

Wage Rigidity in a Competitive Incomplete Contract Market

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Do employers and workers underbid prevailing wages if there is unemployment? Do employers take advantage of workers' underbidding by lowering wages? We hypothesize that under conditions of incomplete labor contracts, wage levels may positively affect workers' propensity to cooperate. This, in turn, may prevent firms from underbidding or accepting the underbidding of workers. Experimental double auctions conducted for the purpose of examining these hypotheses yield the following results: (i) Workers' underbidding is very frequent, but employers refuse to accept workers' low wage offers in markets with incomplete labor contracts. However, in the presence of complete labor contracts, employers accept and actively enforce wages close to the competitive level. (ii) Workers' effort is positively related to the wage level. Therefore, wage cutting is costly for the employer if workers have discretion over their effort level. This holds true even in the presence of explicit performance incentives.

I. Introduction

Do workers underbid prevailing wages if there is unemployment?
Do employers take advantage of underbidding by lowering wages?

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These are the main questions of this paper and of many theories of wage rigidity.¹ Recently performed questionnaire studies with owners and managers of firms suggest that employers are unwilling to cut wages in the presence of unemployment (Blinder and Choi 1990; Agell and Lundborg 1995; Bewley 1995, 1997; Campbell and Kamlani 1997). Some of these studies even indicate that employers do not take advantage of workers' underbidding (Agell and Lundborg 1995; Bewley 1995). Although unemployed workers frequently seem to be willing to work for less than the going wage, firms report that they refuse to employ underbidders. According to these studies, a major reason for firms' refusal to cut wages is the fear that pay cuts will adversely affect work morale. In Bewley's study (1997, chap. 13, p. 12), for example, there are many indications of owners' and managers' reluctance to cut wages. They fear that pay cuts "express hostility to the work force" and will be "interpreted as an insult." As a consequence, they were thought to "provoke hostility" against the firm, with negative consequences for performance. Similar findings are presented in Agell and Lundborg (1995) and Campbell and Kamlani (1997).

The findings in the studies mentioned above suggest that, contrary to the assumptions of the standard competitive model, the wage is affected not only by supply and demand conditions but also by its impact on workers' effort behavior. In this paper we examine this possibility in the context of experimental double auctions. Since the pioneering paper by Smith (1962), a large body of subsequent research has proved the striking competitive properties of experimental double auctions. It has been shown that under a wide variety of conditions, double auctions converge quickly and reliably to the competitive equilibrium (Smith 1982; Plott 1989). This has been confirmed and reported in hundreds of laboratory double-auction markets and can be considered as one of the best-established facts of experimental economics. Even if there are as few as only four sellers or if "zero-intelligence" traders (traders with simple preprogrammed trading rules) are used, the competitive outcome is reached (Smith 1982; Gode and Sunder 1993). The double auction generates higher competitive pressure and market efficiency than any other known institution used by experimental economists

¹ Among these theories are the implicit contract theory as developed by, e.g., Azariadis (1975), the insider-outsider theory of Lindbeck and Snower (1988), job search models as reviewed in Mortensen (1986), and the different versions of the efficiency wage hypothesis as reviewed in Katz (1986). For important criticisms of those versions of the efficiency wage approach that rely on standard assumptions about workers' preferences, see Carmichael (1985, 1990) and Murphy and Topel (1989, 1990).

(Friedman and Rust 1993).² In view of these facts, it seems fair to say that double-auction experiments provide one of the most rigorous and persuasive pieces of evidence in favor of the standard competitive model. Yet this also means that if one can isolate factors that prevent convergence to the competitive equilibrium in a double auction, one has probably identified an important obstacle for convergence.

What are the factors that could lead to nonconvergence? The above-mentioned studies suggest that many owners and managers of firms seem to anticipate that workers' motivation is affected by considerations of reciprocity and fairness. Managers believe that employees interpret pay cuts as a hostile (i.e., unfair) action, which in turn triggers hostile responses from the employees.³ That reciprocity and perceptions of fairness are potentially important determinants of motivation and work behavior is also suggested by a large literature in organization theory (see, e.g., Cropanzano and Folger 1991; Mowday 1991; Steers and Porter 1991; Lawler 1994) and psychology (e.g., Adams 1963, 1965; Argyle 1989; Cialdini 1993). Reciprocity motives seem to affect behavior even among strangers. This is indicated by a large number of experimental studies on ultimatum game bargaining (Güth, Schmittberger, and Schwarze 1982; Thaler 1988; Roth 1995; Camerer and Thaler 1995)⁴ and trust games (Fehr, Kirchsteiger, and Riedl 1993; Fehr et al. 1994; Berg, Dickhaut, and McCabe 1995; Miller 1997; Falk, Gächter, and Kovács 1998).⁵

² "The striking competitive tendency of the double auction institution . . . has been confirmed by at least a thousand market sessions in a variety of designs" (Holt 1995, p. 370). Most double auctions have been conducted under conditions of private information about payoff functions. For the impact of public information, see Sec. III below.

