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SFB 649 Discussion Paper 2007-009

Union Wage Compression in a Right-to-Manage Model

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Union Wage Compression in a Right-to-Manage Model

Thorsten Vogel*

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Trade unions are consistently found to compress the wage distribution. Moreover, unemployment affects in particular low-skilled workers. The present paper argues that an extended Right-to-Manage model can account for both of these findings. In this model unions compress the wage distribution by raising wages of workers in low productivity industries (or low-skilled workers) above market clearing levels. Our analysis suggests that the most direct way to test this model would be via a test for stochastic dominance. We also allow for capital adjustments and compare union and non-union wage distributions in a general equilibrium framework. **Keywords:** Trade unions, wage compression. **JEL Classification:** J51, J31, J41, J21.

1 Introduction

There is strong indication that trade unions compress the wage distribution. Evidence for wage compressing union effects comes from three different directions. First, over the past decades in many industrialised countries unions have severely lost ground as major wage setting institutions while at the same time the wage distribution in these countries seriously deteriorated. Table 1, for instance, shows that in both the United States and the UK the rate of collective bargaining coverage (or simply “coverage”) in the year 2000

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Table 1: Earnings dispersion and collective bargaining coverage in a cross-section of countries

	D9/D1			Bargaining coverage		
	1980-84	1990-94	2000-01	1980	1990	2000
United States	3.91	4.39	4.64	26	18	14
Canada	...	...	3.71	37	38	32
United Kingdom	3.09	3.39	3.40	70+	40+	30+
Germany	2.88	2.79	...	80+	80+	68
<i>West</i> ^a						70
<i>East</i> ^a						55
Netherlands	2.47	2.60	...	70+	70+	80+
Australia	2.88	2.82	3.07	80+	80+	80+
Italy	...	2.35	...	80+	80+	80+
France	3.18	3.21	...	80+	80+	90+
Sweden	2.01	2.11	2.30	80+	80+	90+

Source: OECD (2004, Tables 3.2 and 3.3). D9/D1 is the 90-10 percentile ratio for the gross earnings of full-time employees. ... Data not available. ^a Kohaut and Schnabel (2003, Table 2). + indicates lower bounds.

was only about one-half of its 1980 value. Over the same time period the distribution of earnings in these countries widened significantly as the 90-10 percentile ratio illustrates.

Second, countries with lower union coverage seem to experience lower wage dispersion. Table 1 reports 90-10 percentile ratios of wages and union coverage rates in some important industrialised countries. As can be seen from this table, in countries where coverage rates are low (as for instance in the U.S.) earnings are much wider dispersed than they are, for instance, in Continental Europe where unions so far have been quite successful in maintaining their strong position as wage setting institutions. To some extent this observed wage compression appears to be caused by the greater compression of low wages in countries with high coverage rates. Table 2 reports 90-10 as well as 90-50 and 50-10 percentile ratios of earnings of men in the private sector in the U.S., in Britain and in Germany in the years 1984, 1993 and 2001. Comparing figures for Germany and the U.S. in rows 1 and 8 of the table, we see that the greater 90-10 percentile ratio in the U.S. to large extent stems from the greater 50-10 percentile ratio. In 1993 the 50-10 ratio in the U.S. was 1.74 times larger than in Germany, while the 90-50 ratio was only 1.20 times larger. For Britain this effect at the lower tail of the earnings distribution was even stronger in 1993, though it by and large vanished by 2001.¹

¹See also Blau and Kahn (1996) and Davis (1992) for a cross-country comparison of wage decedentile ratios.

Table 2: Earnings dispersion and collective bargaining coverage in a cross-section of countries

		1984				1993				2001			
		#	D9/D1	D9/D5	D5/D1	#	D9/D1	D9/D5	D5/D1	#	D9/D1	D9/D5	D5/D1
U.S. (<i>PSID</i>)	all	2,001	5.15	1.88	2.75	2,740	5.02	2.01	2.50	1,924	5.56	2.50	2.22
	uncovered	1,499	5.84	2.05	2.86	2,209	5.69	2.18	2.60	1,602	6.17	2.63	2.35
	covered (<i>unadjusted</i>)	493	3.06	1.55	1.97	513	3.00	1.52	1.98	293	3.48	1.78	1.96
	covered (<i>adjusted</i>)		3.21	1.60	2.00		3.41	1.64	2.08		5.68	2.81	2.02
Britain (<i>LFS</i>)	all ^b	...	...	...	...	4,400	3.31	1.92	1.72	17,677	3.74	2.11	1.77
	uncovered ^c	...	...	...	...	1,405	3.51	1.99	1.76	2,951	3.97	2.21	1.80
	covered ^c (<i>unadjusted</i>)	...	...	...	...	771	2.64	1.72	1.53	1,156	2.75	1.72	1.60
	covered ^c (<i>adjusted</i>)	...	...	...	...		2.73	1.79	1.53		2.80	1.76	1.59
Germany (<i>SOEP</i>)													
West	all	1,999	2.38	1.68	1.42	1,502	2.41	1.67	1.44	2,210	2.87	1.89	1.52
East	all					612	2.15	1.54	1.40	617	2.49	1.72	1.44

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Author's calculations. Wage decile ratios of full-time employed men aged 25-54 in the private sector. ^b The British LFS contains questions on bargaining coverage and union membership only in the autumn quarter. For this reason the number of observations is significantly larger when not conditioning on bargaining coverage or union membership. ^c In 1993 union membership is used as proxy for bargaining coverage. For the U.S. and Germany we use weights to account for the different sampling probabilities of the various subsamples. Adjusted wage ratios are computed to account for differences in age and education of covered and uncovered individuals. We generate six 5-year age classes and three (Britain) or four (U.S.) education groups. Persons (Britain) or person weights (U.S.) of the covered sector are then re-weighted such that shares of each age-education cell in the covered sector equal the respective proportion in the uncovered sector.

The third piece of evidence for unions' wage compressing effects finally comes from a direct comparison of earnings of covered and uncovered workers within a country and at a particular point in time. Table 2 also reports percentile ratios for covered and uncovered men in the private sector in the U.S. and in Britain. As clearly evident from the table are wages of workers significantly less dispersed when agreements between trade unions and employers are reported to affect pay. As these differences in the wage structure might be due to composition effects, we also re-weight the unionised workforce so that proportions of age-education cells are identical in both unionised and non-unionised sectors. Still, even after adjusting for differences in the age and skill structure, the reported wage ratios suggest a compressed union wage distribution. (Notice however the strong adjustment of the 90-50 percentile ratio in the U.S. in 2001).² In Continental European countries a direct comparison of covered and uncovered workers is more difficult because of the often strong divergence of coverage and union density rates and the lack of information on coverage in standard survey data.³ Among the few available studies are Gørtzgen (2006) and Stephan and Gerlach (2005) . Both find more moderate returns to education and age in covered establishments and so present some evidence for union wage compressing effects. Hartog, Leuven and Teulings (2002) , however, find only very modest union wage effects in the Netherlands.

