2633

■

Unions' relative concerns and strikes
in wage bargaining

Ana Mauleon, Vincent Vannetelbosch
and Cecilia Vergari

CORE
Voie du Roman Pays 34, L1.03.01
B-1348 Louvain-la-Neuve, Belgium.
Tel (32 10) 47 43 04
Fax (32 10) 47 43 01
E-mail: corestat-library@uclouvain.be
http://www.uclouvain.be/en-44509.html

Bulletin of Economic Research 66:4, 2014, 0307-3378
DOI: 10.1111/j.1467-8586.2012.00455.x

UNIONS' RELATIVE CONCERNS AND STRIKES IN WAGE BARGAINING

*A. Mauleon**, *Vincent Vannetelbosch** *and Cecilia Vergari*†
*CORE, Université catholique de Louvain, Louvain-la-Neuve, Belgium and CEREC, Facultés universitaires Saint-Louis, Brussels, Belgium, and †Department of Economic Sciences, University of Bologna, Bologna, Italy

ABSTRACT

We consider a model of wage determination with private information in an oligopoly. We investigate the effects of unions having relative concerns on the negotiated wage and the strike activity. We show that an increase of unions' relative concerns has an ambiguous effect on the strike activity.

Keywords: private information, relative position, strike activity, wage bargaining

JEL classification numbers: C70, D60, J50

I. INTRODUCTION

Clearly, it is likely that when unions bargain with firms over wages they are also influenced by relative wage considerations.[1] Brown *et al.* (2008), using data collected from 16,000 British workers, have found evidence that the welfare of a worker is not solely determined by his or her material circumstances but also depends on his or her relative wage and the rank-ordered position of his or her wage within a comparison set.[2] The purpose of this paper is to provide a theoretical study of how relative concerns will affect the outcome of wage negotiations in the presence of private information in an oligopoly. The utility function of each union captures both the *pride* of having higher wages than others and the *envy* of others having higher wages. To describe the wage bargaining process, we adopt Rubinstein's (1982) alternating-offer bargaining model

Correspondence: Vincent Vannetelbosch, CORE, Université catholique de Louvain, Voie du Roman Pays 34, bte L1.03.01, B-1348, Louvain-la-Neuve, Belgium. Email: vincent.vannetelbosch@uclouvain.be. We thank an anonymous referee for useful comments on a previous draft. Vincent Vannetelbosch and Ana Mauleon are, respectively, Senior Research Associate and Research Associate of the National Fund for Scientific Research (FNRS). Financial support from Spanish Ministry of Sciences and Innovation under the project ECO 2009-09120, support from the Belgian French Community's programme Action de Recherches Concertée 05/10-331, and support of an SSTC grant from the Belgian Federal government under the IAP contract P6/09 are gratefully acknowledged. Cecilia Vergari acknowledges the financial support from the University of Bologna under the 2010-2011 RFO scheme.

[1] Hopkins (2008) has provided a survey of different theoretical models of relative concerns and their relation to inequality. See also Sobel (2005).

[2] Clark and Oswald (1996), using data on 5000 Bristish workers, have found evidence that workers' reported satisfaction levels are inversely related to their comparison wage rates.

with two-sided incomplete information, which allows the occurrence of strikes at equilibrium. An increase in unions' relative concerns has a twofold effect on the strike activity. On the one hand, it raises the potential payoffs for the union and the firm, and hence longer strikes or lockouts may be needed for screening the private information. On the other hand, each union is more inclined to concede and to accept rapidly a smaller wage increase than before since the smaller increase in wage is compensated by the increased utility due to more pride or less envy. Depending on which effect dominates, an increase in unions' relative concerns will either raise or reduce the strike activity. Notice that, as the number of firms in the industry increases, it becomes more likely that the strike activity will increase when unions care more about relative concerns.

The paper is organized as follows. In Section II the model under complete information is presented. Section III is devoted to the case with private information. Section IV concludes.

II. MODEL

We consider an oligopolistic industry for a single homogeneous product, where the demand is linear and is given by $p = a - q$, p is the market price, and q is the aggregate quantity demanded. Let q_i denote the quantity produced by firm i, and let Π_i denote the profit of firm i, $i = 1, \ldots, n$. There is no entry or threat of entry, and firms are quantity setters (Cournot competition). Production technology exhibits constant returns to scale with labour as the sole input and is normalized in such a way that $q_i = l_i$, where l_i is the labour input. The total labour cost to firm i of producing quantity q_i is $q_i w_i$, where w_i is the wage in firm i. Firm i's profit is given by $\Pi_i = (p - w_i)q_i$. Firm i is unionized, and enters into a closed-shop agreement with union i.

II.1 Unions' preferences

The objective of union i is to maximize the following utility function:

$$U_i(w_1, w_2, \ldots, w_n) = w_i - \gamma \left(\frac{1}{n} \sum_{j=1}^{n} w_j - w_i \right) \tag{1}$$

where $1 > \gamma \geq 0$. In this utility function, γ captures the loss from disadvantageous inequality (envy) if union i's wage is below average ($\frac{1}{n} \sum_{j=1}^{n} w_j > w_i$), or the win from advantageous inequality (pride) if union i's wage is above average ($w_i > \frac{1}{n} \sum_{j=1}^{n} w_j$).[3]

The union's utility function given in (1) implies that the union places no value on employment. Although this may seem implausible, the notion that, in negotiating wages, unions do not take into account the employment consequences of higher wages has a long tradition, and is often stated by union leaders (Mauleon and Vannetelbosch, 2005).[4] This assumption is made to obtain closed-form solutions in order to carry out the analysis under incomplete information. Cramton and Tracy (2003) have concluded that disputes are largely motivated by the presence of private information and the sharply conflicting interests of the union and the firm over the wage.

[3] This utility function is a special case of Fehr and Schmidt's (1999) model of inequality aversion. We discuss this model at the end of this section.