³ Bewley (1997, chap. 9) interprets his findings in terms of reciprocity: "Such reciprocity seems to be real and important . . . [It] seems to be one of the main factors making morale important, and perception of the violation of reciprocity is probably a component of the harm done by pay cuts" (p. 11).

⁴ In an ultimatum game, a proposer has to propose a division of a fixed amount of money. The responder can accept or reject the proposed division. If the responder rejects it, both players get nothing; if the responder accepts it, each player receives the proposed shares. If both players are rational and selfish money maximizers, the prediction is that proposers demand the whole amount of money (less 1 cent), whereas responders are willing to accept any positive share. Yet responders reject offers that are well above zero (but below 25 percent) with a very high probability. Low offers are considered as an insult or a hostile act, which in turn triggers hostility in the form of a rejection. Proposers anticipate this and offer, therefore, on average, 40 percent of the available amount of money.

⁵ In the trust game of Berg et al. and Miller, e.g., first movers are endowed with an amount of money x , which they can keep or transfer to the second mover. Any amount y transferred will be tripled. The second mover then has to decide on a countertransfer z , $0 \leq z \leq 3y$. If both players are rational and selfish money maximizers, the predicted outcome is $y = z = 0$. However, if second movers are motivated by positive reciprocity, even selfish first movers may have an incentive to transfer

The stylized facts of ultimatum bargaining games indicate that many people are willing to punish behavior that they view as hostile or unfair even if this punishment is costly for them. This behavior can be called *negative* reciprocity because hostile actions trigger hostile responses. Trust games, in contrast, indicate the presence of a behavior that can be termed *positive* reciprocity. Positively reciprocal behavior is based on a willingness to pay in order to reward actions that are perceived as generous, kind, or fair: Generous actions trigger cooperative responses even if they are costly for the responder. It is worthwhile to point out that negative as well as positive reciprocity has been observed in games with rather high stake levels. Cameron (1995) reports results that show that negative reciprocity affects the results of ultimatum games even if the available money amounts to three months' income in a single one-shot game. Fehr and Tougareva (1995) confirmed the presence of positive reciprocity in an environment in which subjects earned three times their monthly incomes in an experimental session that lasted for two hours.

What are the conditions that allow reciprocal motivations to play a role in the work process? In our view an essential condition is the existence of incomplete labor contracts; that is, the obligations of the employer and the employee are not specified in each possible state of the world. This incompleteness has been stressed, for example, by Williamson (1975, 1985) and more recently by Milgrom and Roberts (1992) and Hart (1995).⁶ In practice, incomplete labor contracts often take the form of a fixed-wage contract⁷ without explicit performance incentives and a considerable degree of worker discretion over the work effort. The absence of explicit performance incentives can be viewed as a rational response to the difficulties of measuring and verifying a worker's performance in a multitask environment (Holmström and Milgrom 1991; Baker 1992). If a worker should perform n tasks and in some of these tasks explicit incentives are not possible because performance is difficult to measure and

some money. This is also what is observed in the experiments. Most first movers choose a positive transfer y in anticipation of a positive countertransfer z , and most second movers in fact choose a positive countertransfer z .

⁶ Milgrom and Roberts neatly describe the incompleteness of the labor contract as follows: "The employment contract is typically quite imprecise. The employees agree that—within limits that are rarely completely described and only partly understood—they will use their minds and muscles to undertake the tasks that the employer directs them to do. The employer agrees to pay the employees. The range of actions that might be requested or required is unclear" (p. 329). In the absence of incomplete contracting, it is, in fact, not clear why there should be firms at all. This viewpoint is forcefully put forward by Grossman and Hart (1986) and Hart (1995).

⁷ By a fixed wage we mean a monthly or weekly or hourly wage rate that does not directly depend on the performance level.

verify, it is more efficient to provide no explicit incentives for the other tasks, too. Under conditions of incompletely specified obligations and only weak or no explicit performance incentives, a worker's general job attitude, or what Williamson (1985, p. 262) called "consummate cooperation," becomes important. "Consummate cooperation is an affirmative job attitude whereby gaps are filled, initiative is taken, and judgment is exercised in an instrumental way." If it were possible to specify, verify, and enforce a course of action for each potentially arising gap, to specify, verify, and enforce "initiative" and "good judgment," a generally cooperative job attitude would be superfluous because all relevant actions could be enforced by a complete contract. However, managers are aware of the fact that in the absence of complete contracts "workers have so many opportunities to take advantage of employers that it is not wise to depend on coercion and financial incentives alone as motivators" (Bewley 1995, p. 252).

