Internal Wage References and Wage Rigidity[*]

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Abstract

Internal wage references are used to generate wage rigidity in labor market models. However, there is little knowledge about which features an internal reference has to fulfil in order to generate rigid wages. This paper includes profit measures as internal references in a unionized labor market and compares them to the Danthine and Kurmann (2007) model. I show that the way internal pay comparisons were modeled so far do not yield unambiguous rigidity results. In addition wage rigidity is related to the shape of the wage curve as well as to the level of pay and employment.

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1   Introduction

Following the abundance of empirical evidence on wage rigidity in the last two decades, economic theory tried to capture this wage behavior in its labor market models. Especially by including fairness considerations in form of internal wage comparisons, it was possible to bring wage and employment behavior closer to the empirical findings (Danthine and Kurmann 2007, Koskela and Schöb 2009). Internal wage comparisons are made by workers or unions who perceive to have some entitlement to a fair share of the firms revenue or profits (Kahneman et al. 1986).

They are modeled by an internal wage reference. Wages are not only compared to an outside option (external wage reference) but to an internal fairness reference. So far, the literature focused on average productivity of the firm as internal reference. The obvious reason is that it leads to the desired result, namely sticky wages. However, Strifler and Beissinger (2012) showed that this need not necessarily be the case.

Although wage behavior hinges crucially on the internal reference, there are no analyses which try to pin down the connection between each change in the model outcomes and the features of internal references which cause these changes. It is not clear which features an internal reference has to fulfill to generate rigid wages, and which further implications this has on the model outcomes as well as on the utility formulation.

This paper contributes to the literature by analyzing the model outcomes of two, so far unused, firm internal references in a unionized labor market, namely profits and average profits. In addition it examines the predictions of the Danthine and Kurmann (2007) model.

Comparing the two wage references with the findings of Danthine and Kurmann (2007), Koskela and Schöb (2009), and Strifler and Beissinger (2012), the paper shows that there are two decisive features an internal reference has to fulfill in order to generate rigid wages. First, it has to decrease with decrease in employment. This entails a U-shaped wage curve. Second, either the internal reference has to have a certain minimum size, or the size of the external reference has to be limited. This second feature can entail

implications on the level of pay and the employment rate. If these features are not met, the models fail to generate wage rigidity.

The remainder is structured as follows. The next section presents a fairness labor union model with two different internal references. Section 3 compares the fairness model to the Danthine and Kurmann (2007) model. In section 4 the behavior of wages and employment are analyzed and the structure of internal references is discussed. The last section concludes.

2   The Fairness model

I follow the literature in formalizing fairness as internal pay comparison. Workers compare their wages with the profit of the firm and try to bargain for an equitable share. They demand wages to be set in a certain "fair" relation to profits. Especially for unionized labor markets, there exists evidence that social preferences include relative pay considerations with firm internal "close by" references (Rees, 1993, Agell and Bennmarker, 2003).[1]

According to Tversky and Kahneman (1986) people choose their reference transaction according to certain rules. The most succinct or concise reference transaction is chosen. This gives rise to doubt that, in terms of labor contracts, worker choose average productivity, a figure hard to determine, as internal pay reference. In contrast, profits are a concept workers know about and unions include it regularly into their argumentation when bargaining over wage increases.

I consider closed shop firm–level unions. The benchmark model is a standard rent-maximizing union which cares about the outside option only. The first internal reference to be analyzed are firm profits. This is what I call profit fairness:[2]

$$U_i = N_i \left[\rho \left(w_i - \upsilon \Pi_i \right) + \left(1 - \rho \right) \left(w_i - \overline{w} \right) \right] \tag{1}$$

Total utility U_i of the union is given by the number of employees N_i times the indi-

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[1] See Brown et al. (2008) or Strifler and Beissinger (2012) for a short overview.

[2] A logarithmic utility formulation yields qualitatively the same results. However it goes with some disadvantages which are discussed in appendix A.3.

vidual rent of each worker. Following the literature this rent consists of two components. First, wages w_i are compared to the outside option $\overline{w}$ and second, as described above, wages are compared to the firm i's profit Π_i. $0 < \rho < 1$ denotes the relative weight of the two components, whereas υ can be interpreted as a self-serving bias (Babcock and Loewenstein, 1997). If there is doubt about the exact amount of profits the union chooses the number which favors it's purpose most.[3]

The second internal reference is profits per employee Π_i/N_i, what I call average profit fairness:

$$U_i = N_i \left[\rho \left(w_i - \upsilon \frac{\Pi_i}{N_i} \right) + (1 - \rho) \left(w_i - \overline{w} \right) \right] \tag{2}$$

Now, each worker demands a fair share of what he or she contributes to the firms profits. In both set-ups the benchmark model is obtained by setting ρ equal to zero. An internal pay comparison does not take place and the standard rent-maximizing union results.