[4] Mauleon and Vannetelbosch (2005) have shown that, if the union is not too powerful, it is optimal for the union that seeks to maximize the rents to send to the negotiating table delegates who seek to maximize the wage.

Interactions between market competition and wage bargaining are analysed according to a two-stage game. In stage one, wages are negotiated at the firm-level. In stage two, each firm chooses its output (and hence employment) level, taking as given both the output decisions of the other firms and the negotiated wages. The model is solved backwards. In the last stage of the game, the wage levels have already been determined. Firms compete by choosing their outputs simultaneously to maximize profits, with the price adjusting to clear the market. The unique Nash equilibrium of this stage game yields

$$q_i(w_1, \ldots, w_n) = \frac{a - nw_i + \sum_{j \neq i} w_j}{n+1}; \quad \Pi_i(w_1, \ldots, w_n) = \left(\frac{a - nw_i + \sum_{j \neq i} w_j}{n+1}\right)^2$$

for $i = 1, \ldots, n$. The Nash equilibrium outputs of a firm (and hence, the equilibrium level of employment) are decreasing with its own wage, but are increasing with other firms' wages and total industry demand.

The negotiations occur simultaneously in all firms and the agents are unaware of any proposals made (or settlement reached) in related negotiations. Production and market competition occur only when either all firms have come to an agreement with their workers, or when some firms have settled with their unions and the other unions have decided to leave the negotiation forever. Hence, each union–firm pair takes the decisions of the other pairs as given while conducting its own negotiation.

II.2 Wage bargaining

Each negotiation proceeds as in Rubinstein's (1982) alternating-offer bargaining model. The union and the firm make alternate wage offers, with the firm making offers in odd-numbered periods and the union making offers in even-numbered periods. The length of each period is Δ. The negotiation starts in period 0 and ends when one of the negotiators accepts an offer. No limit is placed on the time that may be expended in bargaining and perpetual disagreement is a possible outcome. The union is assumed to be on strike in every period until an agreement is reached.

The union and the firm have time preferences with constant discount rates $r_u > 0$ and $r_f > 0$, respectively. To capture the notion that the time it takes to come to terms is small relative to the length of the contract, we assume that the time between periods is very small. As the interval between offers and counteroffers shortens and shrinks to zero, the alternating-offer model has a unique limiting subgame perfect equilibrium (SPE), which approximates the Nash bargaining solution to the bargaining problem (see Binmore *et al.* 1986). Thus the predicted wages are given by $w_i^* = \arg\max\{\alpha \cdot \log U_i + (1-\alpha) \cdot \log \Pi_i\}$, where $\alpha \in (0, 1)$ is the union bargaining power which is equal to $r_f/(r_u + r_f)$ and the status quo payoffs are zero. Then, the equilibrium wages (w_i^*), outputs (q_i^*), profits (Π_i^*), and consumer surplus (CS^*) are

$$w_i^* = \frac{a(n + \gamma(n-1))\alpha}{2n^2(1-\alpha) + \alpha(\gamma(n-1) + n)}$$

$$q_i^* = \frac{2an^2(1-\alpha)}{(n+1)(2n^2(1-\alpha) + \alpha(\gamma(n-1) + n))}$$

$$\Pi_i^* = \frac{4a^2n^4(1-\alpha)^2}{(n+1)^2(2n^2(1-\alpha) + \alpha(\gamma(n-1) + n))^2}$$

$$CS^* = \frac{2n^6a^2(1-\alpha)^2}{(n+1)^2(2n^2(1-\alpha) + \alpha(\gamma(n-1) + n))^2}$$

Of course, we have that $\partial w_i^*/\partial\alpha > 0\,(\partial U_i^*/\partial\alpha > 0)$, $\partial w_i^*/\partial n < 0\,(\partial U_i^*/\partial n < 0)$, $\partial\Pi_i^*/\partial\alpha < 0$, and $\partial\Pi_i^*/\partial n < 0$. More interestingly, we find that $\partial w_i^*/\partial\gamma > 0$ $(\partial U_i^*/\partial\gamma > 0)$, $\partial q_i^*/\partial\gamma < 0$, $\partial\Pi_i^*/\partial\gamma < 0$, and $\partial CS^*/\partial\gamma < 0$.[5]

Propositon 1. An increase of unions' relative concerns increases wages but decreases outputs, profits, and consumer surplus.

Take as given the wage negotiated in the other firms. As γ increases, each union becomes less inclined to accept lower wages because of having to suffer from more envy. In addition, each union is now more persistent to obtain higher wages because of getting more pride. Hence, the more the union cares about relative concerns the higher the negotiated wages and the lower the profits of the firm.

III. MAXIMUM DELAY IN REACHING AN AGREEMENT

III.1 Wage bargaining with private information

Both the asymmetric Nash bargaining solution and Rubinstein's model predict efficient outcomes of the bargaining process. In particular, agreement is reached immediately. This is not true if we introduce incomplete information into the bargaining. In this case, the early rounds of negotiation are used for information transmission between the two negotiators. We now suppose that negotiators have private information. Neither negotiator knows the impatience (or discount rate) of the other party. It is common knowledge that the firm's discount rate lies in the range $[r_f^{\mathrm{P}}, r_f^{\mathrm{I}}]$, where $0 < r_f^{\mathrm{P}} \leq r_f^{\mathrm{I}}$, and that the union's discount rate lies in the range $[r_u^{\mathrm{P}}, r_u^{\mathrm{I}}]$, where $0 < r_u^{\mathrm{P}} \leq r_u^{\mathrm{I}}$. The superscripts 'I' and 'P' identify the most impatient and most patient types, respectively. The types are independently drawn from the set $[r_j^{\mathrm{P}}, r_j^{\mathrm{I}}]$ according to the probability distribution p_j, for $j = u, f$. This uncertainty implies bounds on the union's bargaining power which are denoted by $\underline{\alpha} = r_f^{\mathrm{P}}/(r_u^{\mathrm{I}} + r_f^{\mathrm{P}})$ and $\overline{\alpha} = r_f^{\mathrm{I}}/(r_u^{\mathrm{P}} + r_f^{\mathrm{I}})$. Watson (1998) has characterized the set of perfect Bayesian equilibrium (PBE) payoffs which may arise in Rubinstein's alternating-offer bargaining game and constructed bounds (which are met) on the agreements that may be made. The bounds and the PBE payoffs set are determined by the range of incomplete information and are easy to compute because they correspond to the SPE payoffs of two bargaining games with complete information. These two games are defined by matching one player's most impatient type with the opponent's most patient type. From Watson's analysis, we have that for any PBE, the payoff of the union belongs to $[U_i^*(\underline{\alpha}), U_i^*(\overline{\alpha})]$ and the payoff of the firm belongs to $[\Pi_i^*(\overline{\alpha}), \Pi_i^*(\underline{\alpha})]$.