In our view it is the requirement of a generally cooperative job attitude that renders reciprocal motivations important. That reciprocity motives may have a powerful impact on effort decisions and the efficiency of trades has been shown in a recent paper by Fehr, Gächter, and Kirchsteiger (1997).⁸ The results of this paper as well as the work from psychology and organization theory cited above suggest that a firm can build up or sustain a cooperative attitude if its actions are considered as fair. On the other hand, it seems quite likely that a cooperative attitude is destroyed if a firm's actions (e.g., wage cuts) are perceived as hostile. Therefore, firms may not want to cut wages because of the implications for workers' performance. Notice that if reciprocity motives provide a channel for firms to affect workers' cooperative propensities, firms' unwillingness to cut wages may be an efficient response that increases the total gains from trade.

Whether reciprocity motives are sufficiently strong to affect firms' wage setting in a competitive market is an empirical question. To examine this question we have conducted competitive double-auction experiments. The essential feature of an experimental double auction is that both workers and firms can propose wages and can accept wages proposed by the other side of the market. Workers can, thus, freely accept low wage offers made by the firms or they can make low wage offers themselves. Since both sides can initiate a process of underbidding, this trading institution is particularly well suited for studying the existence and the impact of underbidding on wage formation.

⁸ Similar results are reported in Fehr, Kirchsteiger, and Riedl (1993).

Almost all double-auction experiments conducted so far implemented complete contracts.⁹ Since we argued above that many labor relations are characterized by incomplete contracts, which renders workers' reciprocal motivations and the associated cooperative attitudes potentially important, we conducted double auctions with complete *and* incomplete contracts. In our *main* treatment condition, contracts were incomplete and there were two stages. At the first stage, wages were determined under double-auction trading rules. If a pair of traders agreed on a wage level, a labor contract was concluded. Contractual incompleteness was captured by the feature that the effort level could not be stipulated in the contract. At the second stage, workers had to make a costly effort decision. The effort cost function implied that a worker who wanted to maximize his or her monetary payoff had to choose the minimal effort level. However, in principle, workers could also exhibit a cooperative behavior by choosing nonminimal (i.e., more costly) effort levels.

In the main treatment, workers could thus vary their effort levels. This provided the opportunity to vary the effort choice in response to the wage level, that is, to make reciprocal choices. In the *control* treatment, the effort decision at the second stage was removed. In this treatment, reciprocal effort choices were, therefore, ruled out. By comparing wages in the two treatment conditions, we are able to test for the impact of contractual incompleteness and the associated reciprocation opportunities on bidding behavior and wage formation. Our most important results are the following: (i) Workers massively underbid but *firms refuse to accept low offers*. Firms' wage bids are, on average, *higher* than workers' wage offers, although firms know that workers are willing to work for lower wages. (ii) Workers choose low effort levels in response to low wages and high effort levels in response to high wages; that is, wage levels positively affect workers' propensity to cooperate. Therefore, firms' high-wage strategy increases total revenue and renders both workers *and* firms better off. (iii) In the control treatment, where effort is exogenously fixed, firms take advantage of workers' underbidding. In addition, firms are themselves actively involved in enforcing low wages. As a result, in the control treatment, wages are much lower than in the main treatment. Results i, ii, and iii indicate that firms did not want to enforce lower wages when effort was an endogenous variable because they anticipated that wages had a significant impact on workers' willingness to cooperate.

These results were obtained in an environment in which workers

⁹ An exception is Lynch et al. (1991). In a previous version of this paper we discuss the differences between Lynch et al. and our experimental design in detail.

had the opportunity to exhibit positive reciprocity by responding to high wages with high (i.e., more costly) effort levels. Therefore, the results do not show the relevance of negative reciprocity for wage formation. To study the impact of negative reciprocity, we conducted additional experiments. As before there was a main treatment condition in which effort levels were determined by the workers and a control treatment in which effort was exogenously fixed. The distinguishing feature of the “new” main treatment was a modified cost function for the workers. Under the modified cost function a money-maximizing worker would always choose the *maximum* effort level because lower levels are *more* costly. This cost function captures a situation in which a firm’s enforcement technology ensures that workers will in general put forward a relatively high effort level. In this situation there is, therefore, no need for firms to elicit positive reciprocity. Yet there is still the danger that wage cuts upset workers and trigger negative reciprocity, that is, submaximal effort levels. The modified main treatment allows us to study the impact of reciprocity under conditions of relatively strong monetary incentives for high performance. If it turns out that workers in fact choose low effort levels in response to low wages, although this is costly for them, and if this gives rise to downward wage rigidity, the case for reciprocity as a determinant of wages is strengthened.