This paper presents a model that offers an explanation for the wage compressing effect of trade unions. We extend a standard Right-to-Manage model by allowing for a large number of labour market segments ('locales') that differ with respect to total factor productivity. Labour is assumed to be immobile between locales. Unions and firms bargain over wages and firms unilaterally choose employment levels so as to maximise profits. One important finding of the analysis of such an extended Right-to-Manage model is that unions compress the wage distribution from below. That is, unions raise in particular the wages of workers who, on spot labour markets, would earn relatively low wages. A side-effect of this policy is that workers in low-productivity localities are made

²In a similar vein, Card, Lemieux and Riddell (2003) find that in the U.S., the UK and in Canada wages of unionised men are less dispersed than are wages of men who are not member of a union. For the year 2001 they show that in the U.S., the UK and in Canada the standard deviation of log hourly wages of union members is 0.184, 0.146 and, respectively, 0.115 points lower than the standard deviation of wages of non-union members.

Moreover, Freeman (1982) shows that, using within-establishment wage data, standard deviations of log wages in unionised establishments in the U.S. range between 5 and 50 per cent below those of non-unionised establishments, with an average difference of 22 per cent.

³See OECD (2004, ch 3) and Visser (2003) for a detailed cross-country comparison of bargaining coverage and union density rates. For example, in Germany coverage is about 2 – 3 times higher than union density rates, suggesting that a comparison of wage distributions of union and non-union members serves more to shed light on the remuneration of a very special group of workers, which are members of trade unions, than on the effects of unions on the wage distribution.

redundant more frequently. Taken together, we can show that under union wage setting the union wage distribution first-order stochastically dominates the non-unionised wage distribution (our Proposition 1). More generally, we show that, when comparing wage distributions of two bargaining arrangements—say the wage distribution in country A with strong unions with that in country B where unions are weak—the wage distribution of country A stochastically dominates that of country B (our Proposition 6). Moreover, when identifying low-productivity workers with low-skilled workers, this model is very much in line with the common empirical finding that low-skilled workers are more affected by unemployment than high-skilled workers.

The intuition for why union wage distributions are less dispersed than the wage distribution on spot labour markets is straightforward. Unions raise wages above market clearing levels whenever market clearing wages are sufficiently close to the reservation wage. That is, a spell of unemployment poses a lower income risk for workers in low productivity locales (“low-skilled workers”) than for workers in high productivity locales (“high-skilled workers”) for which a fall from the relatively high spot market wages to the reservation wage would be fairly large. For this reason unions raise in particular the wages of workers in low productivity locales above market clearing levels which explains the wage compression at the left tail of the earnings distribution. Moreover, due to the resulting unemployment of workers in low productivity locales the *share* (not the absolute mass) of unionised workers in high productivity locales increases. If total factor productivity is fairly uniformly distributed, it is shown that unions then also compress the wage distribution from above by lowering wage percentile ratios, such as for example the 90-50 percentile ratio.

In our model unionised and non-unionised segments of the labour market co-exist (similar but not identical to Horn and Svensson 1986). Apart from pedagogical purposes (we change the perspective from comparing two hypothetical regimes to comparing two actually co-existing regimes), one merit of this approach is that it allows us to study union wage effects in a closed general equilibrium framework. In particular, we allow for capital adjustments and characterise wage distributions and employment levels in a general equilibrium framework when capital owners have the choice to invest in the unionised or the non-unionised sector. We believe there are good reasons for extending the Right-to-Manage model in this direction. First, allowing for capital adjustments is natural when looking at wage distribution from a cross-country perspective. Second, when comparing covered and uncovered sectors in Continental Europe the industries that are unionised can be expected to be less selective than they are, for instance, in the U.S. where unionisation rates are comparatively low. This makes it problematic to think

of capital as being locked-in over long time periods into the unionised industries. We will have more to say on this issue in the concluding section. Third, it is quite common in wage negotiations that firms threaten to withdraw capital, say by investing abroad, if unions were to impose ‘excessive’ wage costs on firms.

We follow Grout (1984), who first formalised the holdup problem in the union context, and assume that capital is installed before unions and firms sign the labour contract but correctly anticipate the future labour agreement—which itself depends on the installed stock of capital. That is to say firms know that, once the capital stock has been installed, unions have the ability to hold the firms’ capital hostage. Anticipating this, firms invest less into unionised than into non-unionised firms. With respect to the wage distribution of the unionised sector the withdrawal of physical capital is shown to imply wage compression from above as those locales paying market clearing wages utilise less capital. As a result, in a joint equilibrium wage distribution functions of unionised and non-unionised sector intersect. This implies that by introducing capital adjustments into the model, on the one hand, we lose our previous results on first-order stochastic dominance. On the other hand, under less restrictive assumption this model could now be tested by a comparison of wage percentiles.

We are of course not the first to present theoretical explanations for why unions can be expected to compress wages. Freeman (1980), for instance, lists several reasons why unions should seek to reduce the wage distribution. First, there is the standard redistribution argument that the income of the median union member is below the average income and hence union leaders favour redistribution from the rich to the poor.⁴ Second, he argues that “union solidarity is difficult to maintain if some workers are paid markedly more than others” (Freeman 1980, p 5). In this argument union wage compression is obviously viewed as a means—not an end—to raise overall wages. He also claims, thirdly, that workers have a preference for objective standards as opposed to subjective decisions of foremen, which suggests that workers have a preference for stable and resilient relations on the workplace.

Yet another strand of the literature on union wage effects follows the literature on implicit contracts by stressing the insurance component of labour contracts. Horn and Svensson (1986) and Agell and Lommerud (1992) follow quite literally the theme of the literature on efficient contracts and argue that unions seek to conclude labour contracts

⁴This argument is extremely prominent in the union literature. When exclaiming at the, in his view, “modest to negligible reference to the models of union wage determination” of most of the empirical studies he surveys, Kaufman (2002) actually writes that “[w]here a formal model of union wage determination is called on, however, in nearly all cases it involves an application of the median voter principle.”

that insure workers against unforeseen events in the future. For instance, in Agell and Lommerud (1992) risk-averse workers are uncertain which position in society they will attain and therefore advocate for an egalitarian union wage policy. More generally, Burda (1995) allows “risk” against which workers seek insurance to be any contingencies of the labour market that affects wage profiles over time, space, and events. In a similar spirit we argue in a companion paper that unions may also intend to compress the wage distribution because workers perceive of a less dispersed wage distribution as fair (for an insightful discussion of the issue and the importance of fairness considerations in the actual wage setting process see also Rees 1993). There, we use the framework of the implicit contract literature as a metaphor to explain workers’ empathy for each others’ concerns and thus their preference for moderately dispersed wage distributions. We argue that in a non-historical and hypothetical Rawlsian Original position in which workers are judging from behind a veil of ignorance, that is, without knowing in advance their place in society, risk-averse workers prefer compressed wage distributions over distributions that offer great opportunities but also great disappointments. Insurance against bad income shocks, however, requires that labour contracts cover wages *and* employment. The crucial difference of the present paper to this literature therefore is that here we analyse the situation in which contracts cover wages but not employment (say, because this part of a labour agreement cannot be enforced).

The remainder of the paper is structured as follows. Section 2 presents the main assumptions of the model. Section 3 discusses the wage distribution on spot labour markets. Section 4 analyses the Right-to-Manage model while holding capital stocks fixed. The latter assumption is relaxed in Section 5 where we study the wage distribution when capital stocks adjust endogenously. Section 6 summarises and concludes.