III.2 Delay in reaching an agreement

The union is assumed to be on strike in every period until an agreement is reached. The wage bargaining game may involve delay, but not perpetual disagreement, in equilibrium.[6] In fact, delay is positively related to the distance between the discount rates of the most and least patient types of the players. If the range of types is reduced, then this leads to a smaller range of

[5] These relationships hold under an alternative specification where unions maximize the surplus and have relative concerns: $U_i(w_i, l_i, w_j, l_j) = w_i l_i - \gamma(w_j l_j - w_i l_i)$.

[6] Watson (1998) has constructed equilibria with delay in which the types of each player behave identically (no information is revealed in equilibrium), players use pure strategies, and players make non-serious offers until some appointed date.

possible payoffs and less delay. Delay can occur even when the game is close to one of complete information (as the type distributions converge to point mass distributions).

Since we allow for general distributions over types and we may have a multiplicity of PBE, we define strike activity as the maximum delay time in reaching an agreement. It is the minimum between the maximum real time the union would spend bargaining and the maximum real time the firm would spend bargaining. Only on average is this measure a good proxy for actual strike duration.[7] The maximum real time the union (firm) would spend bargaining is the time D^u (D^f) such that the union (firm) is indifferent between getting its lower bound PBE payoff at time 0 and getting its upper bound PBE payoff at time D^u (D^f). In the Appendix we derive the expression for the maximum delay in equilibrium which shows that an agreement is reached in finite time and that delay time equals zero as incomplete information vanishes (in that r_j^{P} and r_j^{I} converge).[8] Formally, strike activity is given by

$$D(\gamma) = \min\left\{D^u(\gamma), D^f(\gamma)\right\} \tag{2}$$

where

$$D^u(\gamma) = -\frac{1}{r_u^{\mathrm{P}}} \cdot \log\left[\frac{r_f^{\mathrm{P}}}{r_f^{\mathrm{I}}} \cdot \frac{(n+\gamma(n-1))r_f^{\mathrm{I}} + 2n^2 r_u^{\mathrm{P}}}{(n+\gamma(n-1))r_f^{\mathrm{P}} + 2n^2 r_u^{\mathrm{I}}}\right] \tag{3}$$

is the maximum real time the union would spend negotiating, and

$$D^f(\gamma) = -\frac{1}{r_f^{\mathrm{P}}} \cdot \log\left[\left(\frac{r_u^{\mathrm{P}}}{r_u^{\mathrm{I}}}\right)^2 \cdot \left(\frac{(n+\gamma(n-1))r_f^{\mathrm{P}} + 2n^2 r_u^{\mathrm{I}}}{(n+\gamma(n-1))r_f^{\mathrm{I}} + 2n^2 r_u^{\mathrm{P}}}\right)^2\right] \tag{4}$$

is the maximum real time the firm would spend negotiating. In fact, $D^u(\gamma)$ is the maximum real time the union would spend negotiating if it were of the most patient type. Similarly, $D^f(\gamma)$ is the maximum real time the firm would spend negotiating if it were of the most patient type. So, $D^u(T)$ and $D^f(T)$ are the upper bounds on the maximum time the union of type r_u and the firm of type r_f would spend negotiating. Since $D^u(T)$ and $D^f(T)$ are positive, finite numbers, the maximum real delay in reaching an agreement is finite and converges to zero as r_j^{I} and r_j^{P} become close. We get that $\partial D^u(\gamma)/\partial\gamma < 0$ and $\partial D^f(\gamma)/\partial\gamma > 0$.

Proposition 2. An increase of unions' relative concerns decreases the maximum real time the union would spend negotiating but increases the maximum real time the firm would spend negotiating.

The intuition behind this proposition is as follows. An increase of unions' relative concerns (γ increases) raises the potential payoffs for the union and the firm, and in expanding the payoff set (or range of possible payoffs), also increases the scope for delay (longer strikes or lockouts may be needed for screening the private information). Hence, $\partial D^f(\gamma)/\partial\gamma > 0$. However, for the union, there is a second effect at play. When γ increases, taking as given the wage agreement in the other negotiation, each union is more inclined to concede and to accept rapidly a smaller wage increase than before since the smaller increase in wage is compensated by the increased utility due to more pride or less envy. This second effect dominates the first one. Hence, $\partial D^u(\gamma)/\partial\gamma < 0$. Since the strike activity, $D(\gamma)$, is equal to $\min\{D^u(\gamma), D^f(\gamma)\}$, we conclude that an increase of unions' relative concerns has an ambiguous effect on the strike activity. Such an ambiguous effect is likely to be observed as long as envy and pride dominate

[7] It is not uncommon in the literature on bargaining to analyse the maximum delay before reaching an agreement. See, for instance, Cramton (1992) and Cai (2003).

[8] When the range of types converges to 0, the game reduces to one of complete information and the agreement is reached without delay.