The production function for each firm is subject to diminishing marginal returns to labor $Y_i = AN_i^{\alpha}$ with Y_i denoting firm output and A technology.[4] Monopolistic competition prevails on the goods market enabling firms to set prices and unions to set wages. Unions are assumed to be identical and have the right to manage.[5] Aggregation leads to relative prices equalling unity and all wages are identical $w_i = w$. Assuming firms and employment to be given by a [0-1] continuum $N_i = n$, n is the employment rate. Inverse labor demand is given by eq. (3) with κ denoting the price setting power of the firm[6]:

$$w = \kappa \alpha A n^{\alpha - 1} \tag{3}$$

Labor demand is similar for all specifications, including the benchmark model. To derive the wage curve one has to consider that the outside option is composed out of the possibility to find a job or to stay unemployed and receive unemployment benefits $(\overline{w} = nw + (1 - n)b)$. Unemployment benefits are made up by a lump sum transfer.[7] The

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[3]Exact profit figures might not be available or up-to-date or workers are confused about the different profit measures available like gross profits, net profits or operating profits.

[4]I am following the literature here, see Koskela and Schöb (2009).

[5]Nash bargaining leads qualitatively to the same results.

[6]Which again is determined by the constant goods demand elasticity.

[7]In almost all labor market regulations there exist transfers unrelated to previous earnings.

wage–setting curve when union utility is driven by profit fairness is given by:

$$w = \frac{\rho v(1 + \alpha\kappa)\Pi + (1 - \rho)(1 - n)b}{\alpha\kappa - (1 - \rho)n} \qquad (4)$$

If ρ is equal to zero, the wage curve of the benchmark model results. If $\rho > 0$, it depends on the size of the internal reference if wages are lower or higher than in the benchmark model. We observe three cases depending on the size of the internal reference in figure 1.[8]

Figure 1: Profit fairness: variation of v $(\rho = 0.5)$

(a) Benchmark   (b) Case 1 $(v = 1.5)$ (c) Case 3 $(v = 1.0)$
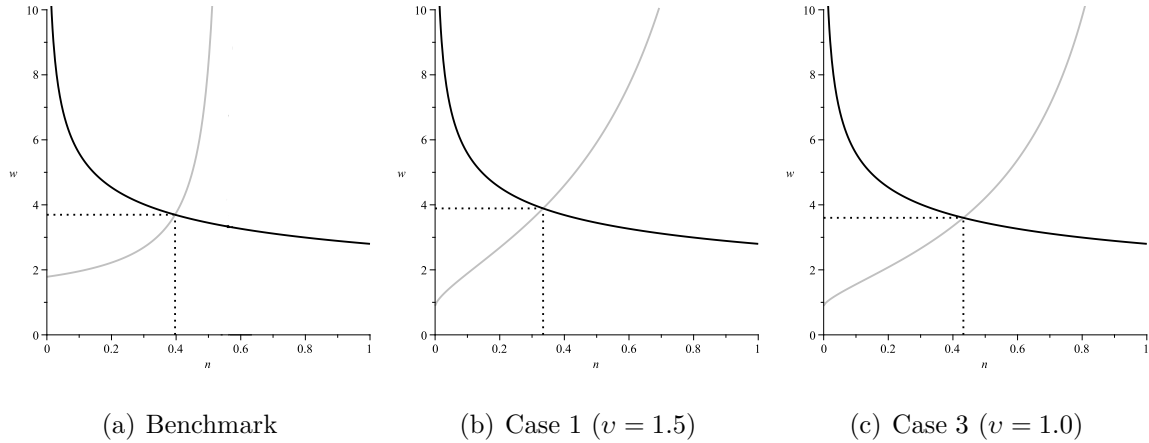
If the internal reference is larger than the benchmark wage, we are in case 1.[9] Wages are higher and employment lower than the benchmark. Case 3 is the other way round. In case 2 the same level of pay and employment result than in the benchmark model. The idea is straightforward, if internal reference and benchmark wage have the same size, a weighted average of the two figures equals to the benchmark outcome. This follows the findings of Strifler and Beissinger (2012). Case 2 is only a threshold. It marks the specific value of v which divides case 1 from case 3.