The results of the modified main treatment indeed show that workers respond to low wages with submaximal effort levels. Their negatively reciprocal behavior induces firms to pay significantly higher wages in the main treatment than in the control treatment. Thus, even if firms are capable of providing performance incentives that will in general ensure high effort levels, they are reluctant to force wages to competitive levels if workers have some opportunity to “retaliate” via their effort choices.

Our paper is organized as follows: In Section II we describe our experimental design in more detail. Section III derives the predictions. Section IV presents and interprets our results and discusses links to the above-mentioned survey studies. Concluding remarks are presented in Section V.

II. Experimental Design

In total we conducted four double-auction sessions with incomplete labor contracts (henceforth called “auction with effort”). As a control treatment we conducted two double-auction sessions with complete contracts in which effort was exogenously fixed and only the

first stage of the two-stage design was implemented.¹⁰ In each session we had 18 experimental subjects. Before each session started they were randomly divided into two groups, seven firms and 11 workers, and were then assigned to two different rooms. They were given their instructions and had to answer several control questions to check their understanding of the experimental procedures.¹¹

At the first stage of an auction with effort session, seven firms and 11 workers traded for jobs with each other. Trading time was 4 minutes per period. Both firms and workers were free to submit and accept bids and offers at any time during the trading period. Bids and offers had to obey the improvement rule. In each room all wages were written on two blackboards (one for workers' offers and one for firms' bids). Every worker and every firm always knew all offers and bids that had been submitted so far. We used two telephone lines to transmit offers/bids into the other room. Whenever a bid or an offer was accepted, a contract was concluded. In each period a firm could employ only one worker and each worker could accept only one job. We thus had an excess supply of four workers in each period. *No firm was ever informed about the identity of the worker with whom it had traded, and vice versa.* When all seven firms had concluded a contract or when trading time was over, the market was closed and the second stage began.

In our auction with effort treatment, contractual incompleteness was captured by the feature that effort was not contractible. At the second stage, after the closing of the market, all the workers who had concluded a contract had to choose an effort level e . The choice of the effort level was *completely private and was revealed only to the firm with which the worker was matched.* To ensure the privacy of the effort decision, subjects sat remotely from each other. This information condition ruled out that group pressure could affect the effort choices of workers.

The first stage of our auction with effort sessions represents a *double* auction in the sense that both workers and firms could propose wages. In double auctions in which a homogeneous good is traded, there is usually the requirement that only the best price offers of the other side can be accepted. In the context of our auction with effort sessions, this would have implied that a worker could accept only the highest current wage bid by firms whereas a firm could

¹⁰ The following description concerns only the experiments that aimed at isolating the impact of positive reciprocity on wage formation. We provide a description of the experiments that isolate negative reciprocity in Sec. IVE.

¹¹ Instructions and control questions are available on request.

TABLE 1

EFFORT LEVELS AND COSTS OF EFFORTS

	EFFORT LEVEL e									
	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
Effort cost $c(e)$	0	1	2	4	6	8	10	12	15	18

accept only the lowest going wage offer by workers. However, since effort is a noncontractible variable in our setting, the wage offered is no unambiguous indicator of the overall profitability of a contract. If, for example, low (high) wage offers are systematically associated with low (high) effort levels, accepting a higher wage may be more profitable for firms. Moreover, since we were interested in studying whether workers would underbid the going wage *and* whether firms would accept such low wages, it would have been useless to force firms to accept the lowest wage. Therefore, we allowed firms to accept *any* current wage offer. To maintain symmetry we also allowed workers to accept any going wage bid. Firms' payoff in experimental money units (guilders) was given by

$$\pi = (v - w)e. \quad (1)$$

The redemption value v of an employed worker was 120; w denotes the wage paid to the employed worker and e the effort level chosen by the worker. Notice that wage costs varied with the chosen effort level. Since wage bids had to obey $w \leq v$, this feature of the payoff function ruled out losses.¹² Yet we would like to stress that the competitive prediction remains the same compared to the more common profit equation $\pi = ve - w$.