TABLE 1
Maximum delay in reaching an agreement

	$n=2$										$n=5$					
γ	2		3/2		1		1/2		0		1		1/2		0	
r^{P}	D^u	D^f	D^u	D^f	D^u	D^f	D^u	D^f	D^u	D^f	D^u	D^f	D^u	D^f	D^u	D^f
0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.17	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0
0.16	1	1	1	1	2	1	2	1	2	1	2	0	2	0	2	0
0.15	2	3	3	2	3	2	3	2	3	1	3	1	3	1	4	0
0.14	4	4	4	3	4	3	4	3	5	2	5	2	5	1	5	1
0.13	5	5	6	5	6	4	6	4	6	3	7	2	7	2	7	1
0.12	7	7	7	7	8	6	8	5	9	4	9	3	10	2	10	2
0.11	9	10	10	9	10	8	11	7	11	6	12	4	12	3	13	2
0.10	12	13	13	12	13	10	14	9	15	8	15	6	16	5	17	3
0.09	15	16	16	15	17	14	18	12	19	10	20	8	21	6	21	5
0.08	20	21	21	20	22	18	23	16	24	13	25	10	26	8	27	6
0.07	26	28	27	26	28	24	29	21	31	18	33	14	34	12	36	9
0.06	34	38	35	35	37	32	38	29	40	25	43	20	45	16	47	12
0.05	46	53	48	49	50	45	52	41	55	35	58	28	60	24	63	18
0.04	65	77	67	72	70	67	73	60	77	53	82	43	85	36	89	28

compassion. Indeed, if compassion is as strong as envy and there is no pride as in (5), then one can show that unions' relative concerns have no effect on the strike activity.

Another result is that the maximum real time the firm would spend bargaining, $D^f(\gamma)$, is decreasing in the number of firms: $\partial D^f(\gamma)/\partial n < 0$. This negative relationship may be explained by the following argument. If each union–firm pair expects to be able to alter its relative wage position in the industry, then each union–firm pair has some incentive to cut its wage in order to gain a larger share of the product market. This incentive increases with the number of firms operating in the industry. As n becomes large, the wage outcome tends to be close to the reservation wage and the strike activity tends to vanish.

We now provide an example of the maximum delay. In this example, let $r_f^{\mathrm{P}} = r_u^{\mathrm{P}} = r^{\mathrm{P}}$, $r_f^{\mathrm{I}} = r_u^{\mathrm{I}} = r^{\mathrm{I}}$, $r^{\mathrm{I}} = 0.36 - r^{\mathrm{P}}$ with $r^{\mathrm{P}} \in [0.04, 0.18]$. Table 1 gives the integer part of the maximum delay for the different values of the parameter γ and for $n = 2$ or $n = 5$. We can interpret r_j as the annual discount rate and the numbers in Table 1 as the maximum number of days needed to reach an agreement. Indeed, the integer part of the maximum delays for $\Delta = 1/365$ are exactly the numbers in Table 1.[9] We observe that (i) the real delay time in reaching an agreement is not negligible: many bargaining rounds may be needed in equilibrium before an agreement is reached; (ii) D^f (D^u) is increasing (decreasing) with γ but decreasing (increasing) with n; (iii) D^u and D^f are increasing with the amount of private information $|r_j^{\mathrm{P}} - r_j^{\mathrm{I}}|$; (iv) the maximum delay $D(\gamma) = \min\{D^u(\gamma), D^f(\gamma)\}$ is increasing with γ when γ is small, and may decrease with γ when γ is becoming large; and (v) the maximum delay $D(\gamma)$ decreases sharply with n. For instance, take $r^{\mathrm{P}} = 0.05$. For $n = 2$, we observe that $D(1/2) = D^f(1/2) = 41$, $D(1) = D^f(1) = 45$, $D(3/2) = D^u(3/2) = 48$, and $D(2) = D^u(2) = 46$. In addition, we notice that $D(1) = 45$ for $n = 2$ but $D(1) = 28$ for $n = 5$. Results (i), (ii) and (iii) hold in general.

[9] The data in Table 1 seem consistent with US strike durations as reported in Cramton and Tracy (1994).

IV. CONCLUSION AND DISCUSSION

We have considered a model of wage determination with private information in an oligopoly. We have investigated the effects of unions having relative concerns on the negotiated wage and the strike activity. We have shown that an increase of unions' relative concerns has an ambiguous effect on the strike activity.

IV.1 Alternative unions' preferences

Fehr and Schmidt (1999) have proposed a model of inequality aversion:

$$U_i(w_1, w_2, \ldots, w_n) = w_i - \frac{\gamma}{n}\sum_{j=1}^{n}\max\{w_j - w_i, 0\} - \frac{\beta}{n}\sum_{j=1}^{n}\max\{w_i - w_j, 0\}$$

where they assume that $\gamma \geq \beta$ and that β satisfies $1 > \beta \geq 0$. The parameter γ captures the envy. If the parameter β is positive, then it captures the compassion. But if β is negative, then it captures the pride.[10] One can see that if β is negative and equal to $-\gamma$, then the Fehr and Schmidt's model reduces to the utility function given in (1) where pride is as strong as envy and there is no compassion.[11] It can be shown that, as long as envy and pride dominate compassion, our main results hold: unions' relative concerns lead to higher wages but have an ambiguous effect on the strike activity.

Notice that, if β is positive and equal to γ, then the Fehr and Schmidt model reverts to Bolton and Ockenfels' (2000) model of inequality aversion:

$$U_i(w_1, w_2, \ldots, w_n) = w_i - \gamma\left(\frac{1}{n}\sum_{j=1}^{n}w_j - w_i\right)^2 \tag{5}$$

This form of utility function implies that an increase in γ does not give more incentives to each union for accepting higher wages or for accepting lower wages. Hence, if compassion is as strong as envy and there is no pride as in (5), then one can show that the symmetric equilibrium wages do not depend on the parameter γ.