2 Assumptions

2.1 Production

A homogenous consumption good is produced using as inputs physical capital and labour, denoted as K and L . Production takes place in a large number of locales. We let the set of locales be represented by the unit interval $[0, 1]$ and use the subscript ν to denote specific locales. There is a large number of price-taking firms in each locale, each of which utilises the technology $\theta F(K, L)$. The production function F is assumed to be concave and linear homogenous. We assume that the elasticity of substitution between

capital and labour, denoted as σ , is greater than zero but not above one.⁵ Although not necessary for the main conclusions of this paper, it might be convenient to think of F as being CES with $\sigma < 1$. Efficiency parameters θ are distributed according to the distribution function $G(\theta)$. Let θ^{\min} and θ^{\max} denote the lower and, respectively, upper bound of the support of $G(\theta)$. We assume that θ^{\min} is sufficiently large so as ensure full employment on spot markets and, to establish existence of non-trivial equilibria, we let θ^{\max} be sufficiently small.⁶

A key assumption of this paper is that labour cannot move between locales, thus allowing for non-degenerated equilibrium wage distributions. Notice that for the purpose of this paper the notion of a locale is quite general. We think of locales as groups of persons differing in age, sex, education, region of residence, industry affiliation and the like. Firms may, but do not have to, hire workers of several different locales. The assumption made here only imposes limits to the interaction of labour of different locales (workers of different types) and the capital installed in these locales.

Firms are risk-neutral and there exists an insurance mechanism such that firms can always return the borrowed capital and the agreed on interest rate r . Equivalently, firms are run by the capitalists themselves where capitalists are risk-neutral. Finally, let $c \in [0, 1]$ denote union coverage, that is, the fraction of locales in which workers collectively bargain with firms over wages and employment.

2.2 Households

There are two types of households: workers and capitalists. Capitalists do not work but rent their capital to firms for which they receive a rate of return of $1 + r$ (accounting for possible depreciation of capital). Capital has no intrinsic utility, implying an inelastic supply of capital. Worker households do not own capital but instead supply inelastically one unit of labour. We normalise the total number of workers to be of measure one. Without loss of generality we let workers be uniformly distributed over locales. So L_ν denotes both the measure of employed workers as well as the probability of being employed in locale ν .

Workers' preferences are defined over leisure and consumption. Importantly, in this paper capital markets are incomplete such that workers are unable to obtain insurance against the vagaries of the labour market. So income (whether derived from wages or benefits) is identical to spending on consumption goods. Locked into a specific locale ν ,

⁵See Hamermesh (1993, ch 3) for empirical evidence for our assertion that it is save to assume that $\sigma \leq 1$.

⁶We will be more precise on what 'sufficiently large' or 'small' means below.

a worker faces the risk of being unemployed (with probability $1 - L_\nu$) in which case he can claim benefits of $b \geq 0$. For simplicity benefits are assumed to be financed by taxes on capital. If employed (with probability L_ν) the worker receives the wage w_ν . Suppose that, on the behalf of workers, trade unions set or bargain over wages. Then unions seek to maximise expected utility where utility of an employed worker receiving wage w_ν is denoted as $u(w_\nu)$ and expected utility of each worker in locale ν is

$$L_\nu u(w_\nu) + (1 - L_\nu) u(\bar{w}) \quad (1)$$

Here \bar{w} denotes the wage equivalent of a worker enjoying leisure and receiving benefits b .⁷ Notice that in the present setting union preferences can be easily derived from individual preferences as workers are assumed to be identical (with respect to, e.g., preferences, wealth, seniority). After all, each worker is both the median and the representative worker. We make the standard assumption about the functional form of $u(w)$: It is assumed to be increasing and strictly concave. Moreover, we normalise u and set $u(\bar{w})$ to zero.

2.3 Time structure

The time structure of actions taken by the agents is as follows:

1. Firms invest into capital so as to maximise expected profits, while correctly anticipating prices.
2. a) Trade unions and firms bargain over wages.
b) The efficiency parameter θ_ν realises in each locale ν .
3. Firms hire as many workers so as to maximise quasi-profits and produce the output good.

Notice that the free-entry conditions drives profits down to zero in equilibrium since F is linear homogenous. Moreover, if workers in a given locale do not unionise, no contracts are signed on stage 2 but, instead, wages are determined at stage 3 by the market clearing condition. Further, the ordering within stage 2 is not important as long

⁷Both the risk of being hit by unemployment as well as the wage level are subject to the realisation of the efficiency parameter θ . Formally, preferences are thus defined for a set of admissible wage distribution functions, an uncountably infinite dimensional space. Assuming the preference ordering satisfies the standard von Neumann-Morgenstern axioms, the preference ordering uniquely determines a continuous utility function \tilde{u} (up to affine transformations) such that the most preferred wage distribution maximises expected utility (Hammond 1998).

as labour contracts can be written down that make wages contingent on the realisation of θ .

In the following we begin the analysis of the model with given capital stocks in all locales and a discussion of stage 2-3. Once the implications of multiple locales for employment and wage distributions are understood, we proceed and let firms make rational investment decisions.

3 Spot markets

Given capital stocks K_ν in locale ν , wages on spot labour markets are determined by the first-order condition

$$w_\nu = \theta_\nu \times F_L(K_\nu, L_\nu)$$

where subscripts on F are used to indicate partial derivatives. Firms correctly anticipate wages when investing into machinery. Expected quasi-profits are

$$\pi_{\text{spot}} = E[\theta F(K_\nu, L_\nu) - w_\nu L_\nu] \quad (2)$$

which shows that the optimal K_ν is uniquely determined whenever $w_\nu \geq \bar{w}$ for some ν .⁸ Now suppose that capital investments are identical in *all* locales, that is, that capital stocks are identical in unionised and non-unionised locales. Then $K_\nu = K$ and thus there is full employment in the non-unionised locale ν if and only if $\theta_\nu \geq \bar{w}/F_L(K, 1)$ for all ν . This inequality makes precise that θ^{\min} is ‘sufficiently large’, as assumed earlier, if $\theta^{\min} \geq \bar{w}/F_L(K, 1)$.

The Hicks-neutral functional form of the production technology implies particularly easy expressions for the moments of the wage distribution:

$$\begin{aligned} E[w_{\text{spot}}] &= \text{const} \times E[\theta] \\ \text{Var}[w_{\text{spot}}] &= \text{const}^2 \times \text{Var}[\theta] \\ \text{Skew}[w_{\text{spot}}] &= \text{const}^3 \times \text{Skew}[\theta] \\ &\vdots \end{aligned}$$

where $\text{const} \equiv F_L(K, 1)$.

⁸More generally, by the above argument investments in two locales are chosen such that the full employment capital intensity in both are identical. This shows that there is no loss in generality when assuming that labour is uniformly distributed over the given set of locales.

4 The Right-to-Manage Model

In the Right-to-Manage model trade unions and firms bargain over wages while firms hire so many workers so as to remain on the labour demand curve. The Monopoly Union model is a special case of this model in which unions are free to set wages unilaterally. If, in contrast, all the bargaining power lies with the firms, equilibrium outcomes in both the unionised and the non-unionised locales are identical. This section therefore begins with a characterisation of equilibrium in the Monopoly Union model. In a series of propositions we summarise the main results of this section.

4.1 Monopoly Unions

Suppose that the union could unilaterally set wages. To contrast our finding with that of the standard literature on trade union effects, let capital investment be identical in all locales, i.e., let $K_\nu = K$ in all $\nu \in [0, 1]$ —independent of whether workers in a given locale are covered by a contract between unions and firms. The problem of the union is to find a state-contingent wage function $w(\theta | K_\nu)$ that maximises expected utility

$$\int [L \times u(w(\theta | K_\nu)) + (1 - L) \times u(\bar{w})] dG(\theta) \quad (3)$$

subject to the constraint that for each worker the probability of finding employment L is given by the labour demand curve $L(w | K_\nu, \theta)$, where wages must never be smaller than the reservation wage \bar{w} .

