sources of endogeneity are accounted for: endogeneity of profits per worker *within and between* several categories of profitability. Four instruments based on exchange rates and the oil price are used to instrument three endogenous regressors. This allows tests of overidentifying restrictions and therefore the validity of the instruments. Fixed effects methods are used to control for worker and firm level unobserved heterogeneity.

Using a comprehensive linked employer-employee data set on all private sector workers and firms of the Finnish labor market, this paper finds that economically significant profit sharing takes place in firms with positive, increasing and positive & increasing profits. However, in firms with negative, decreasing and negative & decreasing profits wages do not move with profits per worker. In fact, in many estimations there is no downward wage adjustment at all. In light of the theoretical evidence on fairness and internal references it is likely that workers focus on profits per worker as a reference in good times (increasing profitability) but resist wage cuts in bad times (decreasing profitability).

The paper is structured as follows. Section 6.2 discusses several different motives for profit sharing and their links to wage rigidity from a theoretical perspective. Section 6.3 gives an overview over the data and section 6.4 discusses the empirical setup. Section 6.5 presents results based on fixed effects estimations while sections 6.6 and 6.7 focus on the instrumentation of profits per worker. Robustness checks are presented in section 6.8 and section 6.9 concludes.

6.2 Theory

Economic theory suggests mainly five different types of reasons behind profit sharing: frictions, risk sharing, human capital/turnover, bargaining and fairness models (Long and Fang, 2012 and Martins, 2009). All predict a positive correlation between firm profitability and wages. As such, it is hard to tell which type of channel might cause or co-determine the correlation by analyzing the data only. However, from a theoretical perspective, among these five different types mainly fairness models connect two empirical phenomena: profit sharing and high levels of wage rigidity. If both are found in the data, it does not allow to rule out that other factors co-determine profit sharing, however it provides evidence that fairness considerations could be involved.

In search theory, frictions in the labor market can lead to a positive wage-profit correlation as high productivity firms offer high wages to reduce search time and save on search costs. The frictions alone however do not provide a rationale for the absence of wage adjustments in case of negative or decreasing profits (McLaughlin, 1994).

In risk sharing models, parts of the fixed wage are substituted by a variable profit sharing component (Weitzman, 1984; Kruse, 1993 and 1996; Bellmann and Möller, 2010). In that way firms are able to react in a more flexible way to fluctuations in demand. In times of high profitability firms pay large profit sharing premiums while they are able to adjust pay downwards and save on firing costs in times of lower profitability. Employees who participate in profit sharing will ask for proper compensation for the additional risk they take. As such these models are able to explain profit sharing but suggest a larger flexibility rather than rigidity in wages. At best, considering risk-neutral workers, there is close to no effect on wage rigidity, see appendix 6.A.1.

The third type of rationale to engage in profit sharing is the intent to attract and retain highly qualified employees. In contrast to risk sharing the aim is not to substitute fixed by variable pay components but to reduce turnover by increasing earnings. As such this can be seen as part of a high-road approach to worker relations (Kochan et al., 1993; Azfar and Danninger, 2001; Long and Fang, 2012). Since bonuses paid through a profit sharing scheme are easier to adjust than contracted wages, this type of profit sharing should not increase wage rigidity. It rather implies that total pay is more flexible.

Fourth, unionization and wage bargaining are maybe the most often cited reason for profit sharing and are also commonly held responsible for generating wage rigidity. Based on Dunlop (1944), Layard et al. (1991) and others, recent empirical literature on profit sharing focused on the degree of centralization (Guertzgen, 2009; Rusinek and Rycx, 2013) and on efficient bargaining solutions (Martins, 2009; Arai and Heyman, 2009) where unions bargain with firms over wages and employment. The main mechanism leading to profit sharing in these type of models stem from rents attained through firms' price setting power on product markets subject to imperfect competition. These rents increase profits and are partially claimed by unions in wage negotiations. Since wages are negotiated and can not be freely adjusted by the firm as in a perfectly competitive labor market, wage bargaining also leads to a certain degree of wage rigidity. However, it falls far from bringing the degree of wage rigidity close to empirical results. It is nevertheless likely that unionization and centralized bargaining has an impact on wage adjustments as shown by Böckerman et al. (2007).

In right-to-manage models, where bargaining takes place over wages only, the wage is set as a markup on the outside option. As shown in Strifler and Beissinger (2016) this can lead to a large degree of wage flexibility compared to a situation with unions including fairness considerations. In efficient bargaining models however, wages are set as markup on the outside option and profits per worker. Thus firm profitability directly occurs in the (empirical) wage equation which is similar to fairness models (Danthine and Kurmann, 2007) and strengthens the profit sharing argument. On the other hand, not only wages are negotiated but so is employment which prevents firms to freely adjust employment. Appendix 6.A.2 shows that efficient bargaining used in Martins (2009 and Arai and Heyman (2009) to motivate both, profit sharing and wage rigidity, fails to generate high levels of wage rigidity. In fact it leads to comparable levels of wage rigidity as in right-to-manage models.

Finally, the fifth rationale behind profit sharing are fairness considerations which are mainly nested in efficiency wage models where workers behave in a reciprocal manner. Strauss (1990) considers profit sharing in this context as a mechanism to enhance worker's motivation and effort. Building on the seminal work of Akerlof (1982) more recent fairness models have incorporated firm internal wage references such as the product respectively revenue per worker (Danthine and Kurmann, 2006, 2007 and 2010; Koskela and Schöb, 2009) into wage setting. Apart from economic psychology and experimental economics the integration of these wage references were motivated by survey evidence, see e.g. Clark and Oswald (1996), Bewley (1999), Agell and Bennmarker (2003) and (2007). Brown et al. (2008) provides a more extensive overview.

In contrast to earlier efficiency wage models, workers compare wages to external as well as internal pay reference in order to determine whether wages offered are fair or not. This leads to a wage setting curve of the same structure as in efficient bargaining. Wages are set as markup on both pay references. The direct effect of firm performance on wages not only implies rent sharing but can also lead to substantial wage rigidity. Thus internal wage references are at the core of fairness models to explain high levels of wage rigidity. Introducing profits per worker as internal reference in a unionized labor market Strifler and Beissinger (2016) show that fairness considerations connect profit sharing and wage rigidity. To summarize, independent of the type of labor market model, fairness considerations in form of firm internal wage references can lead to rent respectively profit sharing and high levels of wage rigidity.

From a theoretical perspective, among five different rationales for profit sharing mainly fairness considerations connect profit sharing and high levels of wage rigidity. If both are found in the data, it indicates that fair wage considerations might be responsible. Of course other rationales also lead to profit sharing, but if wage rigidity is found, it is likely that fairness considerations in form of internal wage references are involved.

6.3 Data

The data used in this study comprises all private sector employees and firms in Finland from 2000 to 2012. Information on employees is gathered mainly from the employment register and wage structure survey. Information on firms stems from the business register and the balance sheet panel. All micro data was provided by Statistics Finland. Employees are linked to their employer through a unique firm identifier. With few exceptions almost all data is register data. For the construction of the instruments, trade data from Finnish Customs is linked to the firm data. Data on bilateral exchange rates was obtained from the Statistical Data Warehouse of the ECB and data on oil prices from www.investing.com.

Only fulltime employees with more that 35 hours per week are considered in the analysis. The lowest and highest percentile of the wage and profit distribution were excluded. So were firms with less than two employees. This leaves a total of over one million employees working in almost 20.000 firms. The number of unique worker-firm combinations or spells is 1.5 million. The total number of observations is over 5 million. Due to the high quality of the data a precise measure of worker and firm characteristics is possible. The employment history of individuals can be traced back to 1970 which provides detailed information on work experience for most of the population. Local unemployment is calculated for 70 different regions and linked to the worker's place of residence. Detailed data on firm's equity, assets and financial figures is used. Data on wages stem from annual tax statistics as well as from the wage structure survey which provides the basis for extensive robustness checks.

The profit measure used in the analysis is operating profits. It is given by the operating margin minus other operating income. The operating margin is defined as the firm's operating result before financial items, taxes and depreciation.[3] Operating profits were chosen as profit measure for the following reasons. Since the profit measure is based on the firm's operating margin it measures firm performance at its core activities. In addition it captures the basis of potential profit sharing. As such operating profits is likely to be known among employers and employees. Since financial items, taxes and extraordinary items, such as e.g. the selling of fixed assets, are not included in operating profits, it is also a measure about which workers know, that they directly contribute to it. This is important because employees will choose a wage reference they feel entitled to (Kahneman et al., 1986). Since data on weekly working hours is collected, the number of fulltime equivalent employees in each firm is available. Together with the register data from the financial statements panel it enables a precise measure of profits per (fulltime) worker.

The first line in table 18 shows how firms are distributed over different profit categories. Over the entire time span of the data roughly 14 % of all firms witness negative profits while the large majority realizes positive profits (over 85 %). Decreasing profits per worker are approximately as common as increasing. A total of almost 10 % of firms are subject to both, negative & decreasing profitability while almost all firms with increasing profits per worker also realize positive profits (93 %). Along these categories there is substantial variation in profits per worker as reported in the second line of table 18. Profitability scaled by 10000 varies from -2.74 in firms with negative profits to 3.85 in firms with positive & increasing profits per worker. Just by this simple look at the data naturally the question arises how pronounced profit sharing is over the different categories, and whether there is any profit sharing if it implies losses for the worker.

Finally the trade data from Finnish Customs contains detailed information

[3] Please see appendix 6.A.3 for more details.

TABLE 18 Operating profits per worker by category

	(1) all data	(2) positive	(3) negative	(4) negative decreasing	(5) decreasing	(6) increasing	(7) positive increasing
Share of firms in %	100	85.6	14.3	9.7	45.3	44.3	41.0
π/n	2.34	3.19	-2.74	-2.69	1.35	3.38	3.85

Notes: Column description refers to operating profits per worker. First column contains all data, second only positive profits, third only negative profits and so on. The data is based on all firm-year observations. π/n are operating profits per worker divided by 10000.
* $p < .10$, ** $p < .05$, *** $p < .01$

on the origin and destination of imports and exports. Moreover it reports details on the types of products traded, based on the Standard International Trade Classification (SITC).[4] This data provides the basis for the construction of the instruments which are presented in detail in appendix 6.A.5.