IV.2 Product differentiation and market competition

We have assumed that firms were competing à la Cournot and were producing homogeneous goods. Product differentiation does not qualitatively affect our results about the effect of unions' relative conerns on wage negotiations. Mauleon and Vannetelbosch (2003) have shown that, when unions maximize rents, wages and strikes are increasing with the degree of product differentiation, and the strike activity is smaller under Bertrand than under Cournot competition. However, an increase in market competition does not always reduce the strike activity. For instance, Mauleon and Vannetelbosch (2010) have shown that, from an initial situation of two-way intra-industry trade, an increase in product market integration decreases the strike activity. But, opening up markets to trade has an ambiguous effect on the wage and the strike activity.

[10] Using data from experiments on two-person bargaining, De Bruyn and Bolton (2008) have found that the positive reciprocity assumption of the Fehr–Schmidt model ($\beta > 0$) is violated.

[11] Brown *et al.* (2008) have studied how British workers do make wage comparisons. Their results support rivalrous preferences rather than inequity aversion. So, workers seem to feel *envy or pride* rather than *envy or compassion* when making wage comparisons.

REFERENCES

Binmore, K. G., Rubinstein, A. and Wolinsky, A. (1986). 'The Nash bargaining solution in economic modelling', *Rand Journal of Economics*, 17, pp. 176–88.

Bolton, G. E. and Ockenfels, A. (2000). 'ERC: a theory of equity, reciprocity, and competition', *American Economic Review*, 90, pp. 166–93.

Brown, G. D., Gardner, J., Oswald, A. J. and Qian, J. (2008). 'Does wage rank affect employees' well-being?' *Industrial Relations*, 47, pp. 355–89.

Cai, H. (2003). 'Inefficient Markov perfect equilibria in multilateral bargaining', *Economic Theory*, 22, pp. 583–06.

Clark, A. E. and Oswald, A. J. (1996). 'Satisfaction and comparison income', *Journal of Public Economics*, 61, pp. 359–81.

Cramton, P. C. (1992). 'Strategic delay in bargaining with two-sided uncertainty', *Review of Economic Studies*, 59, pp. 205–25.

Cramton, P. C. and Tracy, J. S. (1994). 'The determinants of U.S. labor disputes', *Journal of Labor Economics*, 12, pp. 180–209.

Cramton, P. C. and Tracy, J. S. (2003). 'Unions, bargaining and strikes', in Addison, J. T. and Schnabel, C. (eds), *International Handbook of Trade Unions*, Cheltenham, UK: Edward Elgar, pp. 86–117.

De Bruyn, A. and Bolton, G. E. (2008). 'Estimating the influence of fairness on bargaining behavior', *Management Science*, 54, pp. 1774–91.

Fehr, E. and Schmidt, K. (1999). 'A theory of fairness, competition, and cooperation', *Quarterly Journal of Economics*, 114, pp. 817–68.

Hopkins, E. (2008). 'Inequality, happiness and relative concerns: what actually is their relationship?' *Journal of Economic Inequality*, 6, pp. 351–72.

Mauleon, A. and Vannetelbosch, V. (2003). 'Market competition and strike activity', *International Journal of Industrial Organization*, 21, pp. 737–58.

Mauleon, A. and Vannetelbosch, V. (2005). 'Strategic union delegation and strike activity', *Canadian Journal of Economics*, 38, pp. 149–73.

Mauleon, A. and Vannetelbosch, V. (2010). 'Market integration and strike activity', *Journal of International Economics*, 81, pp. 154–61.

Rubinstein, A. (1982). 'Perfect equilibrium in a bargaining model', *Econometrica*, 50, pp. 97–109.

Sobel, J. (2005). 'Interdependent preferences and reciprocity', *Journal of Economic Literature*, 43, pp. 347–91.

Watson, J. (1998). 'Alternating-offer bargaining with two-sided incomplete information', *Review of Economic Studies*, 65, pp. 573–594.

APPENDIX: MAXIMUM DELAY

The negotiation goes as in Rubinstein's (1982) alternating-offer bargaining model. The firm and the union have time preferences with constant discount factors $\delta_f \in (0, 1)$ and $\delta_u \in (0, 1)$, respectively. It is assumed that each union–firm pair i takes the other wage settlements $w_{-i} = (w_1, \ldots, w_{i-1}, w_{i+1}, \ldots, w_n)$ as given during the negotiation. For any wage bargaining which leads to an agreement w_i at period n, $\delta_f^n \Pi_i(w_i, l_i(w_i, w_{-i}))$ and $\delta_u^n U_i(w_i, w_{-i})$ are, respectively, firm i's payoff and union i's payoff. For any wage bargaining which leads to perpetual disagreement, disagreement payoffs are set to zero. As in Binmore *et al.* (1986), the SPE wage outcome is such that $\Pi_i(w_{iu}, l_i(w_{iu}, w_{-i})) = \delta_f \Pi_i(w_{if}, l_i(w_{if}, w_{-i}))$ and $U_i(w_{if}, w_{-i}) = \delta_u U(w_{iu}, w_{-i})$, where w_{iu} is the SPE wage outcome if the union makes the first wage offer, and w_{if} is the SPE wage outcome if the firm makes the first offer. Since the union makes the first offer, the unique symmetric SPE wages are given by

$$w_i^*(\delta_u, \delta_f) = \frac{a(\gamma(n-1)+n)\left[(1-\delta_f)(\gamma(n-1)+n) - (1-\delta_u)n^2\left(\sqrt{\delta_f} - \delta_f\right)\right]}{\Phi}$$

for $i = 1, 2, \ldots, n$, and with

$$\Phi = (1-\delta_f)(\gamma(n-1)+n)^2 + \delta_f(1-\delta_u)n^2[2(\gamma(n-1)+n) - (1-\delta_u)n^2]$$

This SPE wage is also the SPE payoff, $U_i^*(\delta_u, \delta_f)$, and from which we get the SPE profits,

$$\Pi_i^*(\delta_u, \delta_f) = \frac{a^2(1-\delta_u)^2 n^4\left[(\gamma(n-1)+n)\left(\sqrt{\delta_f} - \delta_f\right) + \delta_f(1-\delta_u)n^2\right]^2}{(n+1)^2\Phi^2}$$

for $i = 1, 2, \ldots, n$.