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[8]Calibration is as follows: $\alpha = 0.7$, $\kappa = 0.8$, $A = 5.0$, $b = 1.0$. Calibration of α and κ follows the literature, A and b are chosen such that the rigidity numbers of the different models are easy to compare.
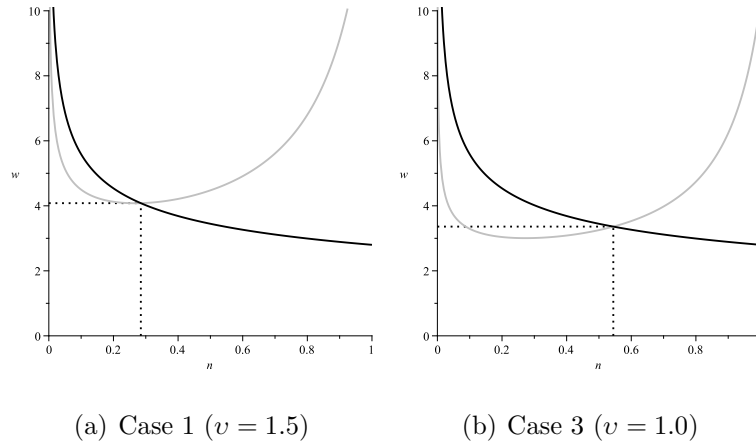
[9]See appendix A.1 for details.

The shape of the wage curve is well-behaved, i.e. upward sloping in the w-n space. The first reason is the outside option. The more people are employed, the higher are the chances to get a job if laid off. This we already have in the benchmark model, and is exactly the same as in an efficiency wage framework, see eg. (Danthine and Kurmann 2007). The second reason is the increase in profits with employment. If profits go up, so do wages, since workers care about overall profits. To conclude, inside as well as outside wage reference increase with employment.

This changes if unions choose firms average profits as internal reference. The wage curve is then given by:

$$w = \frac{\rho \upsilon \alpha \kappa \frac{\Pi}{n} + (1 - \rho)(1 - n)b}{\alpha \kappa - (1 - \rho)n} \tag{5}$$

Setting ρ equal to zero produces the benchmark model. Of course, it is the same as above since only the internal reference was modified. If $\rho > 0$ the size of the internal reference determines if wages are lower (case 3), equal (case 2) or higher (case 1) compared to the the benchmark wage. The logic is as above.[10]

Figure 2: *Average profit fairness: variation of υ ($\rho = 0.5$)*

(a) Case 1 ($\upsilon = 1.5$)   (b) Case 3 ($\upsilon = 1.0$)

As before, internal and external wage reference drive the shape of the wage curve. They

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[10]See appendix A.2 for details.

generate a U-shaped wage curve as found by Sessions (1993), Koskela and Schöb (2009) and Strifler and Beissinger (2012). While the external reference increases in employment, the internal wage reference decreases in employment. This determines the shape of the wage curve. At very low levels of employment average profits are very high, which leads to decreasing wage pressure with rising employment. At some point the outside option gains importance and unemployment benefits make wage pressure to take up again with rising employment. The turning point is determined by v and, of course, is decisive for which equilibrium pay is to result.

3   The Danthine and Kurmann (2007) model

The Danthine and Kurmann (DK) (2007) paper is very innovative since it is the first to include internal wage references in the wage setting process. The main idea of the paper is that workers tend to reciprocate the employer's behavior. If they are treated in a fair manner, paid a fair wage, they reciprocate this gift by giving higher effort to the company. Apart from the fact, that they use an efficiency wage framework and logarithmic utility, the model above is similar to it in several aspects. The utility function is a weighted average of internal and external wage comparison, as is the gift, the firm is giving to the worker in the DK (2007) paper. In the average profit fairness case, the internal reference is decreasing as is average productivity in DK (2007) or Strifler and Beissinger (2012).

However, DK (2007) do not encounter any case distinctions as described in the previous section. This is important as Strifler and Beissinger (2012) showed, that these case distinctions are connected to the level of wage rigidity. In case 1 they find wage rigidity and in case 3 a higher volatility of wages compared to their benchmark model.