6.4 Empirical setup

Following the literature on internal wage references the wage equation is given by a markup on internal and external reference. Based on Strifler and Beissinger (2016), who consider profits per worker as internal reference, the stylized wage equation is given by:

$$w = \vartheta\pi/n + \overline{w} \tag{183}$$

Depending on model assumptions the markup ϑ comprises, among others, effort reaction parameters or unions' bargaining power. The firm external reference $\overline{w}$ comprises earning opportunities outside the firm, the employment rate and unemployment benefits. Most important however, is the direct impact of profits per worker Π/n on wages which allows the following empirical specification based on Abowd et al. (1999).

$$w_{it} = \pi/n_{j(i,t)t}\gamma + \mathbf{y}_{j(i,t)t}\boldsymbol{\delta} + \mathbf{x}_{it}\boldsymbol{\beta} + \alpha_i + \phi_j + \varepsilon_{it} \tag{184}$$

Workers, indexed $i = 1, ..., N$, are observed once per year $t = 1, ..., T$ in firm $j = 1, ..., J$. The function $j(i,t)$ maps worker i to firm j in year t. The dependent variable w_{it} is log hourly pre-tax wages and the main regressor of interest $\overline{\Pi}_{j(i,t)t}$ is yearly operating profits per worker.[5] $\mathbf{y}_{j(i,t)t}$ and $\mathbf{x}_{it}$ comprise time variant observable firm- respectively worker level covariates while α_i and ϕ_j comprise the corresponding observable and unobservable time invariant variables.

4 Officially the product classification follows the Combined Nomenclature which can be matched to the SITC based on EU Regulation No. 2015/1754, Annex I to EEC No. 2658/87.

5 Profits per worker are divided by 10.000 in order to ease exposition.

A short discussion of the estimation of eq. (184) by pooled OLS is provided in appendix 6.A.4 since it allows for the estimation of time invariant covariates. In the following sections fixed effects and panel IV models are estimated with focus on the main variable of interest: profits per worker.

6.5 Results: fixed effects

It is likely that unobserved characteristics are correlated with profits per worker leading to biased OLS estimates. Following Abowd et al. (1999), the panel structure of the data is exploited to control for time invariant individual- and firm level heterogeneity. Writing out eq. (184) regarding time-variant covariates yields:

$$\begin{aligned} w_{it} = \pi/n_{j(i,t)t}\gamma + \text{Experience}_{it}\,\omega + \text{Experience}^2_{it}\,\psi + \text{Education}_{it}\,\chi \\ + \text{White collar}_{it}\,\phi + \text{Log unemployment}_{it}\,v + \text{Lag log total assets}_{j(i,t)t}\,\tau \\ + \text{Lag equity ratio}_{j(i,t)t}\,\sigma + \text{Lag debt equity ratio}_{j(i,t)t}\,\rho \\ + \text{Lag relative indebtedness}_{j(i,t)t}\,\xi + \varepsilon_{it} \end{aligned} \tag{185}$$

The specification follows the majority of the rent sharing literature - see e.g. Martins (2009) or Card et al. (2014), with detailed worker and firm characteristics. The most notable differences are the following: First, tenure is not included in the specification due to the high quality of the data on work history. The number of months worked per year are available back to 1975 which implies that in the spell estimation experience and tenure are (almost) perfectly correlated. Second, instead of log number of workers, log total assets is used as a measure of firm size.[6] The reason lies in the fact that the number of workers is already contained in the main regressor of interest: firm profitability. Third, more firm controls are used than is typical in the literature since access to the financial statements panel allows to control for important capital and financial figures which are likely to affect wages. Especially the equity ratio, which also works as a time variant proxy for the capital intensity of firms, controls for assortative matching. In order to obtain a certain level of exogeneity the first lag of these variables is used. Finally it is worth to point out that the local unemployment rate is measured over 70 different regions within Finland, matched to the respective place of residence of workers. This not only represents a high quality regional control but also captures the effect of the business cycle on wages lagged by one to two periods (Blanchflower and Oswald, 1996).

This specification remains unchanged when estimated by individual, firm and spell fixed effects as well as by panel IV methods in section 6.7. The first controls for individual level heterogeneity while the second controls for heterogeneity on the firm level. Firm effects are identified by movers, workers who change firms. Since it is possible that moves from one firm to another are non-random

6 As a robustness check also log total sales is included as a second measure. See section 6.8.

and endogenous, systematic sorting of workers to firms leads to biased results. This is ultimately accounted for by using spell fixed effects, which controls for both, time invariant individual as well as firm level heterogeneity.

In order to test for wage rigidity, fixed effects models are estimated by different categories based on the profitability situation of the firm. Following Martins (2009) and Arai and Heyman (2009) the effect of profits per worker on wages is estimated separately for firms with increasing and decreasing profits.[7] As profits increase over time we should expect a positive effect on wages since employees try to obtain their fair share of profits. However, as profits decrease we should expect no (or even a negative) effect since employees try to resist wage cuts. In the same spirit the following categories are used: positive and negative profits. Firms' profits can turn negative (or positive) only temporarily, for one period. Nevertheless this might induce management to try to adjust wage costs. If the prediction of fair wage theory holds, we should expect no, or a smaller effect on wages in case of negative profits. In order to determine wage rigidity at the outer ends, also the following categories are used: positive & increasing as well as negative & decreasing profits. The difference between the estimates of these two categories should be larger than between any other.

Controlling for time invariant individual level heterogeneity implies that evidence on profit sharing and wage rigidity stems from within-individual differences across time. Robust standard errors at the individual level are calculated since some individuals change firms. Results are reported in the upper third of table 19, indicating that profit-sharing takes place in firms with positive, increasing and positive & increasing profits (columns 2, 6 and 7) while the coefficient is largest in the last category. This seems intuitive because only the most profitable firms are included in this category. Focusing on columns 3 and 4 suggests that a downward adjustment of wages does not take place in case firms realize negative profits. Both indicate that wages do not move with profits if it leads to wage cuts - which implies wage rigidity. In the decreasing profits category the coefficient is significant and positive. However it is slightly smaller compared to firms with increasing profits. As such there is some evidence on wage rigidity but it is not clear-cut.

Firm level heterogeneity is accounted for by estimating within-firm differences across time, reported in the middle third of table 19. Robust standard errors on the firm level are calculated. Similar to above profit sharing is present in firms with increasing and positive & increasing profits (columns 6 and 7). Again it is stronger in the the last category. The coefficient in the first column, containing all data, is negative which is likely due to accounting bias: Wages are part of firm's costs which directly reduce profits. This implies that the accounting relationship between profits and wages is negative, also leading to a general underestimation of the effect of profit sharing. Evidence on wage rigidity is found in firms with negative, decreasing and negative & decreasing profits (columns 3, 4 and 5). In

[7] A firm belongs to the subsample of firms with increasing (decreasing) profits if its profits increase (decrease) 2 years ore more in a row. The first year is excluded from the subsample since the change of profits from the previous to the first year is unknown.

TABLE 19 Effect of profits on wages: results from fixed effects estimation

	(1) all data	(2) positive	(3) negative	(4) negative decreasing	(5) decreasing	(6) increasing	(7) positive increasing
Individual fixed effects							
π/n	0.00101***	0.00126***	-0.00198***	-0.00166***	0.00120***	0.00125***	0.00158***
	(0.0000234)	(0.0000300)	(0.000140)	(0.000169)	(0.0000334)	(0.0000333)	(0.0000414)
N	4.758.840	4.141.291	616.862	454.990	2.433.800	2.324.975	2.162.600
r2	0.630	0.632	0.555	0.573	0.635	0.648	0.644
Firm fixed effects							
π/n	-0.00133	0.000813	-0.00875***	-0.0118***	-0.00326***	0.00156**	0.00252***
	(0.000815)	(0.00106)	(0.00279)	(0.00377)	(0.00123)	(0.000737)	(0.000765)
N	4.758.840	4.141.291	616.862	454.990	2.433.800	2.324.975	2.162.600
r2	0.242	0.243	0.211	0.212	0.236	0.243	0.245
Spell fixed effects							
π/n	0.00102***	0.00109***	-0.00154	-0.00213	0.00120***	0.00143***	0.00155***
	(0.000182)	(0.000216)	(0.00126)	(0.00193)	(0.000360)	(0.000259)	(0.000252)
N	4.758.840	4.141.291	616.862	454.990	2.433.800	2.324.975	2.162.600
r2	0.591	0.594	0.499	0.521	0.605	0.615	0.615

Notes: Column description refers to operating profits per worker. First column contains all data, second only positive profits, third only negative profits and so on. Worker controls are experience and its squared, level of education, and a white collar dummy. Firm controls are the the first lag of log total assets as a measure of firm size, equity ratio, debt equity ratio and relative indebtedness. Regional control is the log local unemployment rate. Dependent variable is log hourly wage. π/n are operating profits per worker divided by 10000. Robust standard errors clustered at individual level (individual FE) and firm level (firm and spell FE) in parentheses.
* $p < .10$, ** $p < .05$, *** $p < .01$

contrast to above, there is clear cut evidence on wage rigidity.

In order to ultimately account for potentially systematic sorting of workers across firms, spell fixed effects are estimated controlling for both, individual and firm level heterogeneity. Robust standard errors clustered at the firm level are calculated. Results are reported in the lower third of table 19. There is clear evidence on profit sharing in firms with positive, increasing, and positive & increasing profits, see columns 2, 6 and 7. In the last category wages increase by 0,15% if profits per worker increase by 10000 Euros. Moreover there is also evidence on wage rigidity in the relevant profit categories shown in columns 3 and 4. Comparable to the individual fixed effects estimation there is a positive effect in firms with decreasing profits; however it is smaller than in firms with increasing profits which suggest that downward wage adjustment is more sluggish than upward adjustment.