Suppose now that the players have private information. They are uncertain about each other's discount factors. Player j's discount factor lies in the range $[\delta_j^{\mathrm{I}}, \delta_j^{\mathrm{P}}]$, where $0 < \delta_j^{\mathrm{I}} \leq \delta_j^{\mathrm{P}} < 1$. The types are independently drawn from the interval $[\delta_j^{\mathrm{P}}, \delta_j^{\mathrm{I}}]$ according to the probability distribution p_j, for $j = u, f$.

Lemma 1. Consider the wage bargaining with private information in which the distributions p_f and p_u *are common knowledge, and in which the period length shrinks to zero. For any perfect Bayesian equilibria (PBE), the payoff of the union i belongs to* $[U_i^*(\delta_u^{\mathrm{I}}, \delta_f^{\mathrm{P}}), U_i^*(\delta_u^{\mathrm{P}}, \delta_f^{\mathrm{I}})]$ *and the payoff of the firm i belongs to* $[\Pi_i^*(\delta_u^{\mathrm{P}}, \delta_f^{\mathrm{I}}), \Pi_i^*(\delta_u^{\mathrm{I}}, \delta_f^{\mathrm{P}})]$.

This lemma is not a direct corollary to Watson's (1998) Theorem 1 because Watson's work focuses on linear preferences, but the analysis can be modified to handle the present case. Since we allow for general probability distributions over discount factors, multiplicity of PBE is not an exception.

The maximum number of bargaining periods the union would spend negotiating, $I(m^u(\gamma))$, is given by $U_i^*(\delta_u^{\mathrm{I}}, \delta_f^{\mathrm{P}}) = (\delta_u^{\mathrm{P}})^{m^u(\gamma)} U_i^*(\delta_u^{\mathrm{P}}, \delta_f^{\mathrm{I}})$, from which we obtain $m^u(\gamma) = (\log(\delta_u^{\mathrm{P}}))^{-1} \log[U_i^*(\delta_u^{\mathrm{I}}, \delta_f^{\mathrm{P}})/U_i^*(\delta_u^{\mathrm{P}}, \delta_f^{\mathrm{I}})]$. Notice that $I(m^u(\gamma))$ is simply the integer part of $m^u(\gamma)$. It is customary to express the players' discount factors in terms of discount rates, r_u and r_f, and the length of the bargaining period, Δ, according to the formula $\delta_j = \exp(-r_j\Delta)$. With this interpretation, player j's type is identified with the discount rate r_j, where $r_j \in [r_j^{\mathrm{P}}, r_j^{\mathrm{I}}]$. We thus have that $\delta_j^{\mathrm{I}} = \exp(-r_j^{\mathrm{I}}\Delta)$ and $\delta_j^{\mathrm{P}} = \exp(-r_j^{\mathrm{P}}\Delta)$. Note that $r_j^{\mathrm{I}} \geq r_j^{\mathrm{P}}$ since greater patience implies a lower discount rate. As Δ approaches zero, using l'Hopital's rule we obtain that

$$D^u(\gamma) = \lim_{\Delta\to 0}(m^u(\gamma)\cdot\Delta) = -\frac{1}{r_u^{\mathrm{P}}}\cdot\log\left[\frac{r_f^{\mathrm{P}}}{r_f^{\mathrm{I}}}\cdot\frac{(n+\gamma(n-1))r_f^{\mathrm{I}} + 2n^2 r_u^{\mathrm{P}}}{(n+\gamma(n-1))r_f^{\mathrm{P}} + 2n^2 r_u^{\mathrm{I}}}\right]$$

which is a positive, finite number. Notice that $D^u(\gamma)$ converges to zero as r_j^{P} and r_j^{I} become close. We have

$$\frac{\partial D^u(\gamma)}{\partial\gamma} = \frac{-2(n-1)n^2\left(r_f^{\mathrm{I}}r_u^{\mathrm{I}} - r_f^{\mathrm{P}}r_u^{\mathrm{P}}\right)}{\left((n+\gamma(n-1))r_f^{\mathrm{P}} + 2n^2 r_u^{\mathrm{I}}\right)\left((n+\gamma(n-1))r_f^{\mathrm{I}} + 2n^2 r_u^{\mathrm{P}}\right)r_u^{\mathrm{P}}} < 0$$

and

$$\frac{\partial D^u(\gamma)}{\partial n} = \frac{2n((n-2)\gamma + n)(r_f^{\mathrm{I}}r_u^{\mathrm{I}} - r_f^{\mathrm{P}}r_u^{\mathrm{P}})}{\left((n+\gamma(n-1))r_f^{\mathrm{P}} + 2n^2 r_u^{\mathrm{I}}\right)\left((n+\gamma(n-1))r_f^{\mathrm{I}} + 2n^2 r_u^{\mathrm{P}}\right)r_u^{\mathrm{P}}} > 0$$

The maximum number of bargaining periods the firm would spend negotiating, $I(m^f(\gamma))$, is given by $\Pi_i^*(\delta_u^{\mathrm{P}}, \delta_f^{\mathrm{I}}) = (\delta_f^{\mathrm{P}})^{m^f(\gamma)} \cdot \Pi_i^*(\delta_u^{\mathrm{I}}, \delta_f^{\mathrm{P}})$, from which we obtain $m^f(\gamma) = (\log(\delta_f^{\mathrm{P}}))^{-1} \log\left[\Pi_i^*(\delta_u^{\mathrm{P}}, \delta_f^{\mathrm{I}}) / \Pi_i^*(\delta_u^{\mathrm{I}}, \delta_f^{\mathrm{P}})\right]$, and as Δ approaches zero,