The main point to notice about this maximisation problem is that, since firms always operate on their labour demand curve, there is no interaction between different states of the world. This has the important implication that in any model of this type—irrespective of the bargaining power of unions and other specific assumptions about the bargaining solution in a more general Right-to-Manage model—there is no risk-sharing between workers and firms. The intuition for this result is that workers are not willing to make any wage concessions in good states of the world (in order to get something back in bad states) because firms in this model always operate on the labour demand curve and so workers would never get anything back in return from firm in terms of wage or employment security.

With respect to the characterisation of the union maximisation problem, this allows us to disentangle the problem of finding the overall wage *function* into a set of problems of finding a wage for *given* θ . The first-order condition of this problem is fairly standard

(McDonald and Solow 1981, Oswald 1985, Farber 1986, Booth 1995, Naylor 2003):

$$\frac{u'(w)w}{u(w)} - \frac{\sigma}{1-s} \leq 0 \quad (4)$$

This condition holds with equality whenever the optimal wage strictly exceeds the market clearing wage. Figure 1 illustrates how the wage distribution can be derived from this condition. The downward sloping curve depicts the elasticity $u'w/u$ of a typical utility function, while the three increasing curves illustrate the term $\sigma/(1-s)$ where σ is below unity.⁹ For simplicity we only consider utility functions u whose elasticity is everywhere downward sloping which includes the functional forms most frequently encountered in economic models.¹⁰ Consider for instance the case that utility was of the constant rate of relative risk aversion (CRRA) type: $(w^{1-\rho} - \bar{w}^{1-\rho})/(1-\rho)$ where quasi-concavity requires that $\rho \geq 0$. Its elasticity is always downward sloping, even when workers are risk neutral, i.e., if $\rho = 0$.

The term $\sigma/(1-s)$ increases in w because $(1-s)^{-1}$ increases in wages and because σ was assumed to be sufficiently inert to changes in the capital intensity. The labour income share s in turn increases in w because, first, on the labour demand curve the optimal capital intensity increases in the wage rate and, second, the labour income share increases in the capital intensity whenever the elasticity of substitution between labour and capital, σ , is below one.

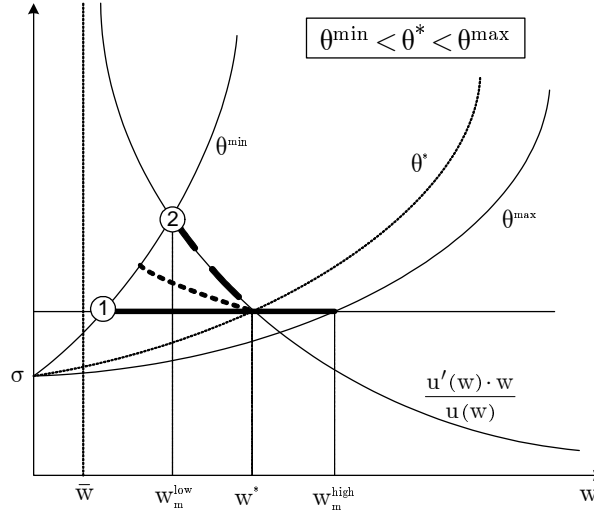
The horizontal line finally is found by inserting $k = K$ into $\sigma/(1-s)$. It depicts where condition (4) holds with equality. For each given θ the intersection of the horizontal and the respective increasing curve determines the particular wage rate such that for all wages above this rate some workers remain without work, while for lower wages there would be an excess demand for labour.

Before proceeding we shall comment briefly on the effects of the reservation wage, risk aversion, and the elasticity of substitution on the union wage markup (thus focusing on a given locale with a given realisation of θ). First, assume risk neutrality, a unitary substitution elasticity (Cobb-Douglas), and set $\bar{w} = 0$. Then $u'w/u = 1$ and $\sigma/(1-s) > 1$. So there is no incentive for unions to set wages above market clearing levels. Now increase the reservation wage \bar{w} above zero, i.e., make the state of being without job less deterring. Then for sufficiently small θ there is some unemployment suggesting that even

⁹We presume that σ is sufficiently inert to changes in the capital intensity so not to offset the changes in s .

¹⁰For $u'w/u > 1$ it is easy to show that this elasticity is actually decreasing in w for all utility functions with $u'' \leq 0$. However, to avoid that the slope of the elasticity switches signs for large wage rates, we restrict the class of utility functions to those with decreasing income elasticities (including, for instance, utility functions of the CRRA type).

Figure 1:



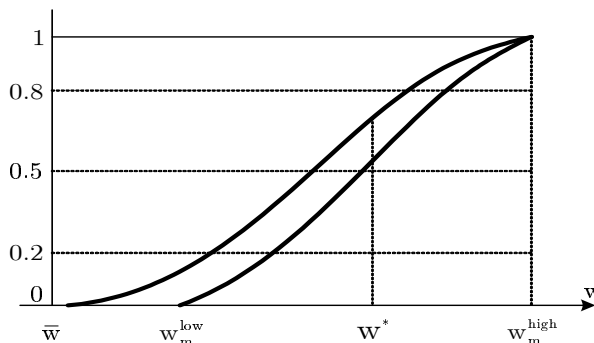
though the non-employment of some workers reduces the wage bill ($w \cdot L = s \cdot \theta F$ while s is fixed whenever $\sigma = 1$) the inflow of income—or income equivalents—overcompensates the decreases in total labour earnings.

Second, let $\bar{w} > 0$ and assume that utility was of the CRRA type. Then workers are the more risk averse the greater ρ . It can be shown that the greater ρ the further to the left is the function $u'w/u$ and thus the greater is the set of locales with full employment of workers. That is, the greater absolute risk aversion the greater the incentive for the union to set moderate wages so as to keep down the income gap between employed and non-employed workers as well as the risk of being hit by unemployment. Finally, let $\sigma < 1$. Then the upward sloping curve depicting $\sigma/(1-s)$ becomes increasingly kinked as σ decreases. So after a sufficient decrease in the elasticity of substitution union wages can be seen to be raised above market clearing levels. The reason for this result is that for sufficiently low σ a decrease in employment has a very strong positive impact on the labour income share s and so the wage bill can strongly increase as employment and hence production is reduced.

4.1.1 Stochastic dominance

Coming back to our model with multiple locales experiencing different realisations of θ , the thick solid line in Figure 1 shows how on spot labour markets wages depend on θ . Due to our assumption on θ^{\min} spot market wages always exceed the reservation wage \bar{w} . The

Figure 2:



thick dashed line illustrates the association between wages and productivity parameters in the Monopoly Union model. The greater θ the higher the monopoly union wage w_m . As shown in the figure, beginning with an intermediate wage, denoted as w^* , both dashed and solid line are identical. This is to say that in all locales with sufficiently great total factor productivity θ all workers find employment and hence wages are identical in both unionised and non-unionised locales.