To conclude the results on profit sharing are robust to estimating the model with different fixed effects methods. As such profit sharing can not be explained by individual or firm level heterogeneity and seems to be a typical feature in the Finnish labor market. Evidence on wage rigidity is more mixed.[8] However, depending on the profit category there is no downward adjustment at all, or the adjustment is smaller than upwards.

6.6 Results: IV fixed effects I

As discussed in the previous section the accounting relationship between profits and wages tends to lead to an underestimation of profit sharing. In the literature there are typically two ways how this problem, and the endogeneity of profits in general, is approached: either quasi-rents are calculated and used in the estimation (see Abowd and Lemieux (1993), Reenen (1996) and more recently Guertzgen (2009)) or if possible, profits are instrumented (see Abowd and Lemieux (1993), Blanchflower et al. (1996), Estevao and Tevlin (2003) and more recently Martins (2009) and Arai and Heyman (2009)).

Within the literature which instruments profits, only Martins (2009) and Arai and Heyman (2009) use linked panel data and, besides profit sharing, also focus on wage rigidity. In effect, both papers estimate IV fixed-effects models where the data is divided by profit categories similar to section 6.5. As such, the authors are able to account for the endogeneity of firm profits within each category, however fall short of accounting for the endogeneity between the categories. It is likely that firms select themselves into the different profit categories - it depends on the market but also on the firm's decisions whether profits are positive or negative, or increasing or decreasing. In other words, it is highly problematic to divide the data into subsamples based on the endogenous regressor and expect to account for profit endogeneity in its entirety (Heckman, 1979).

[8] For a more detailed discussion on wage rigidity in the Finnish context see Obstbaum and Vanhala (2016), Böckerman et al. (2010) and Böckerman et al. (2007).

One possibility to entirely avoid the problem of sample selection (between category endogeneity) lies in a slight change of the specification from eq. (184). Instead of dividing the data by profit categories, testing for wage rigidity remains possible if the interaction of profits per worker with a dummy, indicating the respective profit category, is added to eq. (184):

$$w_{itk} = \pi/n_{j(i,t)t}\gamma_{1,k} + \pi/n_{j(i,t)t} \cdot D_k^*\gamma_{2,k} + D_k^*\gamma_{3,k} + \mathbf{y}_{j(i,t)t}\boldsymbol{\delta} + \mathbf{x}_{it}\boldsymbol{\beta} + \alpha_i + \phi_j + \varepsilon_{it} \quad (186)$$

D_k^* with $k = 1, 2, 3$ is a dummy which refers to the following profit categories:

1. $D_1^* = 1$ if $\pi/n_t < 0$, $D_1^* = 0$ if opposite
2. $D_2^* = 1$ if $\pi/n_t - \pi/n_{t-1} < 0$, $D_2^* = 0$ if opposite
3. $D_3^* = 1$ if $\pi/n_t - \pi/n_{t-1} < 0$ and $\pi/n_t < 0$, $D_3^* = 0$ if opposite

D_1^* equals unity if profits per worker are negative, D_2^* equals unity if profits per worker are decreasing and finally D_3^* equals unity if profits per worker are negative & decreasing. Therefore, in case of $k = 1$, γ_1 gives the effect of profits per worker on wages for firms with positive profits and $\gamma_{1,k} + \gamma_{2,k}$ gives the effect for firms with negative profits ($k = 1$) and so forth. In addition to the interaction term, also the dummy itself is added to the specification. This allows the wage equation to have a different intercept in the respective profit category.

In contrast to eq. (184) the major challenge lies in the fact that there is not only one endogenous variable but three. Since Finland is a small open economy at the periphery of the EU and the Eurozone, the following four instruments enable the IV estimation of eq. (186). In the spirit of Hashmi (2013) standardized trade-weighted exchange rates for the import and export side are calculated, yet not at the industry, but the firm level. The trade weights are calculated from the base year 2000 from the trade with 26 countries outside the Eurozone.[9] Changes in the exchange rate impact exogenously on the cost (through imports), respectively earnings side (through exports) of the firm and ultimately profitability. The instruments should have no other impact on wages as through firm profits since the only variation over time stems from changes in the macro level bilateral exchange rates of the Euro against 26 other currencies.

The third and fourth instrument are built as a combination of the instruments used by Martins (2009) and Blanchflower et al. (1996). Martins (2009) uses the Escudo's nominal effective exchange rate interacted with the share of exports in total sales.[10] Blanchflower et al. (1996) use energy costs at the industry level and rely especially on oil price fluctuations. As the detailed trade data, used for the construction of the first two instruments, also contains information on the type of product traded, the level of oil (SITC division 33) imports and exports is calculated. More precisely, the outside EU average share of oil imports among

9 See appendix 6.A.5.1 for details.

10 The data set the author used is from Portugal and covers the years 1990-1996 before the country joined the Eurozone in 1999.

total costs and the outside EU average share of oil exports among total revenue is determined at the firm-level and interacted with the standardized world oil price.[11] Similarly to above, changes in the oil price impact exogenously on the cost (through imports) and earnings side (through exports) of the firm and thus profitability. Again the instruments should have no other impact on wages as through firm profits since the only variation over time stems from changes in the world oil price.[12]

In the IV estimation of eq. (186) the exact same control variables are used as depicted in eq. (185): experience and its squared, level of education, and a white collar dummy are worker controls. The first lag of log total assets, equity ratio, debt equity ratio and relative indebtedness are firm controls. Regional control is the log local unemployment rate. Similarly to section 6.5 fixed effects models are estimated which is why only time variant variables are considered.

Estimating eq. (186) using IV individual fixed effects controls for the endogeneity of profits within and between the profit categories, time invariant individual level heterogeneity and, obviously, the time variant worker and firm characteristics used as controls. Robust standard errors at the individual level are calculated. The first three columns of table 26, contained in appendix 6.A.6, report the first stage results for all three endogenous regressors.

Based on Bound et al. (1995) the partial R^2 and the Sanderson-Windmeijer F statistic (SWF) are reported in the table for each endogenous regressor separately. As there are more than one instrumented variable the standard first-stage F statistic is not sufficient. The SWF tests for under- and weak identification of each endogenous regressor individually, see Sanderson and Windmeijer (2016). In table 26 both measures indicate high instrument quality. The partial R^2 measures how much of the variation of the endogenous regressor is explained by the instruments. It varies between 0.03 and 0.33 which is quite substantial. Following Staiger and Stock (1997) and Cameron and Trivedi (2005) who suggest a threshold value for the F statistic of 10 to indicate a weak instrument, no such problem occurs as the SWF varies between 19.7 to over 2300. The significant results for the dummy indicating the profit categories indicates that there is considerable endogeneity between, respectively self-selection into the categories which confirms that the IV estimation of eq. (186) is to be preferred to the IV estimation of eq. (184). The first three columns of table 20 contain the second stage results.

As indicated above the first column in table 20 contains the estimates for firms with positive and negative profits, the second column the ones for firms with increasing and decreasing profits and the third column the estimates for firms with positive & increasing and negative & decreasing profits. The coefficient in the first line (which is γ_1 from eq. (186)) indicates statistically significant profit-sharing for firms with positive, increasing and positive & increasing prof-

11 See appendix 6.A.5.2 for details.

12 It is unlikely that the instruments had a direct effect on wage-setting considerations as inflation was quite stable and low over the time period covered by the data. According to Statistics Finland average inflation based on the Consumer Price Index was below 2 % in the years 2000-2012.

TABLE 20 Effect of profits on wages: IV fixed effects I - 2nd stage

	Individual fixed effects			Spell fixed effects		
	(1)	(2)	(3)	(4)	(5)	(6)
π/n	0.0308***	0.00837***	0.0106***	0.0161**	0.0182**	0.0111**
	(0.00464)	(0.00259)	(0.000866)	(0.00726)	(0.00798)	(0.00534)
$\pi/n \cdot D_1^*$	0.0889**			-0.0454**		
	(0.0346)			(0.0177)		
D_1^*	0.493***			0.0325		
	(0.122)			(0.0498)		
$\pi/n \cdot D_2^*$		-0.00948***			-0.0162**	
		(0.00179)			(0.00707)	
D_2^*		0.125***			0.158***	
		(0.00749)			(0.0591)	
$\pi/n \cdot D_3^*$			-0.0306***			-0.0301***
			(0.00251)			(0.0107)
D_3^*			-0.00138			0.00359
			(0.00759)			(0.0302)
N	235.077	235.077	133.690	234.297	234.297	133.127
r2	0.191	0.512	0.604	0.552	0.476	0.601
Hansen's J $\chi^2(1)$	1.492	50.35	3.715	0.723	1.120	0.552
$\chi^2(1)$ p value	0.222	1.29e-12	0.0539	0.395	0.290	0.457

Notes: See table 26. Endogenous variable is log hourly wages.
* $p < .10$, ** $p < .05$, *** $p < .01$

its. A rise in profits per worker by 10.000 leads to increases in hourly wages between 0.8 and 3.1 %. This amounts to a 7 to over 20-fold increase in the estimates compared to table 19. Such an increase is at the upper end of what is typically found in the literature on profit sharing which falls short of controlling for the self-selection of firms (between category endogeneity). For instance Card et al. (2014) find a modest increase of 1.5 due to instrumentation, Reenen (1996) report a doubling of the effect while Arai and Heyman (2009) report a 10-fold increase.

The impact of profits per worker on wages for firms with negative, decreasing and negative & decreasing profits are given by the sum of lines 1 and 2, lines 1 and 4 and lines 1 and 6 respectively (which equals $\gamma_1 + \gamma_2$). Evidence on wage rigidity can be found in columns 2 and 3, where for instance in column 2 the reaction of wages regarding decreasing profitability is almost zero. Regarding firms with negative profits there appears to be downward wage adjustment.

Since eq. (186) is overidentified, there are 3 endogenous regressors and 4 instruments, it is possible to check whether the instruments are uncorrelated with the residuals. As such the exogeneity and thus validity of the instruments is tested (Hansen, 1982). The last two lines in table 20 contain Hansen's J statistic, which is asymptotically $\chi^2(1)$ distributed as the number of overidentifying restrictions is $4 - 3 = 1$, and its respective p value. Because $p > 0.05$ in columns 1 and 3, the null hypothesis, that residuals and instruments are uncorrelated, is not rejected and it can be concluded that the overidentifying restriction is valid. In the second column, the null is clearly rejected at the 1 % level which indicates that at least one instrument is not valid.