A worker who accepted a wage offer had to bear fixed costs c_0 of 20. The payoff function in guilders of an employed worker who chose an effort level of e was therefore given by

$$U = w - c(e) - c_0, \quad (2)$$

where $c(e)$ denotes the effort costs. The range of feasible effort levels and the associated effort costs are shown in table 1.

For both workers and firms, one guilder represented 0.10 Swiss francs (\approx U.S. \$0.08). At the end of the experiment the total income in guilders was converted into Swiss francs and paid out in cash. Both firms and workers earned a profit of zero if they did not conclude

¹² It is a well-known fact that loss aversion can affect behavior (Tversky and Kahneman 1991). The payoff function (1) was implemented to prevent the interaction between loss aversion and fairness effects.

a contract. All payoff functions were common knowledge. Both sides were thus able to determine the implications of their choices for the payoffs of their trading partners. This information condition was essential to allow for fairness considerations. If cost and profit functions had been private information, there would have been no reference standard against which (un-) fair behavior could have been evaluated.¹³

In order to study the impact of opportunities for reciprocity on wage formation, we conducted two control sessions. These sessions consisted only of the first stage, the double-auction labor market. Because no effort level could be chosen, the labor contract was complete. The payoffs in the control treatment were given by

$$\pi = 120 - w \quad (3)$$

for the firms and

$$U = w - 20 \quad (4)$$

for the workers. If someone did not trade, payoffs were zero. Again, payoff functions were common knowledge.¹⁴ By comparing the wage outcome in the control sessions with the outcome in the auction with effort sessions, one can isolate the impact of endogenous effort choices on wage formation. In order to study convergence properties of wages and effort levels, we implemented the common method of stationary replication; that is, we replicated each constituent game 10 times per session. To make subjects familiar with the bidding rules, we started each session with one training period (only the first stage), which did not get remunerated.

III. Predictions

With purely selfish money maximizers the prediction of the market outcome is straightforward. In the market without effort the competitive equilibrium wage is given by $w = 20$. In the market with effort it is also given by $w = 20$ because rational firms anticipate that money-maximizing workers will always choose $e = 0.1$. Therefore, the competitive wage prediction in both sessions is identical.

¹³ The fact that payoff functions were common knowledge does not imply that subjects' payoffs were common knowledge because effort choices were known only by the parties involved in a trade. This means that workers (firms) knew only their own income and the income of the trading partner. They did not know the payoffs of other firms or other workers.

¹⁴ Since in the control sessions effort was set equal to one, each guilder represented 0.06 Swiss francs (\approx U.S. \$0.05). This ensured that total average earnings were similar across treatments.

In view of the questionnaire evidence and the experimental evidence cited in the Introduction, it is, however, likely that many people are not motivated solely by selfish objectives. Note that in the competitive equilibrium described above, firms reap the *whole* gains from trade whereas workers earn nothing. Moreover, since payoff functions are common knowledge, all market participants know that at $w = 20$ an extreme earnings inequality prevails. In our view the combination of an extreme earnings inequality with public information about payoff functions opens the way “for ‘equity considerations’ to modify self-interest choices” (Smith 1976, p. 278). Smith already speculated that such equity considerations might slow down the convergence to the competitive equilibrium.¹⁵

In the meantime there is more evidence available that shows that the combination of an extreme earnings inequality with public information about payoff functions may prevent full convergence to the competitive equilibrium in markets with complete contracts. For example, in the experiments conducted by Kachelmeier and Shehata (1992), the long side of the market is capable of seizing between 13 and 17 percent of the surplus after 10 periods, although according to the competitive prediction, they should receive nothing. However, the results of Kachelmeier and Shehata also indicate the strong drawing power of the competitive equilibrium in markets with complete contracts. If the authors switch from an excess demand to an excess supply regime, the buyers’ share of the surplus quickly increases from roughly 16 percent to 90 percent.¹⁶

In our view the big difference between markets with complete and markets with incomplete contracts is that in the latter equity and fairness considerations can play a much bigger role. In these markets, reciprocally motivated workers can “punish” firms that pay low wages with low effort choices. Contractual incompleteness ensures a kind of private property right in punishment. In contrast, in markets with complete contracts, a worker can try to punish a firm only by refusing to trade with the firm. Yet if other workers are willing to trade with low-wage firms, the refusal to trade is a futile attempt to punish them. Under complete labor contracts, fairness and equity considerations are thus likely to have a much smaller impact on wages. This argument has been made precise recently by Fehr and Schmidt (1997). These authors provide a rigorous proof of the lim-

¹⁵ Smith’s conjecture is based on an experiment similar to our control design. In the final period (i.e., period 4) of his experiment, workers (sellers) were still able to earn 27 percent of the available surplus, although in equilibrium they should earn only 4 percent.