$$D^f(\gamma) = \lim_{\Delta \to 0} \left(m^f(\gamma) \cdot \Delta\right) = -\frac{1}{r_f^{\mathrm{P}}} \cdot \log\left[\left(\frac{r_u^{\mathrm{P}}}{r_u^{\mathrm{I}}}\right)^2 \cdot \left(\frac{(n + \gamma\,(n-1))r_f^{\mathrm{P}} + 2n^2 r_u^{\mathrm{I}}}{(n + \gamma\,(n-1))r_f^{\mathrm{I}} + 2n^2 r_u^{\mathrm{P}}}\right)^2\right]$$

which is a positive, finite number. We have

$$\frac{\partial D^f(\gamma)}{\partial \gamma} = \frac{4(n-1)n^2\left(r_f^{\mathrm{I}} r_u^{\mathrm{I}} - r_f^{\mathrm{P}} r_u^{\mathrm{P}}\right)}{\left((n + \gamma(n-1))r_f^{\mathrm{P}} + 2n^2 r_u^{\mathrm{I}}\right)\left((n + \gamma(n-1))r_f^{\mathrm{I}} + 2n^2 r_u^{\mathrm{P}}\right) r_f^{\mathrm{P}}} > 0$$

and

$$\frac{\partial D^f(\gamma)}{\partial n} = \frac{-4n((n-2)\gamma + n)\left(r_f^{\mathrm{I}} r_u^{\mathrm{I}} - r_f^{\mathrm{P}} r_u^{\mathrm{P}}\right)}{\left((n + \gamma(n-1))r_f^{\mathrm{P}} + 2n^2 r_u^{\mathrm{I}}\right)\left((n + \gamma(n-1))r_f^{\mathrm{I}} + 2n^2 r_u^{\mathrm{P}}\right) r_f^{\mathrm{P}}} < 0$$

The strike activity (i.e. the maximum real delay time before reaching an agreement) is given by $D(\gamma) = \min\left\{D^u(\gamma), D^f(\gamma)\right\}$.

CORE Reprints -- Recent titles

2587. Yurii NESTEROV and Vladimir Y. PROTASOV. Optimizing the spectral radius. *SIAM Journal on Matrix Analysis and Applications,* 34(3), 999-1013, 2013.
2588. David CRAINICH, Louis EECKHOUDT and Olivier LE COURTOIS. Decreasing downside risk aversion and background risk. *Journal of Mathematical Economics,* 53, 59-63, 2014.
2589. Marc FLEURBAEY, Marie-Louise LEROUX and Gregory PONTHIERE. Compensating the dead. *Journal of Mathematical Economics,* 51, 28-41, 2014.
2590. Jacques H. DREZE and Alain DURRE. Fiscal integration and growth stimulation in Europe (with an appendix by Jacques Drèze and Jean-François Carpentier). *Recherches Economiques de Louvain,* 80, 5-45, 2014.
2591. Kris BOUDT and Mikael PETITJEAN. Intraday liquidity dynamics and news releases around price jumps: evidence from the DJIA stocks. *Journal of Financial Markets,* 17,121-149, 2014.
2592. Florian MAYNERIS and Loriane PY. The efficiency of enterprise zone programs. Some conflicting results? *Région et Développement,* 38, 209-224, 2013.
2593. Yurii NESTEROV. Subgradient methods for huge-scale optimization problems. *Mathematical Programming Series A,* 146(1-2), 275-297, 2014.
2594. Olivier DEVOLDER, François GLINEUR and Yurii NESTEROV. First-order methods of smooth convex optimization with inexact oracle. *Mathematical Programming Series A,* 146(1-2), 37-75, 2014.
2595. Mathieu LEFEBVRE, Pierre PESTIEAU and Gregory PONTHIERE. Measuring poverty without the mortality paradox. *Social Choice and Welfare,* 40(1), 285-316, 2013.
2596. Pierre PESTIEAU and Gregory PONTHIERE. Optimal fertility along the life cycle. *Economic Theory,* 55(1), 185-224, 2014.
2597. Claude d'ASPREMONT and Rodolphe DOS SANTOS FERREIRA. Household behavior and individual autonomy: an extended Lindahl mechanism. *Economic Theory,* 55(3), 643-664, 2014.
2598. Johanna M.M. GOERTZ. Inefficient committees: small elections with three alternatives. *Social Choice and Welfare,* 43(2), 357-375, 2014.
2599. Nguyen Thang DAO and Julio DAVILA. Implementing steady state efficiency in overlapping generations economies with environmental externalities. *Journal of Public Economic Theory,* 16(4), 620-649, 2014.
2600. Kristian BEHRENS, Susana PERALTA and Pierre M. PICARD. Transfer pricing rules, OECD guidelines, and market distortions. *Journal of Public Economic Theory,* 16(4), 650-680, 2014.
2601. David A. WUTTKE, Constantin BLOME and Michael HENKE. Focusing the financial flow of supply chains: an empirical investigation of financial supply chain management. *International Journal of Production Economics,* 145(3), 773-789, 2013.
2602. Constatin BLOME, Tobias SCHOENHERR and Matthias KAESSER. Ambidextrous governance in supply chains: the impact on innovation and cost performance. *Journal of Supply Chain Management,* 49(4), 59-80, 2013.
2603. Constatin BLOME, Tobias SCHOENHERR and Dominik ECKSTEIN. The impact of knowledge transfer and complexity on supply chain flexibility: knowledge-based view. *International Journal of Production Economics,* 147(2), 307-316, 2014.
2604. Francesco DI COMITE, Jacques-François THISSE and Hylke VANDENBUSSCHE. Verti-zontal differentiation in export markets. *Journal of International Economics,* 93(1), 50-66, 2014.
2605. Koen DECANCQ, Luc VAN OOTEGEM and Elsy VERHOFSTADT. What if we voted on the weights of a multidimensional well-being index? An illustration with Flemish data. *Fiscal Studies,* 34(3), 315-332, 2013.
2606. Koen DECANCQ. Copula-based measurement of dependence between dimensions of well-being. *Oxford Economic Papers,* 66(3), 681-701, 2014.
2607. Kristof BOSMANS, Koen DECANCQ and André DECOSTER. The relativity of decreasing inequality between countries. *Economica,* 81(322), 276-292, 2014.
2608. Olivier BARGAIN, Mathias DOLLS, Clemens FUEST, Dirk NEUMANN, Andreas PEICHL, Nico PESTEL and Sebastian SIEGLOCH. Fiscal union in Europe? Redistributive and stabilizing effects of a European tax-benefit system and fiscal equalization mechanism. *Economic Policy*, 28(75), 375-422, 2013.
2609. Dominik DORSCH, Hubertus Th. JONGEN, Jan-J. RUCKMANN and Vladimir SHIKHMAN. On the local representation of piecewise smooth equations as a Lipschitz manifold. *Journal of Mathematical Analysis and Applications*, 411(2), 916-930, 2014.