Comparing wage distributions on spot labour markets with those under union wage setting, notice that for each realisation of θ the wage in the unionised sector is never below the respective spot market wage (see Figure 1). The next proposition is an immediate consequence of this:¹¹

Proposition 1 *Suppose capital stocks in both unionised and non-unionised locales are identically large. Then the wage distribution as implied by the Monopoly Union model first-degree stochastically dominates the spot market wage distribution.*

Proof. See the appendix. ■

To draw this conclusion we did not have to make further assumptions about the distribution of efficiency parameters $G(\theta)$. So Proposition 1 does not condition on unobservable objects and is thus in principle a testable hypothesis. Figure 2 sketches the wage distribution for a hypothetical continuous random variable θ . An important fact to notice about Figure 2 is that union wage setting increases the lower bound of the support of the wage distribution. Remember that the distributions shown in Figure 2

¹¹A distribution $X(w)$ is said to first-order stochastically dominate a distribution $Y(w)$ if $Y(w) \geq X(w)$ for all w , with strict inequality holding for at least one w . The distribution $X(w)$ second-order stochastically dominates $Y(w)$ if $\int_{-\infty}^{\tilde{w}} [Y(w) - X(w)] dw \geq 0$ for all \tilde{w} , with strict inequality holding for at least one \tilde{w} .

depict *observed* wage distributions, not income distributions of all workers which would also cover unemployed workers receiving benefits.

Let us discuss some testable implications of first-degree stochastic dominance. The first implication is obvious and concerns mean wages:

Corollary 2 *The mean wage in the unionised sector is strictly larger than the mean wage in the non-unionised sector.*

A similar conclusion concerning the geometric mean can also be shown (Levy 1998, ch 3). Anderson (1996) proposed a direct test for stochastic dominance which is basically an extension of a Goodness of Fit test (see also Davidson and Duclos 2000, Barrett and Donald 2003). The Gini coefficient connects stochastic dominance and standard inequality measures. It can be defined either via the area under the Lorenz curve or, equivalently, as half the ratio of the average absolute difference between observation pairs w' and w'' to the mean $E[w]$, that is, as $\frac{E|w'-w''|}{2E[w]}$ (Dorfman 1979). Denote the Gini coefficient of the wage distribution in unionised and non-unionised locales as Γ_m and, respectively, Γ_{spot} . The following implication of stochastic dominance for Γ_m , Γ_{spot} and mean wages in both distributions is due to Yitzhaki (1982).

Corollary 3 *If union wages w_m first-order stochastically dominate spot market wages w_{spot} then it holds that*

$$E[w_m] \times (1 - \Gamma_m) > E[w_{spot}] \times (1 - \Gamma_{spot}) \quad (5)$$

To illustrate the corollary, consider the case of two distribution functions where the cumulative distribution function (c.d.f.) of the second is a simple rightward shift of the c.d.f. of the first. Then their Gini coefficient is the same and condition (5) mimics the condition in Corollary 2. The above condition (5) is moreover necessary when union wages second-order stochastically dominate spot market wages. Since first-order stochastic dominance implies second-order stochastic dominance but not vice versa, test based on condition (5) would however lack some power.¹²

¹²One final remark about condition (5). It certainly holds if $E[w_m] \geq E[w_{spot}]$ and $\Gamma_m \leq \Gamma_{spot}$. The crucial difference between the variance and the Gini coefficient as inequality measures is that the Gini coefficient is based on mean absolute differences between all pairs w' and w'' , while the variance is the mean squared difference between such pairs:

$$\text{Var}[w] = E[(w - E[w])^2] = \frac{1}{2}E[(w' - w'')^2]$$

Due to this similarity it comes as no surprise that for a number of prominent distributions, such as the normal, lognormal, exponential, and uniform distribution, the conditions $E[w_m] \geq E[w_{spot}]$ and

4.1.2 Standard inequality measures

As stated in Corollary 2, the model makes clear predictions concerning the ordering of first moments of the two wage distributions. However, conclusions concerning the ordering of higher moments of the wage distributions, in particular of wage variances or the variances of log wages, *cannot* be drawn from the model without making further assumptions about the precise forms of utility, production, and distribution functions.¹³ The reason for this negative result is that union wage setting not only increases the lower bound of the support of the wage distribution in the Monopoly Union model, denoted as w_m^{low} —which apparently “compresses” the wage distribution—but unions also increase the mean wage. Hence, the mean squared distance from a *given* wage is the smaller, the larger w_m^{low} , but since the mean wage is different in both distributions, this model does not make unambiguous predictions about whether or not unions structure wages so as to decrease its variance.

Similarly, the model also does not have testable implications concerning the ordering of percentile ratios (or, equivalently, of log wage differences of these percentiles). For certain specifications the model can predict that 90-10, 90-50 and 50-10 percentile ratios are greater in the non-unionised than in the unionised sector. If for two given wage quantiles, say w^{90} and w^{50} , the average slope of the distribution function of log union wages is greater than the average slope of the log non-union wage distribution function, the model in fact predicts that the union wage distribution is compressed with respect to 90-50 percentile ratio. The reason is that for at large wages union wage markups vanish and, due to the unemployment of low wage workers, the wage distribution function of unionised workers is steeper for large wages. So, for fairly uniformly distributed *theta*'s inequality measures as the 90-50 percentile ratio should indicate that union wages are also compressed at the upper end of the distribution. However, if for some log wage quantiles the distribution function of log union wages has a lower slope than the

$\Gamma_m \leq \Gamma_{\text{spot}}$ are satisfied whenever $E[w_m] \geq E[w_{\text{spot}}]$ and $\text{Var}[w_m] \leq \text{Var}[w_{\text{spot}}]$ (see Yitzhaki 1982, Levy 1998). So for these distribution functions a comparison of the first two moments does tell us something about stochastic dominance. This is however not very useful in the present context because we know that both wage distributions of unionised and non-unionised locales cannot be both normal, lognormal, exponential, or uniform *at the same time*.

¹³To illustrate that first-order stochastic dominance does not allow one to draw any conclusions about a comparison of variances consider the following counter-example. Suppose there are only three states s_1 , s_2 , and s_3 with outcomes 0, 1, and 10, respectively. Let the probabilities of the dominated distribution be 0.1, 0.8, and 0.1 in each of the three states and, respectively, let 0, 0.2, and 0.8 be the probabilities of each state of the dominant distribution. The arithmetic mean of the dominated and dominant distribution can be calculated to be 1.8 and, respectively, 8.2 while the variance of the former is 7.56 and of the latter 12.96. Thus, even though the support of the dominated distribution is larger, its variance is smaller.

distribution function of log non-union wages, then we can find some percentile ratio for which a comparison of these ratios does not indicate that the union wage distribution is compressed relative to the non-union wage distribution.

Notwithstanding these negative results regarding *testable implications* of these distribution measures (which are standard in labour economics), they of course remain useful measures to succinctly *describe* key properties of observed wage distributions.

4.1.3 The association between wages and employment

In line with most empirical studies, the Monopoly Union model of this section predicts that unemployment most strongly affects low-income workers. The lower the efficiency parameter θ , the smaller the gap between the market clearing wage rate and the reservation wage and hence the lower the loss in expected utility when some workers are without job.

More technically speaking, an increase of θ shifts the upward sloping curves, depicting the term $\sigma/(1-s)$ as a function of the wage w , to the right because wages must increase proportionally in θ so as to keep k (determined by the labour demand curve) constant. However, since the elasticity of utility $u'w/u$ is downward sloping, the wage that satisfies condition (4) with equality increases less than proportionally in θ . Hence, an increase in efficiency is associated with an increase in both wages and employment. Algebraically, this can be shown when invoking the implicit function theorem on condition (4) and the first-order condition $w_\nu/\theta_\nu = F_L(K/L_\nu)$:

$$\begin{bmatrix} w'(\theta) \\ k'(\theta) \end{bmatrix} = \frac{1}{1 - \alpha'\theta f \frac{(1-s)^2}{\sigma(1-\sigma)}} \begin{bmatrix} sf \\ \frac{f^2(1-s)^2\alpha'}{f'(1-\sigma)} \end{bmatrix} \left\{ \begin{array}{l} \geq 0 \\ < 0 \end{array} \right\} \quad (6)$$

where $f \equiv F(K/L_\nu, 1)$ and $f' \equiv F_K(K/L_\nu, 1)$. We have thus shown the next proposition.