In the constant effort model of DK (2007) labor demand is given by eq. (15), p. 869. It can be rewritten inversely as given in eq. (6).

$$lnw = ln\frac{\psi\alpha}{1 - \varphi\nu(1 - \alpha)} + ln\left(Ae^{\alpha}n^{\alpha-1}\right) \tag{6}$$

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The wage curve given in eq. (13), p. 868, can be rewritten as follows:

$$lnw = \frac{\frac{1-\varphi\nu}{\theta-1} + \varphi\nu ln\left(Ae^{\alpha}n^{\alpha-1}\right) + (1-\varphi)(1-n)lnb}{1-(1-\varphi)n} \qquad (7)$$

The wage equation is similar to the one from the fairness model above. The internal reference has weight φ and the external reference has weight $(1-\varphi)$. DK argue, that restricting $\nu < 1$ is necessary in order for the extreme case $\varphi = 1$ to make sense (see, p. 865). By doing so, they rule out case 3. If comparison takes place only inside the firm, the internal wage reference can not be higher than average productivity. Apart from the fact, that this restriction is only needed if comparison is totally internal it does not help to rule out a case 3 situation.[11]

By giving b values below 1, the outside utility is negative since the model is given in logs. This implies that case 3 is obtained by higher values of ν rather than smaller values. The logic is the same with the replacement ratio used in the paper. If you parameterize the model with b and A larger than 1, e.g. 1.5, you reach case 3 by lowering ν. The restriction ($\nu < 1$) is therefore not able to rule out the existence of a case 3 situation.[12] Figure (3) shows the equilibrium in their benchmark model (with $\varphi = 0$) as well as a case 1 and a case 3 equilibrium (both with $\varphi = 0.5$) of the constant effort model.[13]

Obviously there are case distinctions in the DK (2007) model. They are comparable to the ones found by Strifler and Beissinger (2012) and the ones presented in section 2. In case 1 employment is lower and in case 3 employment is higher than the benchmark. However, wages do not correspond accordingly. Even in case 3, wages are higher than the benchmark.[14] In both cases the U-shape of the wage curve is not as pronounced as above which is due to the log formulation.

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[11]The question is if it is sensible to assume that the external wage reference does not play any role at all. Especially since this implies a downward sloping wage curve, see figure 2, p. 873. It is more plausible that workers care about both references. In that case φ can be larger than one. Workers could choose a number which is larger, which suits their purpose better, see Babcock and Loewenstein (1997).

[12]See appendix A.3 for a precise case distinction.

[13]Calibration is as follows: $\alpha = 0.7$, $\psi = 0.8$, $\theta = 6.0$, $e = 1.0$, $A = 5.0$, $b = 1.0$.

[14]See appendix A.3 for details.

Figure 3: Benchmark model and the cases in the Danthine and Kurmann model (2007)

(a) Benchmark   (b) Case 1 ($\nu = 0.8$)   (c) Case 3 ($\nu = 0.6$)
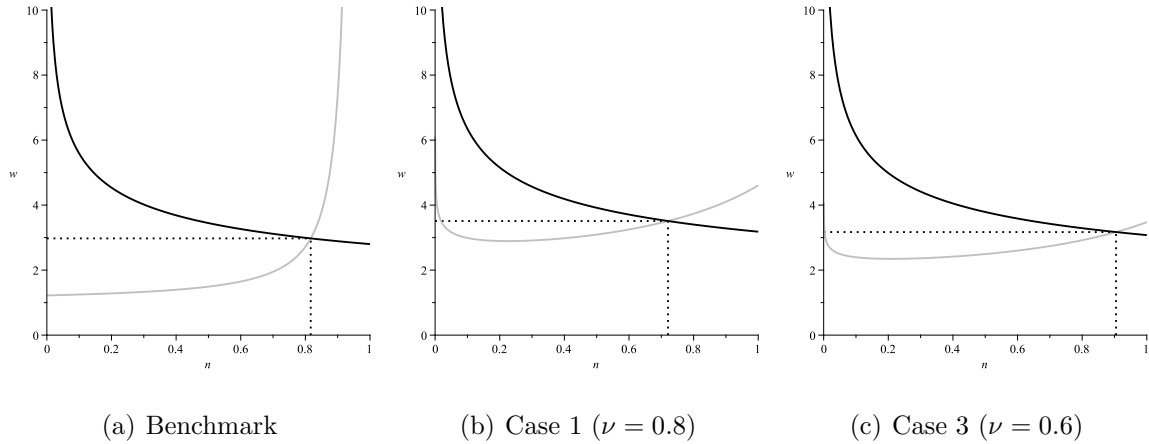
4 Wage rigidity and internal references

Internal references influence labor market outcomes such as the level of pay and employment. Consequently they matter for how these figures react to shocks. The question is, how exactly. I perform a technology shock of $\triangle A = -0.5$. In case of profit fairness the wage curve is shifted strongly and equilibrium pay is more volatile than in the benchmark model.