2610. Dirk VAN DE GAER, Joost VANDENBOSSCHE and José Luis FIGUEROA. Children's health opportunities and project evaluation: Mexico's oportunidades program. *The World Bank Economic Review,* 28(2), 282-310, 2014.
2611. Mathieu VAN VYVE, Laurence A. WOLSEY and Hande YAMAN. Relaxations for two-level multi-item lot-sizing problems. *Mathematical Programming Series A,* 146(1-2), 495-523, 2014.
2612. Monalisa SEN and Anil K. BERA. The improbable nature of the implied correlation matrix from spatial regression models. *Regional Statistics,* 14(1), 3-15, 2014.
2613. Johanna M.M. GOERTZ and François MANIQUET. Condorcet jury theorem: an example in which informative voting is rational but leads to inefficient information aggregation. *Economics Letters,* 125(1), 25-28, 2014.
2614. Thierry BRECHET, Carmen CAMACHO and Vladimir M. VELIOV. Model predictive control, the economy, and the issue of global warming. *Annals of Operations Research,* 220(1), 25-48, 2014.
2615. Giuseppe DE FEO and Jean HINDRIKS. Harmful competition in insurance markets. *Journal of Economic Behavior & Organization,* 106, 213-226, 2014.
2616. Jean HINDRIKS, Susana PERALTA and Shlomo WEBER. Local taxation of global corporation: a simple solution. *Annals of Economics and Statistics (Special Issue on the Economics of Taxation),* 113-114, 37-65, 2014.
2617. Paul BELLEFLAMME, Thomas LAMBERT and Armin SCHWIENBACHER. Individual crowdfunding practices. *Venture Capital: An International Journal of Entrepreneurial Finance,* 15(4), 313-333, 2013.
2618. Feng QIU, Shabbir AHMED, Santanu S. DEY and Laurence A. WOLSEY. Covering linear programming with violations. *INFORMS Journal on Computing,* 26(3), 531-546, 2014.
2619. Gautier M. KRINGS, Jean-François CARPANTIER and Jean-Charles DELVENNE. Trade integration and trade imbalances in the European Union: a network perspective. *PLoS One,* 9(1), e83448, 2014.
2620. Jean-Charles DELVENNE and Henrik SANDBERG. Finite-time thermodynamics of port-Hamiltonian systems. *Physica D,* 267, 123-132, 2014.
2621. Volker BRITZ, P. Jean-Jacques HERINGS and Arkadi PREDTETCHINSKI. A bargaining theory of the firm. *Economic Theory,* 54(1), 45-75, 2013.
2622. Volker BRITZ, P. Jean-Jacques HERINGS and Arkadi PREDTETCHINSKI. On the convergence to the Nash bargaining solution for action-dependent bargaining protocols. *Games and Economic Behavior,* 86*,* 178-183, 2014.
2623. Mathieu VAN VYVE. Fixed-charge transportation on a path: optimization, LP formulations and separation. *Mathematical Programming Series A,* 142(1-2), 371-395, 2013.
2624. Philippe MICHEL and Pierre PESTIEAU. Social security and early retirement in an overlapping-generations growth model. *Annals of Economics and Finance,* 14-2(B) 705-719, 2013.
2625. Jacques-François THISSE. The new science of cities by Michael Batty: the opinion of an economist. *Journal of Economic Literature,* 52(3), 805-819, 2014.
2626. Bas de GEUS, Bart DEGRAEUWE, Grégory VANDENBULCKE, Luc INT PANIS, Isabelle THOMAS, Joris AERTSENS, Yves DE WEERDT, Rudi TORFS and Romain MEEUSEN. Utilitarian cycling in Belgium: a cross-sectional study in a sample of regular cyclists. *Journal of Physical Activity and Health,* 11, 884-894, 2014.
2627. Helmuth CREMER and Pierre PESTIEAU. Social long-term care insurance and redistribution. *International Tax and Public Finance,* 21(6), 955-974, 2014.
2628. Philippe CHEVALIER, Alejandro LAMAS, Liang LU and Tanja MLINAR. Revenue management for operations with urgent orders. *European Journal of Operational Research,* 240(2), 476-487, 2015.
2629. Alain PHOLO BALA, Dominique PEETERS and Isabelle THOMAS. Spatial issues on a hedonic estimation of rents in Brussels. *Journal of Housing Economics,* 25, 104-123, 2014.
2630. Jorge MANZI, Ernesto SAN MARTIN and Sébastien VAN BELLEGEM. School system evaluation by value added analysis under endogeneity. *Psychometrika,* 79(1), 130-153, 2014.
2631. Jens Leth HOUGAARD, Juan D. MORENO-TERNERO and Lars Peter Østerdal. Assigning agents to a line. *Games and Economic Behavior,* 87, 539-553, 2014.
2632. Ana MAULEON, Jose J. SEMPERE-MONERRIS and Vincent VANNETELBOSCH. Farsighted R&D networks. *Economics Letters,* 125(3), 340-342, 2014.
2633. Ana MAULEON, Vincent VANNETELBOSCH and Cecilia VERGARI. Unions' relative concerns and strikes in wage bargaining. *Bulletin of Economic Research,* 66(4), 374-383, 2014.