As unobserved firm heterogeneity is neglected in the estimation above, eq. (186) is estimated using IV spell fixed effects. This represents the most preferred identification strategy since it controls for the endogeneity of profits within and between the profit categories, time invariant individual and firm level heterogeneity and the time variant worker and firm characteristics used as controls. Moreover this allows the calculation of robust standard errors clustered at the firm level. The results for the first stage are presented in columns 4-6 in table 26, appendix 6.A.6. The indicators for instrument quality are similar to above with the range of partial R^2 between 0.04 and 0.35 and the SWF statistic between 11.23 and 768.9. However clustering the standard errors at the firm level leads to substantially larger standard errors compared to the IV individual fixed effects estimation above. This renders several coefficients insignificant.

Columns 4-6 in table 20 present the second stage results. Again the first line shows that profit-sharing takes place in firms with positive, increasing and positive & increasing profits. A rise in profits per worker by 10.000 leads to increases in hourly wages between 1.1 and 1.8 %. This amounts to a 4.4 to almost 20-fold increase in the estimates compared to table 19. For the average wage earner in the data this implies that 6.1% of the increase in profitability accrues to workers. This shows that profit sharing is also economically significant. The interaction term in lines 2, 4, and 6 is throughout negative and significant which implies that downward wage adjustment is throughout smaller or non-existent. In firms with decreasing profits the coefficient $(\gamma_1 + \gamma_2)$ equals 0.002 which makes it more than

9 times smaller compared to firms with increasing profits. In case of negative profits and negative & decreasing profits the coefficient becomes even negative. This can be interpreted as clear evidence on missing downward adjustment of wages with profits per worker. There is wage rigidity.

The tests of overidentifying restrictions is given in the last two lines of table 20. Contrary to the IV individual fixed effects method the p value is large in all three columns such that the null is clearly not rejected. The overidentifying restriction is valid.

Although the set of instruments presented above allows the consistent estimation of eq. (186), which captures the endogeneity of profits entirely, it rises the question of external validity. The number of firms engaged in oil trade (SITC division 33) in Finland is, of course, limited which leads to a substantial drop in observations. For that reason, and for the sake of comparability with Arai and Heyman (2009) and Martins (2009) IV fixed effects are estimated in section 6.7 based on the profit categories as presented in section 6.5. Moreover appendix 6.A.4 elaborates more on external validity: comparing pooled OLS estimates, based on the whole sample and the one used in the IV estimations above, suggests that there is reason to expect that the results hold beyond oil trading companies.

6.7 Results: IV fixed effects II

Estimating eq. (184), based on the identical set of controls as given in specification (185), by IV fixed effects neglects the sorting of firms in different categories of profitability (between category endogeneity), however comes with the advantage of a considerably larger sample size compared to the previous section. Firm-level trade-weighted exchange rates for import and export side (Instruments 1 and 2) are used to instrument profits per worker. This implies that almost any firm which trades with a country outside the Eurozone is included in the data.

The upper half of table 27, shown in appendix 6.A.6, reports the first stage results from IV individual fixed effects estimation, while the upper half of table 21 reports the second stage. The first stage reveals the significance of the instruments. However, in comparison to section 6.6, a much smaller partial R^2 prevails, ranging from 0.0004 to 0.015. The F statistic nevertheless ranges from 96 to 2497.1 which indicates the quality of the instruments.

The second stage results indicate profit sharing for firms with increasing and positive & increasing profits. The coefficient is 8 to 15 times larger compared to columns 6 and 7 in table 19 which confirms the accounting bias. This increase is comparable to Arai and Heyman (2009) and Martins (2009), and to a certain extent to the one reported in the previous section. The coefficients are even somewhat larger, especially in the case of increasing profits compared to table 20. In contrast to section 6.5 there is now also clear evidence on wage rigidity not only for firms with negative, negative & decreasing but also for firms with decreasing profits (see columns 3, 4, and 5). The last two lines contain test statistics of

TABLE 21 Effect of profits on wages: IV fixed effects II: 2nd stage

	(1) all data	(2) positive	(3) negative	(4) negative decreasing	(5) decreasing	(6) increasing	(7) positive increasing
Individual fixed effects							
π/n	-0.00413***	-0.00275***	-0.0179***	-0.0330***	-0.00650***	0.0186***	0.0132***
	(0.000541)	(0.000684)	(0.00430)	(0.00210)	(0.00109)	(0.00241)	(0.00329)
N	2.649.319	2.316.763	236.010	153.650	1.260.723	1.199.368	1.123.831
r2	0.616	0.621	0.516	0.426	0.615	0.542	0.594
Hansen's J $\chi^2(1)$	0.475	0.0206	214.5	110.7	0.268	11.00	24.51
$\chi^2(1)$ p value	0.491	0.886	1.41e-48	6.81e-26	0.605	0.001	7.38e-7
Spell fixed effects							
π/n	-0.00510**	-0.00490*	-0.0196	-0.0288**	-0.0105	0.0182	0.00721
	(0.00249)	(0.00279)	(0.0187)	(0.0141)	(0.00969)	(0.0195)	(0.00920)
N	2.576.878	2.250.308	227.347	145.435	1.204.196	1.138.384	1.067.434
r2	0.601	0.605	0.468	0.418	0.576	0.541	0.619
Hansen's J $\chi^2(1)$	1.524	1.995	3.462	0.888	0.217	3.565	5.205
$\chi^2(1)$ p value	0.217	0.158	0.0628	0.346	0.642	0.0590	0.0225

Notes: See table 19. Robust standard errors clustered at individual level (individual FE) and firm level (firm and spell FE) in parentheses.
* $p < .10$, ** $p < .05$, *** $p < .01$

overidentifying restrictions. Similarly to section 6.6 the number of overidentifying restrictions is $2 - 1 = 1$. The p value of Hansen's J is large in columns 1, 2 and 5 which implies that the null hypothesis is not rejected and the overidentifying restriction is valid. However in columns 3, 4, 6 and 7 the null is rejected which indicates that one of the instruments is not valid which is possibly due to the fact that the categories themselves are endogenous. Note however, that the number of observations is in some columns more than half compared to the full sample. This makes it quite reassuring that the similar results found in this as well as in the previous section extend to the whole sample.

First stage estimates based on within-spell differences are reported in the lower half of table 27, appendix 6.A.6. Although the partial R^2 is in a similar range as in the individual fixed effects estimation the SWF statistic clearly indicates a weak instruments problem. Consequently only few coefficients are significant in the second stage as shown in the lower half of table 21. Sign and size of the coefficients are very close to the individual fixed effects estimates. However standard errors are much larger which is due to the clustering at the firm level. Another problem inherent in the estimation is, of course, the neglect of the endogeneity of the profit categories which is likely to contribute to this result. For example the sign of the coefficient in column 2 is negative, which disagrees with the results found above and which is hard to rationalize.

6.8 Robustness

In order to test for robustness, the most preferred identification strategy (IV spell fixed effects estimation of eq. (186)) is modified in several ways. Special focus is on the measure of pay and firm size. Although hourly wages, used above, represent a measure of pay which is already independent of the amount of time worked - specific data on overtime pay and shift surcharges is used. Firms subject to an increase in the demand for their products are likely to adjust labor on the intensive margin first, i.e. increase overtime, instead of hiring new employees. The latter is encompassed with potentially expensive hiring, and firing costs in case demand drops again. As there commonly are surcharges on overtime work and extra shifts, the hourly wage of employees will necessarily increase. Obviously the surge in demand will simultaneously lead to an increase in profits which ultimately leads to the correlation of profits per worker and wages. In general, firms might realize profit sharing through different types of bonus payments and extra pay which affect differently on respective wage measures. This warrants robustness checks regarding different measures of the dependent variable.

The wage measures available in the data which suit that purpose are monthly wages minus overtime pay and monthly wages minus night, weekend, and shift surcharges. Similar to above the natural log is used in the estimations which allows the coefficients to be read as semi-elasticities. The first stage results of all robustness checks are reported in appendix 6.A.6; since they are similar to table 26 they are not discussed separately. Table 22 reports the second stage results of IV spell fixed effects estimations of eq. (186) with log monthly wages minus overtime pay as dependent variable in columns 1-3. As was to be expected the coefficients are smaller than in table 20. Only the coefficient in the first column is statistically different from zero at the 10 % level, and indicates profit sharing in firms with positive profits. Standard errors remain roughly similar. This indicates that overtime pay is partly responsible for the evidence on profit sharing. Evidence on downward wage rigidity is found in columns 1 and 3 which report significantly negative interaction terms.

As a further robustness check columns 4-6 in table 22 report the second stage results of IV spell fixed effects estimations of eq. (186) with log monthly wages minus shift surcharges as dependent variable. In contrast to the correction for overtime pay, the results are similar to table 20 and profit sharing is even more pronounced in firms with positive, increasing and positive & increasing profits. Evidence on wage rigidity is found in all 3 columns. Taken both robustness checks together, evidence on profit sharing is somewhat mixed. It seems to be partly driven by overtime. The results on wage rigidity however remain virtually unchanged.

As a final robustness check the first lag of log revenue is added as a second proxy for firm size, see e.g. Martins (2009). Columns 7-9 in table 22 report the second stage results. In column 9 the exact same degree of profit sharing is found as in table 20. In columns 7 and 8 profit sharing is now even more pronounced with an increase in wages by almost 2.5 % in firms with increasing profits per worker. Evidence on wage rigidity as denoted by the sum of the coefficient in the first line and the interaction term remains almost unchanged compared to section 6.6. Overall, it can be concluded that the results on profit sharing are quite robust towards different wage measures. Results on downward wage rigidity are very robust. Controlling for firm size also through revenue leads to even stronger results on profit sharing.

6.9 Conclusions

Theoretical research on internal wage references, nested in efficiency wage or union models, suggests a close connection between rent- or profit sharing and wage rigidity. Yet, there is little empirical research exploring that connection.