Since profits increase with employment along labor demand, an adverse technology shock having a negative effect on employment makes wages drop sharply. The exact mechanism is as follows. The adverse shock decreases the internal wage reference which leads, *cet. par.* , to a decrease in the wage level. Since the shock reduces labor demand, too, and makes employment go down, profits decrease even further. This again decreases the internal reference which makes wages drop even more, see figure (4). Profit fairness makes wages even more volatile than in the benchmark model, see table 1. In the benchmark model the relative change in wages is more than 1.5 times higher than the relative change

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Figure 4: Profit fairness: technology shock ($\rho = 0.5$)

(a) Benchmark   (b) Case 1 ($v = 1.5$)   (c) Case 3 ($v = 1.0$)
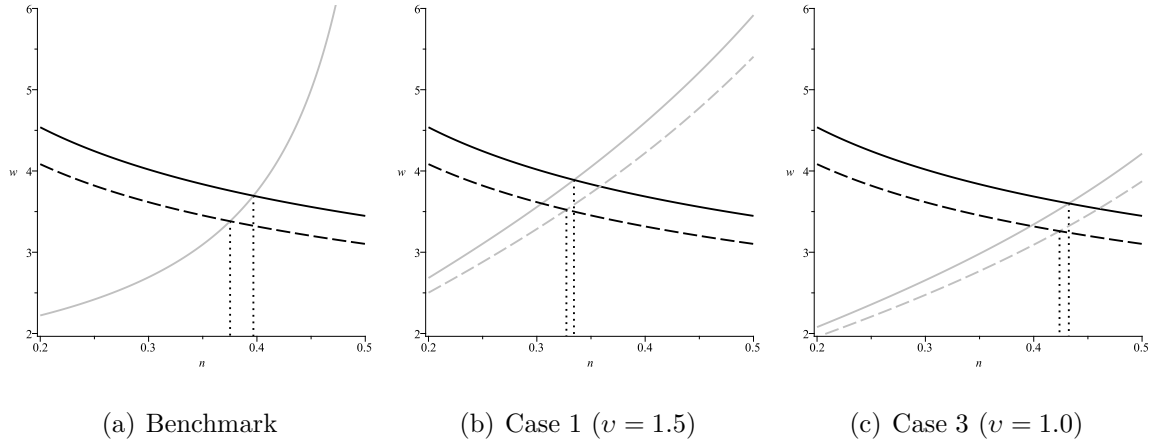
in employment. In every parameter constellation the profit fairness model wage volatility is higher. The reason why profit fairness fails to establish wage rigidity is the fact, that both wage references increase with employment.

Figure 5: Average profit fairness: technology shock ($\rho = 0.5$)

(a) Case 1 ($v = 1.5$)   (b) Case 3 ($v = 1.0$)

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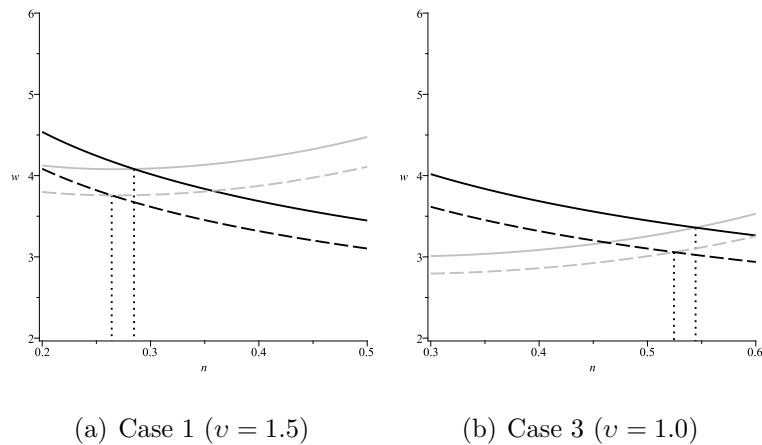
This is not the case with average profit fairness. Here, the internal reference decreases with employment and generates rigidity on the aggregate level in case 1 (see table 1). The relative change of wages compared to employment drops from 1.57 to 1.10 which implies that employment absorbs more of the shock than in the benchmark.