Proposition 4 *Suppose all workers are employed in all non-unionised locales but not in all unionised locales. Then the correlation between wages and unemployment is zero in non-unionised locales but strictly negative in unionised locales.*

4.1.4 The association between wages and the capital income share

Both Hildreth and Oswald (1997) and Arai (2003) present evidence that wages and (quasi-)profits—where the latter are standardised to take account of differences in firm size—are positively correlated. Moreover, there is some indication that unionisation and

financial performance are negatively linked (Metcalf 2003, Sec. 3). Identifying financial performance with the capital income share $1 - s$, it is interesting to see whether the Monopoly Union model of this section is able to explain such a positive correlation between wages and capital income shares. Consider the interesting case in which the realised efficiency parameter θ is sufficiently low in some locales such that at the monopoly union wage not all workers are employed. Then within this set of locales, as argued previously (see (6)), both employment and wages are the larger the greater θ . This in turn implies that the labour income share decreases (remember that $\sigma < 1$) or, vice versa, capital income shares increase in θ . We summarise this finding in the next proposition.

Proposition 5 *Suppose some workers are unemployed in a set of unionised locales of positive measure. Then under union wage setting there is a positive correlation between wages and capital income shares in these locales, while they are uncorrelated on spot labour markets.*

The last result follows simply from the fact that the capital intensity is constant in non-unionised locales and so are capital income shares.

4.2 Wage bargaining

Let us now abandon the strong assumption that unions could unilaterally impose wages on firms and, following Nickell and Andrews (1983), assume instead that unions and firms bargain over wages. It is unnecessary to be very specific about the precise bargaining solution. It simply has to have the following standard properties: (1) Wages increase in the bargaining power of the union. (2) The union wage markup is zero when unions have no bargaining power. (3) Wages are set as in the Monopoly Union model if all the bargaining power lies with the unions. (4) For given bargaining power wages increase with the threat points, i.e., with spot market and monopoly union wages.

The impact of union bargaining power on the union wage distribution is best understood by inspection of Figure 1. Consider locales with the smallest realised efficiency parameter θ^{\min} . In the figure circles marked 1 and 2 indicate how wages on spot markets and, respectively, in the Monopoly Union model are determined. If bargaining power of unions is positive but limited, the agreed-on wage will be somewhere between these two wage rates. Now, due to assumption (4) of the bargaining solution these agreed-on wages, say w_{RTM} , increase in θ because both w_{spot} and w_{m} do. The thick dotted line depicts one possibility how efficiency parameters θ and wages w_{RTM} are associated. The important fact to notice is that the above assumptions about the bargaining solution imply that

the thick dotted line must always be between the thick dashed line (Monopoly Union model) and thick solid line (spot labour markets). Then, by the same arguments that lead us to deduce Proposition 1, we can infer the next proposition relating bargaining power and stochastic dominance.

Proposition 6 *Suppose there are two bargaining regimes, A and B, differing only in the union's bargaining power. Let the union's bargaining power in regime A be greater than in regime B. Then the wage distribution in regime A first-order stochastically dominates the wage distribution in regime B.*

Thus, Proposition 1 is basically a simple corollary of Proposition 6. By Corollary 2 this also shows that the union wage markup is the greater the larger the union bargaining power.

5 Endogenous capital adjustments

So far we have kept investments constant and, for easier comparison of our model with the standard Right-to-Manage model, we simply assumed that the stock of capital was identically large in all locales. We obtained the expected result that, given efficiency θ , higher wages in the unionised locales are associated with higher capital intensities. From the point of view of the outside observer this may appear as if firms in unionised locales substitute relatively expensive labour with relatively cheap capital, even though firms only adjust their labour inputs, not capital stocks. We next explicitly model investment decisions of firms and find that, due to the positive union wage markup, firms invest less in unionised than in non-unionised sectors. So, as far as the utilisation of capital is concerned, while the substitution effect of the union wage markup is positive, the scale effect is negative (see also the discussion in Kuhn 1998, p 1049).

Clearing of the capital market requires that

$$\begin{aligned} \frac{\partial \pi_m}{\partial K} &= E \left[\theta F_K \left(\frac{K_m}{L_m}, 1 \right) - r \right] \\ &= E \left[\theta F_K \left(\frac{K_{\text{spot}}}{L_{\text{spot}}}, 1 \right) - r \right] = \frac{\partial \pi_{\text{spot}}}{\partial K} \end{aligned} \quad (7)$$

whenever in equilibrium firms are active in both set of locales, unionised and non-unionised ones. Let us refer to these derivatives simply as ‘rates of return’. Remember that the particular efficiency parameter θ^* was constructed in such a way that under symmetric capital stocks at $\theta = \theta^*$ the effective minimum wage in the unionised sector w_m just

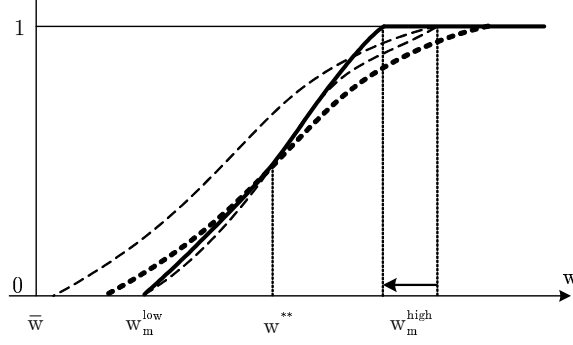


Figure 3: Wage distributions in unionised and non-unionised locales before (thin dashed lines) and after (thick lines) capital adjustments where the dotted and solid lines depict the c.d.f. within the set of non-unionised and, respectively, unionised locales.

binds. Thus, we know that the capital intensity in all unionised locales with $\theta \geq \theta^*$, $k_m(\theta^*)$, is equal to the capital intensity on spot labour markets, $k_{\text{spot}}(\theta^*)$, had firms invested identical amount in all locales. However, then in all locales with $\theta < \theta^*$ some workers cannot find employment and, hence, there $k_m(\theta) > k_{\text{spot}}(\theta)$. This shows that whenever $\theta^* > \theta^{\text{min}}$, which is the interesting case and what is assumed, expected rates of return in the unionised sector are below those in the non-unionised sector. So, in equilibrium capital stocks cannot be identically large in all locales.