First, despite the large empirical literature on downward wage rigidity there is little known about its sources. It is commonly related to fairness considerations based on qualitative and survey based evidence. Likely due to the macro orientation of that literature there are few connections to profit sharing and the basis of wage increases. Second, with few exceptions, the empirical literature on rent sharing (i.e. upward wage adjustments) leaves wage rigidity (i.e. missing downward wage adjustments) entirely aside. This research is often motivated by theoretical models of profit sharing and unionization.

TABLE 22 Robustness: IV spell FE I - 2nd stage

	Overtime pay			Shift surcharges			Revenue as control		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
π/n	0.0128*	0.0100	0.00982	0.0170**	0.0187**	0.0162**	0.0215*	0.0249**	0.0111**
	(0.00733)	(0.00725)	(0.00632)	(0.00829)	(0.00797)	(0.00785)	(0.0123)	(0.0115)	(0.00527)
$\pi/n \cdot D_1^*$	-0.0478***			-0.0379*			-0.0546**		
	(0.0143)			(0.0205)			(0.0271)		
D_1^*	-0.0158			0.0835			0.0540		
	(0.0537)			(0.0567)			(0.0838)		
$\pi/n \cdot D_2^*$		-0.00953			-0.0177***			-0.0214**	
		(0.00605)			(0.00661)			(0.00965)	
D_2^*		0.113**			0.174***			0.211**	
		(0.0477)			(0.0661)			(0.0921)	
$\pi/n \cdot D_3^*$			-0.0303***			-0.0348**			-0.0293***
			(0.0117)			(0.0168)			(0.0101)
D_3^*			-0.00828			0.0356			0.0100
			(0.0424)			(0.0389)			(0.0384)
N	234.359	234.359	133.144	234.332	234.332	133.175	234.297	234.297	133.127
r2	0.582	0.549	0.622	0.536	0.455	0.573	0.525	0.399	0.601
Hansen's J $\chi^2(1)$	0.967	2.172	0.000991	0.198	0.468	0.581	0.466	0.263	0.673
$\chi^2(1)$ p value	0.325	0.141	0.975	0.656	0.494	0.446	0.495	0.608	0.412

Notes: See table 20. Columns 1-3: endogenous variable is log monthly wages minus overtime pay. Columns 4-6: endogenous variable is log monthly wages minus shift surcharges. Columns 7-9: endogenous variable is log hourly wage; First lag of log revenue is added as a second control for firm size.

* $p < .10$, ** $p < .05$, *** $p < .01$

Against this backdrop, theoretical evidence is provided that while standard models of profit sharing or wage bargaining are able to motivate profit sharing, they are not suitable to motivate higher degrees of wage rigidity, i.e. zero downward adjustment. In contrast, labor market models containing internal references can do both and thus suggest a closer link between the two phenomena.

Using a large linked employer-employee data set on all private sector employees of the Finnish labor market from the years 2000 to 2012, this link is explored by estimating the impact of profits per worker on wages over different firm profitability categories. The simultaneity problem is resolved by instrumentation. Moreover, in contrast to the literature, this paper is the first to fully account for the self-selection of firms into different profit categories. As such, both, endogeneity within and between profit categories is accounted for. In this particular specification three endogenous variables are instrumented by the following four instruments: Firm-level trade-weighted exchange rates on import and export side as well as the world oil price interacted with the average share of oil imports among total costs, and interacted with the share of oil exports among revenue. As there is more than one endogenous regressor, Sanderson-Windmeijer F statistics are calculated to test for weak instruments. Moreover, given the overidentification of the model, the instruments are tested for exogeneity. Worker and firm level heterogeneity is controlled for by estimating fixed effects models.

Over different specifications and methods the results indicate that profit sharing takes place in firms with positive, increasing and positive & increasing profits. In the most preferred identification strategy, log hourly wages increase by 1.82 % in firms where profits per worker increase by 10000. For the average wage earner in the data this implies that 6,1 % of the increase in profitability is shared with workers. Moreover there is clear evidence that negative, or, decreasing profits are not shared. Over different specifications and methods very little to no (downward) wage adjustments are found in firms with negative, decreasing and negative & decreasing profits.

In light of the theoretical connection between profit sharing and wage rigidity it is likely that profits per worker serve as internal reference for employees. The empirical evidence provided in this paper definitely supports that view.

6.A Appendix

6.A.1 Substitutive profit sharing and wage rigidity

In risk sharing models total payment to workers (r_i) is composed of a base wage (w_i) and a profit sharing bonus ($\tau\Pi_i/N_i$) where τ denotes the degree of profit sharing, Π_i firm profits and N_i firm employment. Assuming risk neutral workers total pay is given by:

$$r_i = \tau\Pi_i/N_i + w_i \tag{187}$$

Following Koskela and Stenbacka (2012) with imperfect competition on the goods market with κ denoting price setting power and bargaining over base wages, the Nash product is given by:

$$\max_{w_i} \quad \left[U_i - U_i^0\right]^{1-\gamma} [(1-\tau)\Pi_i]^{\gamma} \tag{188}$$

The utility function of the union on the firm level is given by $U_i = N_i r_i + (L - N_i)\,\overline{w}$. L denotes total labor force and $\overline{w}$ the outside option. The status quo payments during the negotiation are given by $U_i^0 = L\overline{w}$ and $\Pi_i^0 = 0$. The production function is subject to decreasing returns $Y_i = AN_i^{\alpha}$. After firms choose employment and wages are bargained over, aggregation takes place by setting $w_i = w$, $N_i = n$ and considering the outside option of $\overline{w} = nr + (1-n)b$ where total pay reads as $r = \tau\Pi/n + w$ and b denotes unemployment benefits. The general equilibrium of the model is thus given by labor demand, base wage setting and the profit equation:

$$w = \alpha\kappa A n^{\alpha-1} \tag{189}$$

$$w = -\tau\Pi/n + \frac{1-\gamma(1-\alpha\kappa)}{\alpha\kappa - (1-\gamma(1-\alpha\kappa))n}(1-n)b \tag{190}$$

$$\Pi/n = (1-\alpha\kappa)An^{\alpha-1} \tag{191}$$

The base wage as given in eq. (190) reveals the substitutive character of profit sharing. Total pay is ultimately given by the second term in that equation. As such the direct impact of profit sharing on total pay is confined to a mere structural effect. This result is due to the assumption of risk neutrality of workers. Considering a technology shock in A which directly impacts profitability (see eq. (191)) the elasticity of equilibrium employment is given by:

$$\varepsilon_{n^*A} = \frac{1}{1-\alpha+\xi} \quad \text{with} \quad \xi \equiv \frac{(1-\alpha\kappa)(1-\gamma)}{\alpha\kappa - (1-\gamma(1-\alpha\kappa))n}\frac{n}{1-n} \tag{192}$$

The elasticity of pay is given by:

$$\varepsilon_{r^*A} = \frac{\xi}{1 - \alpha + \xi} \tag{193}$$

Evidently there is no direct impact of profit sharing (τ) on the equilibrium reaction of employment as well as pay. To be precise, there is nevertheless a general equilibrium effect through employment. However, if the model is calibrated to fit certain employment rates this effect is zeroed or at best negligible. This ultimately shows that profit sharing motivated by risk sharing has a structural effect on wages but fails to generate a substantial impact on wage rigidity. In fact, assuming risk averse workers should increase wages through profit sharing but make wages also more flexible. Therefore profit sharing of the substitution type can be ruled out as a source of wage rigidity from a theoretical perspective.

6.A.2 Unions, efficient bargaining and wage rigidity

Martins (2009) and Arai and Heyman (2009) interpret their empirical findings in light of weakly efficient contracts where employers and unions negotiate over wages (w_i) and employment (N_i). Assuming imperfect competition on the goods market with price setting power κ, a production function with decreasing returns $Y_i = AN_i^{\alpha}$, a rent-maximizing union with $U_i = N_i(w_i - \overline{w})$ and for both sides zero status quo payments, the Nash bargaining solution is given by:

$$\max_{w_i N_i} \quad {\Pi_i}^{\gamma} {U_i}^{1-\gamma} \tag{194}$$

Optimization over w_i leads to the wage curve $w_i = \overline{w} + (1-\gamma)/\gamma \Pi_i / N_i$ as given in eq. (2) in Martins (2009) and eq. (1) in Arai and Heyman (2009). Profits per worker have a direct impact on wages. Optimization over N_i and aggregation with $w_i = w$, $N_i = n$ and $\overline{w} = nw + (1-n)b$ leads to the following equations defining the general equilibrium:

$$w = (1 - \gamma(1 - \alpha\kappa))An^{\alpha-1} \tag{195}$$

$$w = \frac{1-\gamma}{\gamma(1-n)} \frac{\Pi}{n} + b \tag{196}$$

$$\Pi / n = \gamma(1 - \alpha\kappa)An^{\alpha-1} \tag{197}$$

Proceeding as in appendix 6.A.1, and considering a technology shock in A which directly impacts on profitability (see eq. (197)), the elasticity of equilibrium employment is given by:

$$\varepsilon_{n^*A} = \frac{1}{1 - \alpha + \xi} \quad \text{with} \quad \xi \equiv \frac{(1-\alpha\kappa)(1-\gamma)}{\alpha\kappa - (1 - \gamma(1-\alpha\kappa))n} \frac{n}{1-n} \tag{198}$$

The elasticity of pay is given by:

$$\varepsilon_{r^*A} = \frac{\xi}{1 - \alpha + \xi} \tag{199}$$

Both elasticities have the same formula as in right-to-manage models where bargaining takes place over wages only. Compare equations (198) and (199) to equations (192) and (193). Union's bargaining power has thus the same direct impact on wage rigidity irrespective of employment being included or excluded from negotiations. It is nevertheless possible, that equilibrium employment differs between the two bargaining regimes but this fails to bring substantial changes to the degree of wage rigidity. As shown in Strifler and Beissinger (2016) who use a right-to-manage framework it needs fairness considerations to generate high levels of wage rigidity. Therefore union models especially efficient bargaining can explain profit sharing but from a theoretical perspective fall short in explaining high levels of wage rigidity. Considering unionized workers with fairness considerations the bargaining power of unions can however increase wage rigidity since it helps them to defend their (fair) wage claims.