The shock decreases the internal reference and, *cet. par.* , leads to lower wages. Since labor demand is affected, employment decreases. This leads to an increase in the internal wage reference which attenuates the drop in wages. The main difference compared to the mechanism above is that now employment enters negatively in the internal wage reference. This mechanism for generating wage rigidity was first pointed out by DK (2007). However, the existence of case 3 proves, that this is only a necessary but not a sufficient condition for the existence of wage rigidity. The reason is the following. In case 3, the size of the internal wage reference is relatively small and employment is relatively high. A decrease in employment at this level has only a minor impact on average profits. Consequently the attenuation in wages, which stems from the effect of n on the internal reference, drops out.[15]

The equilibrium results in the average fairness model case 2 correspond exactly to the benchmark model. As shown in appendix A.2, the case distinction boils down to a simple parameter condition. This does not hold for profit fairness, see appendix A.1. Here the cases depend on the level of employment which means that the value of the case-2-v depends on employment. In the DK (2007) model it gets more complicated. Appendix A.3 shows, that the case distinctions depend not only on employment but on the level of unemployment benefits. In fact, this is the crucial difference to the average profit fairness model.

Figure 6 shows the equilibrium reaction in Danthine and Kurmann (2007) model in case of constant effort. Parameter values are as before, with a shock of $\triangle A = -0.5$.

The figure show a higher degree of wage rigidity in all cases, compared to the average profit fairness model. Wage rigidity is roughly the same in case 1 and case 3. In case 1, wages are rigid because of the attenuating effect of the decrease in employment on the

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[15]See Strifler and Beissinger (2012) for a more detailed analysis.

Table 1: Wage rigidity in the fairness models

		Profit fairness	Average profit fairness
	Case 1	4.52	1.10
Case distinctions	Case 2	4.65	1.57
	Case 3	4.77	2.46

The figures are calculated as a relative change in wages divided by a relative change in employment. If numbers are higher than 1.57 (benchmark model), wages are more volatile, if they are below, wages are more rigid.

Figure 6: Danthine and Kurmann model (2007): technology shock

(a) Benchmark (b) Case 1 ($\nu = 0.8$) (c) Case 3 ($\nu = 0.6$)
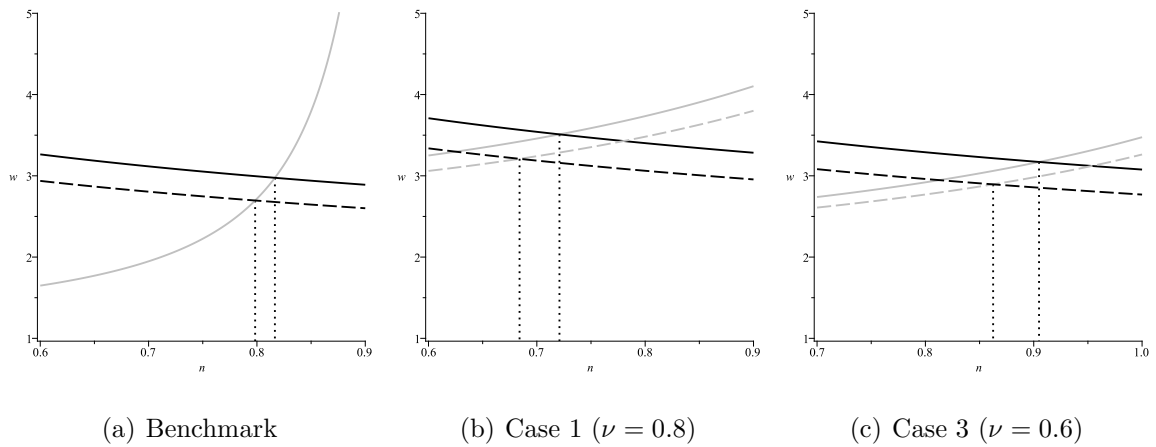
wages trough the internal reference, see Danthine and Kurmann (2007). In case 3, the wage curve is very flat and does not shift much due to the technology shock. This makes

labor demand shifting along an almost stiff, flat wage curve.