¹⁶ Kachelmeier and Shehata conducted experiments in China and in Western countries. We refer here to the auction results generated by Western subjects.

ited impact of fairness and equity considerations in markets with complete contracts. They show that although fairness preferences may give rise to Nash equilibria above the competitive equilibrium, the *least* fair player is decisive for the Nash equilibrium outcome. In contrast, under incomplete contracts, the least fair player is not more influential than the other players. If this argument is correct, we should observe systematically higher wages in auction with effort sessions relative to the control sessions.

IV. Results and Discussion

All participants of the experiment were students of the University of Zurich or the Swiss Federal Institute of Technology. All of them received \$12.50 as a show-up fee plus their earnings in the experiment. The two-stage sessions lasted about 2.5 hours, and a participant earned, on average, between \$34 (firms) and \$40 (workers), including the show-up fee. In the control sessions, which lasted about 1.5 hours, participants earned, on average, between \$18 (workers) and \$49 (firms), including the show-up fee. In comparison to the usual earnings in economic experiments, the average earnings of our subjects were quite high. As a result they were well motivated and took the experiments very seriously. In the four auction with effort sessions, there were 280 potential trades; in the two control sessions, there were 140 potential trades. The actual number of trades in the auction with effort sessions was 280. In the control sessions, workers refused to accept offered wages in 11 cases; that is, there were 129 actual trades.

A. *The Drawing Power of the Competitive Equilibrium*

Remember that if all agents are rational and selfish, we should not observe any significant difference between average wages in the auction with effort sessions and the two control sessions. In both treatments wages should converge rather quickly toward the competitive equilibrium wage of $w = 20$ and should be indistinguishable from each other over time. Yet if the extreme earnings inequality in this equilibrium evokes fairness and equity considerations, wages may not fully adjust to $w = 20$ in the control sessions. In addition, and more important, wages in the auction with effort sessions may be considerably above wages in the control sessions because reciprocally motivated workers can punish low-wage firms with low effort levels in the auction with effort sessions.

In table 2 and figure 1 we present the behavior of wages in both treatment conditions. As one can see, wages in the auction with effort (AE) sessions are far above wages in the control (A) sessions. There is not a single period in which wages in the control treatment exceed wages in the auction with effort treatment. Moreover, over time the difference in the average wage across treatments even increases. While the average wage decreases from 39 to 34 in the control sessions, it increases from 54 to 65 in the auction with effort sessions. The fact that in period 1 there is already a large wage gap, which even increases over time, is consistent with our view that contractual incompleteness allows for a much bigger impact of fairness and equity considerations on wages. The fact that wages in the control sessions are much lower and decrease over time indicates that the competitive equilibrium still exerts a considerable drawing power under complete contracts.¹⁷ The upward trend of wages in the auction with effort sessions, however, casts serious doubts on the drawing power of the competitive equilibrium under incomplete contracts.

B. *Do Workers Underbid?*

To what extent is the apparent wage rigidity in the auction with effort sessions due to a lack of underbidding on the workers' side? According to Solow (1990), the existence of a fairness rule or a social convention may deter the unemployed from underbidding. However, the results of our experiments show that Solow's conjecture does not hold in a double-auction environment. In our experiments it is not a lack of underbidding that hinders wages from falling. *We observe massive underbidding by the workers.* In figure 2a we show workers' underbidding behavior in session AE4. All other auction with effort sessions show the same qualitative pattern.¹⁸ Except for the first few periods, there is always a large number of wage offers below contract wages in these sessions. This reveals severe competition for scarce jobs among workers. Underbidding is thus a strong and persistent phenomenon in our auction with effort treatment. The absence of underbidding can therefore be ruled out as a reason for the apparent rigidity of wages.

¹⁷ Note that our results in the control sessions are in line with the results in Kachelmeier and Shehata (1992). In the final period of their experiments, the long side of the market was capable of seizing between 13 and 17 percent of the available surplus. In our control sessions, workers receive 14 percent of the available surplus.

¹⁸ The pattern of all auction with effort sessions is presented in a previous version of this paper, which is available on request.

TABLE 2
MEAN WAGES

	AUCTION WITH EFFORT SESSIONS				AUCTION WITHOUT EFFORT SESSIONS			
	1	2	3	4	1-4	1	2	1-2
Mean wage over all periods	59.21 (10.96)	61.64 (13.1)	61.15 (15.14)	62.51 (15.11)	61.13 (13.68)	32.05 (6.32)	37.76 (4.32)	34.96 (6.09)
Mean wage of the last period	61.57 (10.69)	67.71 (8.18)	56.85 (24.20)	72.51 (8.01)	64.67 (14.88)	29.28 (1.11)	38.71 (1.60)	34.00 (5.06)

NOTE.—Standard deviations are in parentheses.