6.A.3 Variable and data description

Wage measures from the wage structure survey and tax statistics:

– Log hourly wages: Baseline wage measure used throughout the paper
– Log monthly wages minus overtime pay: used as robustness check
– Log monthly wages minus shift surcharges: used as robustness check

Profit measure from balance sheet panel:
Operating profits = operating margin - other operating income. The operating margin is the firm's operating result before financial items, taxes and depreciation.

Profits per worker (π/n):

$$pi/n \equiv \frac{\text{Operating profits}}{\text{Number of fulltime equivalent employees}} \cdot 1x10^{-4}$$

Worker characteristics
Gender, **age** and **mother tongue** are form the population register. Mother tongue has 3 categories (Finnish; Swedish; Other).
Experience and its square: Years of employment based on the employment register. This data goes back to 1975 which implies that there is precise information for the large part of employees.
Tenure and its square: Years of employment at the firm based on the employment

TABLE 23 Descriptive statistics

Variable	Mean	Std. Dev.	N
Log hourly wage	2.782	0.404	5.499.903
Log monthly wage - overtime	7.875	0.403	5.499.818
Log monthly wage - shift	7.862	0.413	5.499.839
Experience	12.284	6.159	5.499.875
Tenure	4.267	3.27	5.494.615
Education	2.438	0.496	5.499.903
Female	0.339	0.473	5.499.903
Swedish	0.04	0.196	5.499.903
White collar	0.669	0.471	5.499.903
Log unemployment	2.307	0.324	5.499.903
π/n	2.822	12.566	5.499.903
Log assets	18.265	2.586	5.496.674
Equity ratio	0.432	0.219	5.496.674
Debt-equity ratio	1.32	47.869	5.496.372
Relative indebtedness	6.852	2151.887	5.496.677

Notes: Experience and tenure is measured in years. 3 levels of education based on ISCED 1997 classification. Swedish is a dummy referring to mother tongue, default is Finnish. Profits per full time worker are measured on yearly basis divided by 10000. N refers to number of worker-firm-year observations. With very few exceptions the figures on the individual, firm and spell level are very similar.

register.
Field of education: 10 categories based on ISCED 1997 classification (General programmes; Education; Humanities and Arts; Social Sciences, Business and Law; Natural Sciences; Engineering, Manufacturing and Construction; Agriculture; Health and Welfare; Services; Other).
Level of education: 3 levels of education based on ISCED 1997 classification (Basic education; Secondary degree; Tertiary degree).
Form of payment: 2 categories (Monthly=1; Hourly=0). Blue- and white-collar affiliation is based on the payment form dummy.

Firm characteristics
Log total assets: main control for firm size.
Equity ratio, **debt-equity ratio** and **relative indebtedness** from balance sheet panel. Controls for capital intensity and the firm's financial health.
Log revenue: second control for firm size used as robustness check.
Legal form: 14 categories. Not-for-profit organizations were excluded from the data.
Firm ownership: 4 categories (Private domestic; State; Municipality; Foreign).
Industry affiliation: Level 1 NACE classification with 21 categories. Out of those 5 were excluded from the analysis based on missing profit orientation, e.g. public administration and defence or activities of extraterritorial organizations.

Regional characteristics
Local labor market tightness: Unemployment rate in the area of residence of the employee. 70 areas in total.

6.A.4 Results from pooled OLS

Estimating the model from eq. (184) using pooled OLS allows to obtain estimates on time invariant observable covariates. The firm level characteristics comprised in $\mathbf{y}_{j(i,t)t}$ are: firm size in terms of the lag of log total assets, lag of equity ratio, debt-equity ratio and relative indebtedness. The set of individual level characteristics in $\mathbf{x}_{it}$ are level of education (ISCED 1997 classification), labor market experience and tenure as well as their quadratic. Both are measured in years and calculated based on the employment register dating back to 1975. Furthermore blue-collar status and the log unemployment rate in the region of residence are comprised. Time invariant worker variables in α_i are gender, mother-tongue and field of education (ISCED 1997 classification). Time-invariant firm variables in ϕ_j are an import/export dummy, industry affiliation (NACE classification level 1 with 21 categories), firm ownership and legal form dummies. Standard errors account for heteroscedasticity and are clustered at the firm level.

Table 24 presents the profit-sharing coefficients under different specifications. Without any controls as given in the first column an increase in operating profits per worker by 10000 leads to a wage increase by approximately 1%. Adding worker and firm controls and dummies in column 2-4 leads to a steady decrease of the coefficient, while adding time dummies in column 5 leads to a slight increase. In the most complete specification the coefficient is roughly one third the size compared to the first column with a wage increase of 0,32%. This lies in the range estimated by the literature using linked data. Given that profits are used directly in the estimation also a negative coefficient could result due to the accounting bias. See eg. Martins (2009). Considering the average worker in the sample the wage increase implies that 1.1% of the profitability increase accrues to workers.

The impact of worker and firm controls are similar to the empirical literature using matched panel data. Experience and tenure have a positive impact on wages while the impact of experience is much larger. Wages increase by more than 20% due to completing secondary respectively tertiary education. Being female reduces wages by 18% and white collar workers earn up to 10% more than blue collar workers. An increase in the local unemployment rate by 1% leads to a wage decrease of around 16%. The firm size wage elasticity is 1,8% where firm size is measured as the lag of log total assets. The lagged equity ratio has a negative while the lagged debt-equity ratio as well as lagged relative indebtedness has a small positive impact on wages.

6.A.4.1 Pooled OLS: IV sample

Given the large drop in observations in section 6.6 the main concern regards external validity. Workers and firms in the sample used for IV estimations are likely to be different to the average worker and firm in several aspects, especially due to the constriction on firms engaged in oil trade (SITC division 33). However estimating eq. (184) with pooled OLS for that sample can, in comparison to table 24, give some idea about external validity. Table 25 contains the exactly identical specifications as discussed above and constraints the sample to those workers and firms used in the IV estimations in section 6.6.

Comparing the effect of profitability on wages between table 24 and 25 shows that there is no clear-cut difference between the data. In columns 1-3 the effect is more pronounced in the IV sample however the effect is not significant in columns 4 and 5 and also substantially smaller in column 5. Regarding worker and firm controls the results are very similar in large parts with the largest difference existing with regard to the white collar dummy and firm's relative indebtedness. The effect of being a white collar worker is much smaller and often not significant in the IV sample. This might be due to, on average, higher education and specific skills, blue collar worker possess in the sector of oil refinement and transportation. Another rather small yet surprising difference lies with female workers. In table 25 the negative effect of the female dummy is 2 percentage points smaller than in table 24. In general it can be concluded that there appear to be no major relevant differences between the data, especially with regard to the effect of profits on wages. Together with the results from section 6.7 this allows the conclusion that the effects found in section 6.6 are likely not to hold only in the oil trade sector but in general.

TABLE 24 Effect of profits on wages: results from pooled cross-section

	(1)	(2)	(3)	(4)	(5)
π/n	0.0107***	0.00650***	0.00360***	0.00244***	0.00322***
	(0.00153)	(0.000977)	(0.00131)	(0.000927)	(0.000746)
Experience		0.0395***	0.0404***	0.0398***	0.0366***
		(0.00121)	(0.00141)	(0.00117)	(0.00100)
Tenure		0.00417**	-0.00178	-0.00191	0.00945***
		(0.00190)	(0.00201)	(0.00182)	(0.00110)
Education		0.248***	0.240***	0.206***	0.198***
		(0.00725)	(0.00677)	(0.00698)	(0.00722)
Female		-0.184***	-0.184***	-0.180***	-0.179***
		(0.00443)	(0.00472)	(0.00362)	(0.00341)
White collar		0.0638***	0.0655***	0.0904***	0.0914***
		(0.0143)	(0.0159)	(0.0145)	(0.0151)
Local unemployment		-0.181***	-0.169***	-0.165***	-0.146***
		(0.00820)	(0.00701)	(0.00615)	(0.00749)
Lag log total assets			0.0183***	0.0189***	0.0185***
			(0.00284)	(0.00228)	(0.00220)
Lag equity ratio			-0.0538**	-0.0632***	-0.0387***
			(0.0243)	(0.0153)	(0.0137)
Lag debt equity ratio			0.00000137***	0.00000165***	0.00000168***
			(0.000000166)	(0.000000157)	(0.000000165)
Lag relative indebtedness			0.000631***	0.000351**	0.000335***
			(0.000220)	(0.000137)	(0.0000697)
Worker dummies	No	Yes	Yes	Yes	Yes
Firm dummies	No	No	No	Yes	Yes
Time dummies	No	No	No	No	Yes
N	5285176	5280670	4755516	4755516	4755516
r2	0.0197	0.401	0.411	0.443	0.492

Notes: Worker dummies: 10 fields of education based on ISCED 1997 classification. Mother tongue based on 3 categories (Finnish, Swedish, other). Experience and tenure squared included in specifications shown in columns 2 to 5. Firm dummies: Legal form based on 14 categories; Firm ownership based on 4 categories; Industry affiliation based on level 1 NACE classification with 21 categories. Dependent variable is log hourly wage. π/n are operating profits per worker divided by 10000. Robust standard errors at firm level in parentheses.