Instead, it is straightforward to show that in a joint equilibrium, that is, an equilibrium in which both unionised and non-unionised firms are active, firms in the non-unionised sector invest less into machinery. We defer the details to an appendix but here only notice that in joint equilibrium K_{spot} must still be smaller than $k_m(\theta^{\text{min}})$. Assume otherwise, that is, assume K_m becomes so small and K_{spot} so large that even in the least productive locales the capital intensity in the unionised sector is smaller than the capital intensity in the non-unionised sector. Then, as can be seen from inspection of (7), rates of return in the unionised sector, $\partial\pi_m/\partial K$, would in fact be greater than those in the free-market sector which cannot hold in a joint equilibrium either. Thus, in equilibrium $K_{\text{spot}} < k_m(\theta^{\text{min}})$ and therefore

$$\min(w_{\text{spot}}) = \theta^{\text{min}} F_L(K_{\text{spot}}, 1) < \theta^{\text{min}} F_L(k_m(\theta^{\text{min}}), 1) = w_m^{\text{low}}.$$

Figure 3 shows how the increase in K_{spot} and the corresponding decrease in K_m (as compared to the baseline model with identical capital stocks) affects the wage distribution of both unionised and non-unionised sectors. The first thing to notice is that the

spot market wage distribution shifts in parallel to the right as K_{spot} increases because firms in all non-unionised locales pay higher wages while still employing all available labour. Second, due to the decrease in K_m the highest paid wage (w_m^{high}) in the unionised sector goes down, if prior to the reduction of K_m there had been some unionised locales paying market clearing wages. Third, wages do not change with K_m in all those locales paying above market clearing wages; so the lower bound of the union wage distribution w_m^{low} remains constant. Finally, as argued earlier, the lowest wage paid on spot labour markets remains below the lowest union wage.

An important implication of these findings is that after capital adjustments neither wage distribution stochastically dominates the other any more. That is, once we allow for capital to adjust, the model is now even inconclusive about the sign of the *mean* union wage markup—while it had already been inconclusive about higher moments when capital stocks were assumed to be identically large. Still, since c.d.f.'s of both wage distributions cross at least once, a comparison of ratios of quantiles of the wage distribution can now be used to describe and test for union wage compression.

Proposition 7 *Suppose in equilibrium firms in both unionised and non-unionised locales are active and pay wages such that cumulative distribution functions of both wage distributions intersect exactly once, say at the wage w^{**} . Then for all quantiles $w^{q'} \geq w^{**} > w^{q''}$ (where $q' > q''$) the difference of log wage quantiles $\log w^{q'} - \log w^{q''}$ is smaller in unionised than in non-unionised locales.*

Existence of joint equilibrium We next turn to the question whether a joint equilibrium actually exists; that is, whether in fact there exists a distribution K_m and K_{spot} such that firms are active in all locales. We only discuss existence of a joint equilibrium in the Monopoly Union model as an extension to allow for a varying degree of bargaining power is straightforward. Notice that in our model imposing Inada-like conditions on the production function F is not sufficient since both w_m and \bar{w} function as minimum wage. In particular, for sufficiently low K_m expected quasi-profits π_m become independent of K_m and so are expected rates of return. Therefore

$$\lim_{K_m \rightarrow 0} \frac{\partial \pi_m}{\partial K} = \text{E}[\theta F_K(k_m, 1)] < \infty$$

where $k_m > 0$ depends on θ , does not change with K_m , and is uniquely determined by (4) holding with equality.

Now, since there is no Inada-like condition on π_m and the aggregate capital stock K is finite, it comes as no surprise that even if $K_{\text{spot}} \rightarrow K/(1-c)$, the rate of return on

investments into non-unionised locales can still be greater than the rate of return on investments into firms in the unionised sector. In general, a joint equilibrium does not exist if and only if

$$\lim_{K_{\text{spot}} \rightarrow K/(1-c)} \frac{\partial \pi_{\text{spot}}}{\partial K} \geq \lim_{K_{\text{m}} \rightarrow 0} \frac{\partial \pi_{\text{m}}}{\partial K} \quad (8)$$

In the appendix we show that this can occur, for instance if K and c are sufficiently small.

Expected utility, wages and bargaining power If condition (8) holds, the threat of high wage demands by the union deters unionised firms from investing into capital. An immediate consequence of this is that unionised workers can be worse off in income and utility terms than non-unionised workers. In the extreme case in which all unionised firms completely withhold investments and shut down (or, rather, never open) utility of all unionised workers is $u(\bar{w})$ while utility of non-unionised workers is $E[w_{\text{spot}}]$, which is strictly greater because $w_{\text{spot}} > \bar{w}$ everywhere. By a simple continuity argument, this also implies that even in the less extreme case in which unionised firms do, though moderately, install machinery, utility of unionised workers is still smaller than utility of non-unionised workers. This shows that it actually can be harmful for workers to have the ability to form a union if this threat is substantial enough to make affected firms withhold investments—a conclusion which is very much in line with an important result in Grout (1984).

We have shown that capital stocks decrease in the union’s bargaining power because greater bargaining power implies higher wage markups and thus, for given investments, lower rates of return. This raises the question whether in a joint equilibrium average union wages are greater or smaller than average spot market wages, once capital stocks adjust so as to equalise expected profits in all firms. So far, our analysis is inconclusive about this question. Notice however that, if after capital adjustments the average union wage markup was negative in the Monopoly Union model, average union wages would actually *decrease* in the bargaining power of unions. In such instance in which firms react strongly to the threat of unionisation of workers by withholding investments, workers would in fact be better off if they could credibly commit not to form a union.

6 Conclusions

This article presents an extension of the popular Right-to-Manage model to explain union wage compression in a general equilibrium model. Our discussion of the Right-

to-Manage model shows that firms are effectively unable to provide wage insurance as long as they retain the authority to unilaterally set employment levels. Since firms remain on the labour demand curve and labour demand curves shift with the efficiency ('shock') parameters, the model is able to generate a non-degenerate wage distribution. We compare wage distributions in both the unionised and non-unionised locales and find that unions compress wages because union wage markups are particularly large for low wage workers. We argue that this model should not be tested via a comparison of wage variances in unionised and non-unionised sectors but that research should rather focus on tests for stochastic dominance of the union wage distribution.

Apart from extending standard trade union models to study wage compressing union effects, this paper also introduces capital into the model and discusses wages, employment, and (quasi-)profits in a general equilibrium framework. We believe a general equilibrium analysis to be warranted because in countries with large union coverage rates capital can be expected to be, at least somewhat, mobile between industries. The reason for this assessment is that the set of businesses which are covered by union labour agreements can be expected to be the more selective the lower the overall coverage rate. Consider for instance the U.S. where coverage rates are low and bargaining between firms and unions takes place on the firm level. There, it seems the more plausible that workers form unions in those firms that find it difficult to pull out capital from their establishment and invest it into the non-unionised sector because capital is to a large extent sunk. As one example, unions have traditionally been strong in mining and firms most likely cannot escape the bargaining power of unions because the geologic realities do not allow that. One may also think of car manufacturers whose capital to a great extent consists of their brand, their reputation, and possibly also their customer relations. Such capital depreciates fairly slowly and cannot be withdrawn to set up a business in a sector where unionism is less prevalent. So we think that for industrial relations as they prevail in North America and possibly the UK it is sensible to study union wage effects in a partial equilibrium framework and so, in particular, to hold fixed the stock of capital. However, in a Continental European context with large but incomplete union coverage the sectors, industries, or firms that are covered, are most likely less selective. So in these countries it would be strong and possibly overly restrictive to assume that capital stocks are fixed when studying the effects of unions on wages and employment.

Now, when making their investment decision, firms anticipate that unions will use their bargaining power to set wages and possibly also employment such that quasi-profits are reduced, as compared to spot labour markets. So in effect we are facing a standard holdup problem—even though we cannot discriminate between the effects due to the

‘holdup’ of capital and the monopolising of labour supply because there is only one type of labour and this is necessary for producing the output good. As can be anticipated from the first study of this kind in the union context (Grout 1984) we find the overall union effects on wages and expected workers’ utility to be ambiguous. In particular, firms are found to invest less into machinery the greater the bargaining power of the union. In the extreme case in which the threat of forming a strong union deters firms from investing at all, unionised workers are worse off than workers who find employment on spot labour markets.