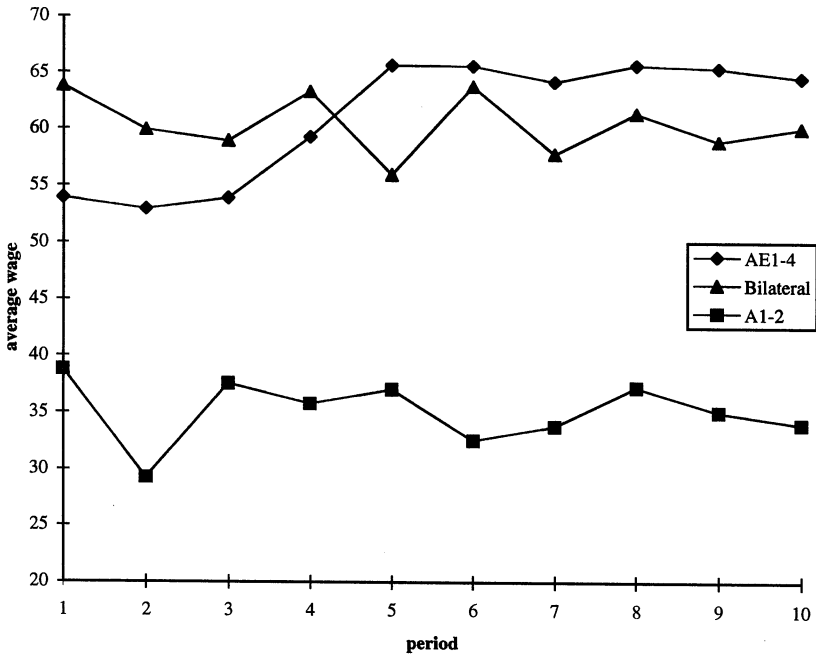


FIG. 1.—Evolution of average wages in the auction with effort (AE1-4), the auction without effort (A1-2), and the bilateral case.

Workers' underbidding in the auction with effort sessions indicates that firms could have enforced lower wages than they actually paid. To achieve a reduction in wages, they would have had to accept only the available low wage offers. It seems that they did not want to enforce lower wages; that is, they voluntarily paid workers above their reservation wages. To show this in more detail, we have computed an upper bound for each worker's reservation wage. On the basis of our data we measure the upper bound for worker i in each period by $\min(w^a, w^o)$, where w^a denotes a bid accepted by worker i and w^o denotes i 's lowest wage offer. Notice that $\min(w^a, w^o)$ gives us only an upper bound for the reservation wage because a worker may in fact accept less. The average of the seven lowest upper bounds in each period of an auction with effort session indicates the average wage that (the seven) firms could have enforced in this period with certainty.¹⁹ The gap between actual average wages and

¹⁹ Each of the seven firms has traded or could have traded (if it wanted) at one of these upper bounds.