* $p < .10$, ** $p < .05$, *** $p < .01$

TABLE 25 Effect of profits on wages: results from pooled cross-section - IV sample

	(1)	(2)	(3)	(4)	(5)
π/n	0.0129***	0.00771***	0.00691***	0.00310	0.00122
	(0.00394)	(0.00195)	(0.00209)	(0.00297)	(0.00189)
Experience		0.0352***	0.0358***	0.0352***	0.0348***
		(0.00255)	(0.00280)	(0.00281)	(0.00221)
Tenure		0.0126**	0.00847	0.0111**	0.0189***
		(0.00541)	(0.00617)	(0.00555)	(0.00365)
Education		0.242***	0.232***	0.216***	0.215***
		(0.0154)	(0.0167)	(0.0134)	(0.0124)
Female		-0.162***	-0.159***	-0.163***	-0.163***
		(0.0179)	(0.0176)	(0.0176)	(0.0158)
White collar		0.0169	0.0236	0.0435*	0.0334
		(0.0233)	(0.0249)	(0.0237)	(0.0236)
Local unemployment		-0.112***	-0.101***	-0.119***	-0.0765***
		(0.0210)	(0.0211)	(0.0219)	(0.0238)
Lag of log total assets			0.0105**	0.0156*	0.00929
			(0.00526)	(0.00851)	(0.00638)
Lag equity ratio			-0.0330	-0.0441	-0.0615
			(0.0348)	(0.0430)	(0.0375)
Lag debt equity ratio			0.00127	0.00245	-0.0143*
			(0.0108)	(0.0124)	(0.00821)
Lag relative indebtedness			-0.116**	-0.228*	0.00222
			(0.0522)	(0.119)	(0.0737)
Worker dummies	No	Yes	Yes	Yes	Yes
Firm dummies	No	No	No	Yes	Yes
Time dummies	No	No	No	No	Yes
N	281563	281378	257439	257439	257439
r2	0.0252	0.370	0.363	0.369	0.417

Notes: As in table 24 but with the sample restricted to observations used for IV estimations in section6.6.
* $p < .10$, ** $p < .05$, *** $p < .01$

6.A.5 Instruments

6.A.5.1 Firm-level exchange rates

The countries included in the construction of the trade shares are Australia, Brazil, Canada, Switzerland, China, Czech Republic, Denmark, Great Britain, Hong Kong, Croatia, Hungary, Indonesia, India, Japan, South Korea, Mexico, Norway, New Zealand, Poland, Romania, Russia, Sweden, Singapore, Turkey, Taiwan and USA. Several EU member countries which joined the Eurozone towards the end or after the time span covered in the data, or which did not join at all, were not included in the calculation of the trade shares, e.g. Estonia, Latvia, Lithuania and Bulgaria. Although some of those did not even take part in the ERM II schedule the value of their currency varies 1:1 with the Euro which is why they were not considered. The bilateral exchange rates were obtained from the Statistical Data Warehouse of the ECB at sdw.ecb.europa.eu on 08.04.2016.

The import shares are calculated based on the CIF-value (cost-insurance-freight) of imports and the export shares based on the FOB-value (free-on-board), both before taxation. Standardization takes place through the division of the average over time. The first instrument is thus given by:

$$\text{Instrument}^{1}_{jt} = \frac{\sum_{n=1}^{N=26} \text{Import share}_{\text{firm j,country n,t=1}} \cdot \left(\frac{\text{Currency country n}}{\text{EUR}}\right)_t}{\frac{\sum_{t=1}^{T=13} \sum_{n=1}^{N=26} \text{Import share}_{\text{firm j,country n,t=1}} \cdot \left(\frac{\text{Currency country n}}{\text{EUR}}\right)_t}{T=13}} \tag{200}$$

Similarly the second instrument is given by replacing import shares with export shares in eq. (200). As the trade shares in both instruments are taken from the base year 2000 (t=1), the only time variation stems from changes in the macro level bilateral exchange rates. Obviously trade shares change over time which makes the instruments grow weaker from year to year. Since the trade shares on import and export side are different two instruments can be constructed from the bilateral exchange rates.

6.A.5.2 Oil imports and exports

As indicated in section 6.6 oil trade refers to products contained in division 33 of the Standard International Trade Classification (SITC), which includes petroleum, petroleum products and related materials. The share of oil imports among total costs, respectively the share of oil exports among revenue, is averaged over time which leads to an increase in observations, yet ensures that the only time variation of the instrument stems from changes in the oil price. Oil price refers to yearly Crude Oil Futures of the type West Texas Intermediate traded at the NYMEX (OTC). The data was obtained from www.investing.com/commodities/crude-oil-historical-data on 07.04.2016. Since a substantial amount of oil trade is done with Russia the shares are based on outside EU trade. This lowers the number of observations but increases the quality of the instruments. Similar to the first two instruments the oil price is standardized by dividing it by its own average. The third instrument is thus given by:

$$\text{Instrument}^3_{jt} = \frac{\sum_{t=1}^{T=13} \text{Share of oil imports among costs}_{\text{firm j,t}}}{T = 13} \cdot \frac{\text{Oil price}_t}{\frac{\sum_{t=1}^{T=13} \text{Oil price}_t}{T=13}} \quad (201)$$

Replacing the cost share of oil imports by the revenue share of oil exports yields the fourth instrument. The only variation over time stems from the second term, the standardized oil price. Interacting it with the shares on the import and export side enables the construction of two instruments.

6.A.6 First stage results

This appendix contains the first stage results from the IV estimations of eq. (186) and (184) described in sections 6.6 to 6.8.

TABLE 26 First stage to table 20

	Individual fixed effects			Spell fixed effects		
	(1)	(2)	(3)	(4)	(5)	(6)
	π/n	π/n	π/n	π/n	π/n	π/n
Instrument^1	-7.222***	-7.222***	-12.75***	-7.038	-7.038	-12.89*
	(0.114)	(0.114)	(0.199)	(4.495)	(4.495)	(6.687)
Instrument^2	-0.823***	-0.823***	-0.242	-1.023	-1.023	-0.0106
	(0.113)	(0.113)	(0.177)	(4.512)	(4.512)	(6.453)
Instrument^3	5.474***	5.474***	75.35***	33.29**	33.29**	66.95*
	(1.834)	(1.834)	(2.980)	(13.14)	(13.14)	(38.62)
Instrument^4	29.05***	29.05***	-372.5***	-294.2***	-294.2***	-396.8***
	(3.652)	(3.652)	(10.28)	(17.05)	(17.05)	(28.95)
pr2	0.0785	0.0785	0.199	0.117	0.117	0.203
SWF	19.72	182.8	1.308.2	20.40	22.10	11.60
	$\pi/n \cdot D_1^*$	$\pi/n \cdot D_2^*$	$\pi/n \cdot D_3^*$	$\pi/n \cdot D_1^*$	$\pi/n \cdot D_2^*$	$\pi/n \cdot D_3^*$
Instrument^1	-1.152***	-13.85***	-2.598***	-1.060	-13.71**	-2.610*
	(0.0288)	(0.131)	(0.0492)	(0.993)	(5.639)	(1.448)
Instrument^2	-2.393***	3.328***	-2.913***	-2.626*	3.304	-3.055*
	(0.0441)	(0.105)	(0.0571)	(1.528)	(3.261)	(1.708)
Instrument^3	-4.564***	50.08***	21.22***	4.776	89.67***	14.97**
	(0.675)	(2.841)	(1.734)	(3.528)	(13.04)	(6.987)
Instrument^4	5.034***	27.03***	-165.3***	-114.9***	-194.7***	-177.6***
	(1.350)	(2.787)	(4.451)	(3.631)	(14.59)	(7.839)
pr2	0.145	0.165	0.331	0.236	0.180	0.351
SWF	24.32	207.4	2.309.3	70.86	15.02	348.8
	D_1^*	D_2^*	D_3^*	D_1^*	D_2^*	D_3^*
Instrument^1	0.562***	-0.889***	1.257***	0.547	-0.884	1.262**
	(0.00939)	(0.0195)	(0.0182)	(0.410)	(0.598)	(0.610)
Instrument^2	0.732***	1.223***	0.823***	0.781*	1.307**	0.859*
	(0.0111)	(0.0217)	(0.0150)	(0.431)	(0.597)	(0.442)
Instrument^3	0.317***	4.685***	-4.805***	-0.975*	5.971**	-4.113*
	(0.0983)	(0.372)	(0.258)	(0.592)	(2.356)	(2.467)
Instrument^4	-2.027***	3.201***	22.49***	13.42***	17.22***	24.60***
	(0.177)	(0.156)	(0.681)	(1.276)	(3.499)	(2.925)
pr2	0.152	0.0348	0.229	0.162	0.0419	0.235
SWF	20.35	385.6	2.323.8	768.9	11.23	176.7

Notes: Specification as given in eq. (186). Set of control variables is identical to previous section, see table 19. Robust standard errors clustered at individual (individual FE) respectively firm level (spell FE) in parentheses.
* $p < .10$, ** $p < .05$, *** $p < .01$

TABLE 27 First stage to table 21

	(1) all data	(2) positive	(3) negative	(4) negative decreasing	(5) decreasing	(6) increasing	(7) positive increasing
Individual fixed effects							
Instrument[1]	-1.632***	-1.365***	0.462***	0.0519	-0.481***	0.444***	0.112***
	(0.0263)	(0.0251)	(0.0607)	(0.0675)	(0.0236)	(0.0297)	(0.0285)
Instrument[2]	-0.504***	-0.423***	-0.690***	-1.751***	-0.875***	0.333***	0.408***
	(0.0250)	(0.0218)	(0.0449)	(0.0571)	(0.0268)	(0.0353)	(0.0340)
pr2	0.00457	0.00461	0.00272	0.0150	0.00236	0.000609	0.000426
F statistic	2.497.1	2.011.6	126.7	499.0	795.0	200.6	96.04
Spell fixed effects							
Instrument[1]	-5.100	-4.857	1.397	0.830	-2.437*	-0.626	-1.235
	(3.156)	(3.061)	(1.542)	(2.024)	(1.378)	(1.066)	(1.036)
Instrument[2]	-0.0165	0.556	-1.972	-3.527	-1.478	1.645	1.880
	(2.753)	(1.818)	(1.752)	(2.449)	(3.758)	(1.753)	(1.891)
pr2	0.0182	0.0215	0.00874	0.0297	0.00954	0.00157	0.00225
F statistic	6.870	2.544	0.843	1.055	3.310	0.525	0.972

Notes: Specification as given in eq. (184). Set of control variables is identical to section 6.5, see table 19. Robust standard errors clustered at individual (individual FE) respectively firm level (spell FE) in parentheses.
* $p < .10$, ** $p < .05$, *** $p < .01$