Table 2: Wage rigidity in the Danthine and Kurmann (2007)
and the average profit fairness model

	b=1.0	b=1.5	b=2.0	b=2.5	b=3.0	b=3.5
DK (2007) constant effort model						
Benchmark	4.20	1.58	0.60	0.24	0.11	0.06
$\nu = 0.6$	1.86	1.05	0.56	0.27	0.11	0.04
$\nu = 0.7$	1.77	0.94	0.49	0.25	0.13	0.07
$\nu = 0.8$	1.68	0.84	0.43	0.23	0.13	0.08
$\nu = 0.9$	1.59	0.75	0.38	0.20	0.12	0.07
Average profit fairness model						
Benchmark	1.57	0.64	0.30	0.15	0.09	0.05
$v = 1.5$	1.10	0.45	0.22	0.11	0.07	0.04
$v = 1.0$	2.46	0.97	0.42	0.20	0.11	0.06

The figures are calculated as above. If numbers are higher than the benchmark model, wages are more volatile, if they are below, wages are more rigid.

At first sight the case distinctions have no implications on the level of wage rigidity in the model. However there are two drivers of wage rigidity. At first, employment entering negatively in the internal wage reference and a second, one inherent in the benchmark model. Equation 8 shows the benchmark wage curve of the Danthine and Kurmann (2007)

model.

$$lnw = \frac{1}{(\theta - 1)(1 - n)} + lnb \qquad (8)$$

A technology shock decreases the employment rate which, in turn, decreases the wage level. However, this effect looses its strength the higher unemployment benefits are. The higher b, the lower the relative change in wages and the higher the degree of wage rigidity in the benchmark model. This is the same in the benchmark of the average profit fairness model. Table 2 shows how wage rigidity increases in the benchmark situation of both models.

This is why the crucial difference among the models can be found in the case distinctions. In the Danthine and Kurmann (2007) model the cases are dependent on n and b. In the average profit fairness model the cases are independent of n and b. They boil down to a parameter condition. If b increases, the cases remain unaffected. In case 1 ($v = 1.5$) wages are always more rigid than in the benchmark, in case 3 ($v = 1.0$) they are always more volatile, see table 2. Obviously this is not the case in the Danthine and Kurmann (2007) model. At some point unemployment benefits reach a level ($b = 2.5$) where including the internal wage reference leads to wage volatility. The benchmark's level of wage rigidity is too high for the internal wage reference to play it's intended role. This is because the cases are not independent of b. The first drive, a decreasing internal reference with regard to employment, is present throughout the different levels of b. Increasing the size of the internal reference (ν) at low levels of b, increases wage rigidity and at higher levels of b it merely lowers the degree of volatility. Thus, both models have ambiguous effects on the degree of wage rigidity.

Following Danthine and Kurmann (2007) as well as the analysis above, it is necessary for the generation of wage rigidity to have a firm internal wage reference which decreases with employment. Given the convincing assumption of decreasing marginal returns to labor in the production function it is average productivity, average revenue or average profits which fulfill this characteristic.[16] Deploying such an internal wage reference has a

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[16]Having profits or revenue as reference instead makes wages more volatile and thus indicates that they may play no role in real world wage–setting.

major effect on the shape of the wage curve as found in Koskela and Schöb (2009) and Strifler and Beissinger (2012). The internal reference then always entails a U-shaped wage curve. No matter whether it is in an efficiency wage framework or in a labor union model.

The sufficient condition for wage rigidity is more complicated. If the cases are independent of variables (i.e. can be simplified to parameter conditions), the sufficient condition is that the internal wage reference has to be above the benchmark model's wage level. This condition entails implications on the level of pay as well as on the employment rate. If the cases are not independent of variables, the sufficient condition entails an upper bound on the degree of rigidity in the benchmark model. Moreover, the cases entail implications on the level of employment only.

In a static general equilibrium model with internal and external wage comparisons, one inevitably faces a more or less pronounced U-shaped wage curve when aiming at generating wage rigidity. Depending on the sufficient conditions there are implications on the level employment and there can be implications on the level of pay. Unfortunately however wage rigidity is not the only possible outcome, when modeling fairness as internal pay comparison. A case 3 situation with higher wage volatility can not be ruled out.