7 Appendix

Proof of Proposition 1: For convenience let $Z_{\text{spot}}(w)$ denote the mass of workers employed on spot labour markets who earn not more than w . That is, define

$$Z_{\text{spot}}(w) \equiv \int_{-\infty}^{\theta=w_{\text{spot}}^{-1}(w)} L(w_{\text{spot}}^{-1}(w) | \theta, K) dG(\theta)$$

and similarly $Z_{\text{m}}(w)$. Then the cumulative distribution function (c.d.f.) of spot market wages is $Z_{\text{spot}}(w)/Z_{\text{spot}}(\infty)$. Similarly, the c.d.f. of wages in unionised locales is $Z_{\text{m}}(w)/Z_{\text{m}}(\infty)$ where in the definition $Z_{\text{m}}(w)$ we simply substitute w_{m} for w_{spot} . For first-order stochastic dominance of the unionised wage distribution we have to show that

$$\frac{Z_{\text{spot}}(w)}{Z_{\text{spot}}(\infty)} \geq \frac{Z_{\text{m}}(w)}{Z_{\text{m}}(\infty)}$$

with strict inequality for at least one w . Since $w_{\text{spot}}^{-1}(w) \geq w_{\text{m}}^{-1}(w)$ with strict inequality for sufficiently small w (see Figure 1),

$$G(w_{\text{spot}}^{-1}(w)) \geq G(w_{\text{m}}^{-1}(w))$$

Moreover, because $Z_{\text{spot}}(w) = G(w_{\text{spot}}^{-1}(w)) \cdot Z_{\text{spot}}(\infty)$ and $Z_{\text{m}}(w) < G(w_{\text{m}}^{-1}(w)) \cdot Z_{\text{m}}(\infty)$ for all $w < w_{\text{m}}^{\text{low}}$, this implies that

$$\frac{Z_{\text{spot}}(w)}{Z_{\text{spot}}(\infty)} \geq G(w_{\text{m}}^{-1}(w)) > \frac{Z_{\text{m}}(w)}{Z_{\text{m}}(\infty)}$$

for all $w < w_{\text{m}}^{\text{low}}$.

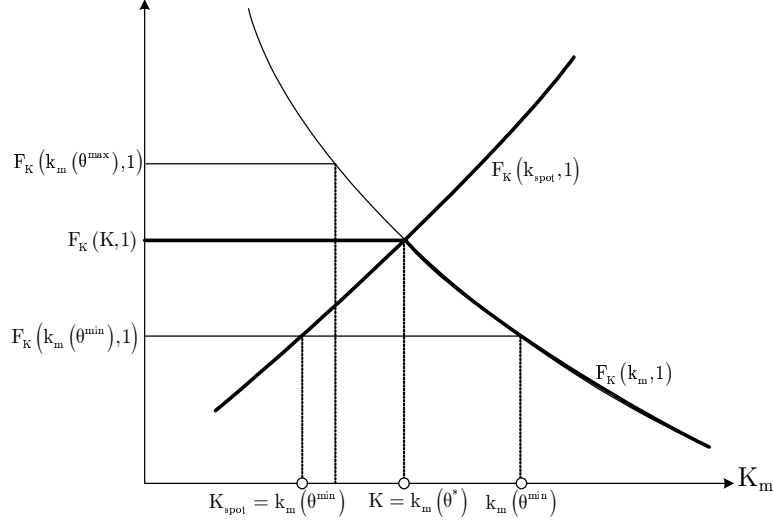


Figure 4:

Investment into machinery in unionised and non-unionised firms and existence of equilibrium This appendix discusses why in a joint equilibrium $K_{\text{spot}} > K_m$ and when such an equilibrium actually exists. Fix $\theta \in [\theta^{\min}, \theta^{\max}]$. There is a unique capital intensity, denoted as $k_m(\theta)$, associated with this θ such that for all $K_m < k_m(\theta)$ the utilised capital intensity equals $k_m(\theta)$ and so $F_K(k_m(\theta), 1)$ does not change with small K_m . For $K_m \geq k_m(\theta)$, however, there is full employment in the unionised locale with efficiency parameter θ and so $F_K(k_m(\theta), 1) = F_K(K_m, 1)$ decreases in K_m . The thick kinked downward sloping curve in Figure 4 depicts the marginal product of capital for the particular case in which $\theta = \theta^*$.

Taking K_m , K and c as given, investments into the typical free-market locale, K_{spot} , are given by the market clearing condition $K_{\text{spot}} \cdot (1 - c) + K_m \cdot c = K$. Whenever for a given K_m the corresponding K_{spot} is sufficiently large so that $w_{\text{spot}} > \bar{w}$, the marginal product of capital in the non-unionised locale $F_K(k_{\text{spot}}(\theta), 1)$ the strictly downward sloping in K_{spot} and hence upward sloping in K_m . Due to symmetry, both marginal products $F_K(K_m, 1)$ and $F_K(K_{\text{spot}}, 1)$ intersect at $K = K_m = K_{\text{spot}}$. However, only if $\theta \geq \theta^*$ it also holds that then $F_K(k_m, 1) = F_K(k_{\text{spot}}, 1)$. In fact, for $K = K_m = K_{\text{spot}}$ some workers are unemployed in locales with $\theta < \theta^*$, therefore $k_m > k_{\text{spot}}$ (remember $w_m > \bar{w}$ for all θ) and hence $F_K(k_m, 1) < F_K(k_{\text{spot}}, 1)$. We assumed that $\theta^{\min} < \theta^* < \theta^{\max}$ and we can therefore state the following about *average* rates of return: $\partial\pi_m/\partial K < \partial\pi_{\text{spot}}/\partial K$ if $K = K_m = K_{\text{spot}}$. Since $F_{KK} < 0$ in joint equilibrium it must therefore

hold that $K_m < K_{\text{spot}}$.

Figure 4 illustrates the case in which $K > k_m(\theta^{\min}) \cdot (1 - c)$ and in which K is sufficiently large such that we can let $K_{\text{spot}} = k_m(\theta^{\min})$ while both sectors remain open. Since this implies $K_{\text{spot}} > K$ we know that $w_{\text{spot}} > \bar{w}$ for all $\theta \in [\theta^{\min}, \theta^{\max}]$ and, hence, that $k_{\text{spot}} = K_{\text{spot}}$ everywhere. However, $k_m(\theta) < k_m(\theta^{\min})$ and therefore $F_K(k_{\text{spot}}, 1) < F_K(k_m(\theta), 1)$ for all $\theta > \theta^{\min}$. By a continuity argument, this proves that in this instance (1) there exists a joint equilibrium, (2) in equilibrium $K_{\text{spot}} < k_m(\theta^{\min})$ and (3) $\min w_{\text{spot}} < \min w_m$.

A joint equilibrium may however not exist. This happens if K is so small or c so large such that the marginal product of capital $F_K(K_{\text{spot}}(K, K_m, c), 1)$ does not decrease sufficiently fast in K_m . Then, even as $K_m \rightarrow 0$, the *average* rate of return $\partial\pi_m/\partial K$ is below $\partial\pi_{\text{spot}}/\partial K$. In such instances, firm in unionised locales will not invest into capital ('shut down') and therefore all workers in these locales will remain without work.

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