TABLE 28 First stage to columns 1-3, 4-6 in table 22

	Overtime pay			Shift surcharges		
	(1)	(2)	(3)	(4)	(5)	(6)
	π/n	π/n	π/n	π/n	π/n	π/n
Instrument^1	-7.034	-7.034	-12.88*	-7.027	-7.027	-12.84*
	(4.493)	(4.493)	(6.687)	(4.495)	(4.495)	(6.686)
Instrument^2	-1.025	-1.025	-0.0148	-1.030	-1.030	-0.0513
	(4.512)	(4.512)	(6.451)	(4.515)	(4.515)	(6.444)
Instrument^3	33.28**	33.28**	66.89*	33.28**	33.28**	67.07*
	(13.14)	(13.14)	(38.63)	(13.15)	(13.15)	(38.59)
Instrument^4	-294.1***	-294.1***	-396.7***	-294.1***	-294.1***	-396.8***
	(17.05)	(17.05)	(28.98)	(17.03)	(17.03)	(28.96)
pr2	0.117	0.117	0.203	0.117	0.117	0.203
SWF	20.40	22.04	11.58	20.25	22.10	11.64
	$\pi/n \cdot D_1^*$	$\pi/n \cdot D_2^*$	$\pi/n \cdot D_3^*$	$\pi/n \cdot D_1^*$	$\pi/n \cdot D_2^*$	$\pi/n \cdot D_3^*$
Instrument^1	-1.057	-13.71**	-2.609*	-1.054	-13.68**	-2.604*
	(0.994)	(5.629)	(1.448)	(0.993)	(5.639)	(1.448)
Instrument^2	-2.628*	3.305	-3.055*	-2.630*	3.282	-3.058*
	(1.529)	(3.258)	(1.709)	(1.529)	(3.254)	(1.709)
Instrument^3	4.773	89.67***	14.97**	4.760	90.11***	14.96**
	(3.530)	(13.04)	(6.993)	(3.528)	(13.03)	(6.988)
Instrument^4	-114.9***	-194.7***	-177.6***	-114.8***	-195.1***	-177.4***
	(3.635)	(14.60)	(7.847)	(3.625)	(14.55)	(7.831)
pr2	0.236	0.180	0.351	0.236	0.180	0.351
SWF	71.03	14.98	347.4	70.67	15.00	342.2
	D_1^*	D_2^*	D_3^*	D_1^*	D_2^*	D_3^*
Instrument^1	0.546	-0.886	1.261**	0.545	-0.882	1.259**
	(0.410)	(0.597)	(0.610)	(0.410)	(0.596)	(0.610)
Instrument^2	0.781*	1.308**	0.859*	0.782*	1.304**	0.860*
	(0.431)	(0.597)	(0.443)	(0.431)	(0.596)	(0.442)
Instrument^3	-0.971	5.972**	-4.107*	-0.968	6.022**	-4.096*
	(0.592)	(2.354)	(2.468)	(0.591)	(2.360)	(2.463)
Instrument^4	13.41***	17.22***	24.59***	13.42***	17.15***	24.59***
	(1.277)	(3.499)	(2.927)	(1.273)	(3.491)	(2.924)
pr2	0.162	0.0420	0.235	0.162	0.0418	0.235
SWF	768.7	11.20	176.7	769.7	11.23	177.5

Notes: Specification as given in eq. (186). Set of control variables is identical to previous section, see table 19. Robust standard errors clustered at firm level in parentheses. Columns 1-3: endogenous variable in the second stage is log monthly wage minus overtime pay. Columns 4-6: endogenous variable in the second stage is log monthly wage minus shift surcharges.

TABLE 29 First stage to columns 7-9 in table 22

	(1)	(2)	(3)
	π/n	π/n	π/n
Instrument^1	-6.632	-6.632	-13.49*
	(4.272)	(4.272)	(7.005)
Instrument^2	-2.234	-2.234	-0.426
	(3.740)	(3.740)	(6.042)
Instrument^3	23.70*	23.70*	63.34*
	(13.04)	(13.04)	(38.46)
Instrument^4	-284.1***	-284.1***	-393.6***
	(15.31)	(15.31)	(31.48)
pr2	0.128	0.128	0.213
SWF	13.58	17.08	7.127
	$\pi/n \cdot D_1^*$	$\pi/n \cdot D_2^*$	$\pi/n \cdot D_3^*$
Instrument^1	-1.092	-13.23**	-2.385*
	(1.027)	(5.168)	(1.300)
Instrument^2	-2.531	1.895	-2.900
	(1.603)	(2.843)	(1.865)
Instrument^3	5.526	78.51***	16.31**
	(3.516)	(12.69)	(7.344)
Instrument^4	-115.7***	-183.0***	-178.7***
	(3.659)	(16.49)	(7.313)
pr2	0.232	0.189	0.331
SWF	33.59	11.92	319.1
	D_1^*	D_2^*	D_3^*
Instrument^1	0.557	-0.816	1.140**
	(0.424)	(0.547)	(0.522)
Instrument^2	0.749	1.102*	0.775
	(0.465)	(0.593)	(0.532)
Instrument^3	-1.226*	4.352*	-4.841*
	(0.695)	(2.269)	(2.702)
Instrument^4	13.68***	18.91***	25.24***
	(1.458)	(3.453)	(2.690)
pr2	0.157	0.0333	0.202
SWF	451.7	7.496	83.59

Notes: Specification as given in eq. (186). Set of control variables as in section 6.6 plus the first lag of log revenue. Robust standard errors at firm level in parentheses. Endogenous variable in the second stage is log hourly wages.
* $p < .10$, ** $p < .05$, *** $p < .01$

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YHTEENVETO (FINNISH SUMMARY)

Palkkapreemion ja palkkajäykkyyden taloustiede

Väitöskirja tarkastelee työnantajan ominaisuuksien vaikutuksia palkkoihin ja palkkajäykkyyteen sekä sitä, miten nämä ominaisuudet vaikuttavat palkkasopimuksiin. Väitöskirja koostuu johdantoluvusta ja viidestä artikkelista. Johdanto taustoittaa tutkimusta ja keskustelee seuraavista avainsanoista: palkkajäykkyys, oikeudenmukaisuus, yrityskoon palkkapreemio ja voittojen jakaminen. Luvut kaksi ja kolme tutkivat miten yrityksen sisäiset referenssiarvot (internal references) vaikuttavat palkkoihin ja palkkajäykkyyteen teoreettisesta näkökulmasta. Neljäs luku arvioi yrityskoon vaikutusta palkkoihin Suomen työmarkkinoilla. Viides luku analysoi voittojen jakamisen vaikutusta yrityskoon palkkapreemioihin. Luku kuusi tutkii empiirisestä näkökulmasta miten sisäiset referenssiarvot voivat johtaa voittojen jakamiseen ja palkkajäykkyyteen.

Ensimmäisessä artikkelissa (toinen luku) analysoidaan miten työntekijöiden harkinta/käsitys oikeudenmukaisuudesta vaikuttaa ammattiliiton palkkasopimukseen ja lopulta palkkoihin, työllisyyteen ja palkkajäykkyyteen. Oikeudenmukaisuus on mallinnettu sisäiseksi referenssiarvoksi: työntekijät vertaavat palkkoja yrityksen tuottavuuteen sekä sitä vastaavaan kannattavuuteen. Jos sisäinen referenssiarvo on korkea suhteessa ulkopuoliseen vaihtoehtoon, palkat nousevat tuottavuus-/kannattavuuspreemion kautta ja syntyy reaalipalkkajäykkyyttä.

Toisessa artikkelissa (kolmas luku) tarkastellaan keskeisintä tutkimuskirjallisuutta sisäisestä referenssiarvosta ja palkkajäykkyydestä. Yhtä poikkeusta lukuun ottamatta tutkimukset indikoivat yksiselitteisesti että sisäiset referenssiarvot kasvattavat palkkajäykkyyttä. Näiden tulosten vastaisesti luvussa kolme tarjotaan analyyttisia todistuksia ja parametrisointituloksia, jotka näyttävät, että sisäisellä referenssiarvolla on tilanneriippuvaisia seurauksia. Sisäisen referenssiarvon koko suhteessa ulkopuoliseen vaihtoehtoon määrittää, kasvaako vai laskeeko palkkajäykkyys.

Kolmannessa artikkelissa (luku neljä) tutkitaan yrityskoon yhteyttä palkkoihin Suomen työmarkkinoilla. Luvussa osoitetaan Tilastokeskuksen laajaa rekisteriaineistoa käyttämällä yrityskoon vaikutuksen palkkoihin olevan merkityksetön jokaisella identifikaatiomenetelmällä kun työntekijän ja työnantajan ominaisuuksia kontrolloidaan.

Neljännessä artikkelissa (viides luku) analysoidaan yrityskoon, palkkapreemion ja voittojenjakojärjestelmän vuorovaikutusta. Teoreettinen analyysi näyttää, että yrityskoon palkkapreemio laskee kun voittojen jakaminen on mahdollista. Empiirisessä analyysissä käytetään laajaa yhdistettyä työntekijä-työnantaja-aineistoa, jossa voidaan havaita käytettiinkö yrityksessä voittojenjakojärjestelmää vai ei. Empiirinen analyysi osoittaa, että voittojen jakamisen lisäksi myös työntekijöiden erotteleva valikoituminen (assortative matching) ja monopsonivoima vähentävät yrityskokopreemiota.

Viidennessä artikkelissa (kuudes luku) tutkitaan voittojen jakamisen ja palkkajäykkyyden yhteyttä. Voitot työntekijää kohti mitataan suoraan tilinpäätöspaneelista. Instrumenttimuuttujamenetelmää käyttämällä vältetään voittojen endogeenisuus ja yritysten itsevalikoituminen eri voittokategorioihin. Voittojen jakamista ilmenee, jos voitot ovat positiivisia tai nousussa, kun taas palkkojen tarkistusta alaspäin ei havaita jos voitot ovat negatiivisia tai laskussa. Tuloksen perusteella voitot työntekijää kohti toimivat sisäisenä vertailuarvona.