5   Conclusions

This paper provides evidence that not all types of internal wage references generate wage rigidity. No matter whether this is in a union or an efficiency wage model. It argues that, as a necessary condition, the firm internal wage reference has to decrease with employment. The necessary condition inevitably entails a U-shaped wage curve and thus links the shape of the wage curve to the issue of rigidity. The sufficient conditions depend on the case distinctions. If the case distinctions are independent, as a sufficient condition, the internal wage reference has to be above the benchmark model wage level. Only then internal wage comparisons lead to wage rigidity. The sufficient condition includes implications for the level of wages and employment and links them to the issue of rigidity. If the case distinctions are not independent, there is need for an upper bound in the

degree of wage rigidity of the benchmark model. This is achieved by limiting the level of unemployment benefits. Here, no implications on the level of pay can be derived. If the sufficient condition is not met, higher wage volatility results. Internal pay comparisons have therefore no unambiguous effect on the degree of wage rigidity. If it is really fairness which accounts for wage rigidity there is need for modeling it in a way which brings unambiguous results.

A   Appendix

A.1   Case distinctions in the profit fairness model

In the profit fairness model case 1 prevails if the internal wage reference is larger than a function of unemployment benefits. More precisely this function of unemployment benefits equals the benchmark model wage curve. The size of the internal reference depends on v.

$$v\frac{1+\alpha\kappa}{\alpha\kappa}\Pi > \frac{(1-n)}{\alpha\kappa-n}b$$

By rewriting profits as a function of wages and employment and rewriting wages as given in the benchmark model and replacing those in the wage curve from eq. (4) this condition can be simplified to:

$$v > \frac{(\alpha\kappa)^2}{(1-(\alpha\kappa)^2)n_{benchmark}}$$

If the condition holds we are in case 1. If v is smaller than the RHS case 3 prevails. The intuition is straightforward. In case 1 wages are higher (employment lower) than in the benchmark model since the internal wage reference is higher than wages in the benchmark model. Case 3 is exactly the opposite. Case 2 is the threshold. Internal and external reference have the same size, thus the equilibrium wage employment combination is the same as in the benchmark. Of course, the shape of the wage curve differs from the benchmark in this situation, too.

A.2   Case distinctions in the average profit fairness model

Case 1 prevails under the same condition as in appendix A.1. The size of the internal reference depends on v.

$$v\frac{\Pi}{n} > \frac{(1-n)}{\alpha\kappa-n}b$$

By rewriting average profits as a function of wages and rewriting wages as given in the benchmark model and replacing those in the wage curve from eq. (5) this condition can

be simplified to:

$$v > \frac{\alpha\kappa}{1 - \alpha\kappa}$$

The intuition is as in appendix A.1. The only difference is that now the case distinctions boil down to a simple parameter condition which is even independent of employment.

A.3 Case distinctions in Danthine and Kurmann (2007)

In comparison to above the case distinctions in this model are hard to determine since the model's benchmark implies not only a different wage function but a different labor demand, too. The only way to obtain the case distinctions is thus to work with the equilibrium expression of the wage.

$$ln\frac{\psi\alpha}{1 - \varphi\tilde{\nu}(1 - \alpha)} + ln\left(Ae^{\alpha}n_b^{\alpha-1}\right) = \frac{\frac{1-\varphi\tilde{\nu}}{\theta-1} + \varphi\tilde{\nu}ln\left(Ae^{\alpha}n_b^{\alpha-1}\right) + (1 - \varphi)(1 - n_b)lnb}{1 - (1 - \varphi)n_b}$$

n_b denotes the benchmark employment rate. Note, that the size of the internal reference is now given by $\tilde{\nu}$. Solving the equation above for it, gives the value for ν which yields case 2. Obviously, the case distinctions are not stable in the sense that they are not independent of A and b which makes them harder to implement. Moreover the case distinctions only refer to the level of employment, they carry no simultaneous implication for the level of pay.

Case 1 results if the internal reference (the value of ν) is larger than $\tilde{\nu}$. It implies a lower level of employment. Case 3 results if $\nu < \tilde{\nu}$. This implies a higher level of employment. As figure 3 c) shows, wages are in this case higher than in the benchmark, too. The case distinctions carry no implication on the level of pay.

It is not possible to rewrite the case distinctions in terms of parameters only. In this sense they are not stable towards changes in b.

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