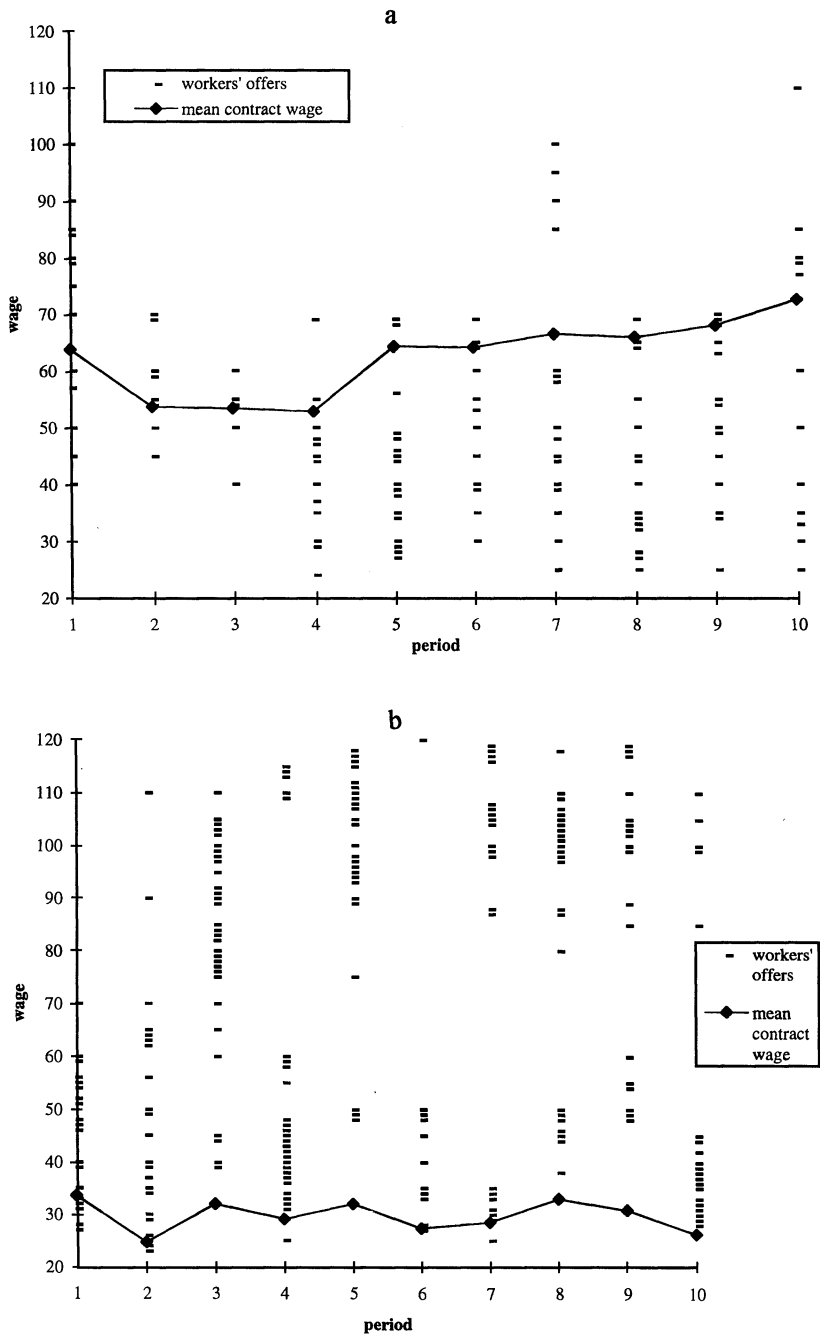


FIG. 2.—Workers' offers and mean contract wages: *a*, in the auction with effort session AE4; *b*, in the auction without effort session A1.

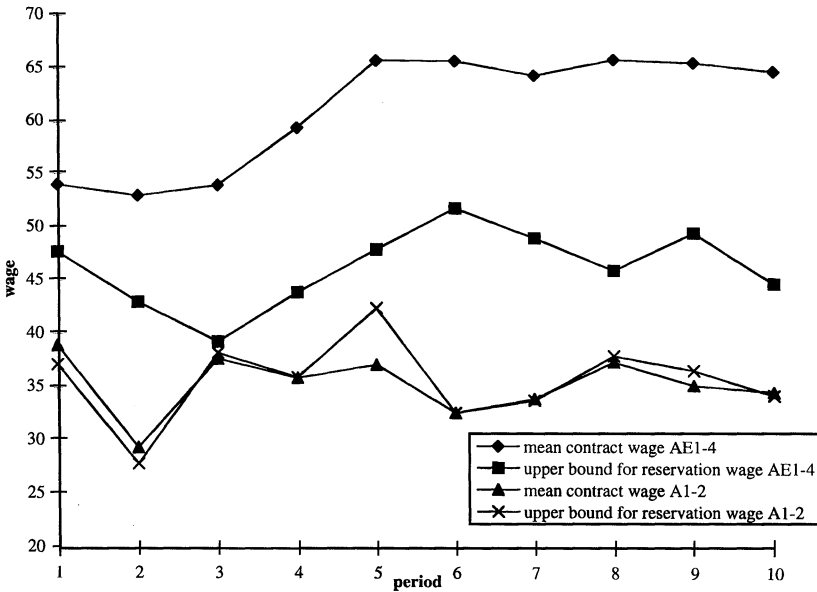


FIG. 3.—Mean contract wages and upper bounds for workers' reservation wages

this average upper bound shows, therefore, that firms voluntarily paid workers above their reservation wages. As figure 3 reveals, there is always a positive gap in these sessions.

This is, however, not yet the full story because our control treatment provides further information about workers' reservation wages. The relation between workers' wage offers and actual wage payments differs radically across treatments. While the majority (71 percent) of workers' offers in the auction with effort treatment lie *below* the average contract wage, almost *all* offers in the control treatment lie *above* the average contract wage. This difference is illustrated by the comparison between figures 2*a* and 2*b*, which are both representative of the data pattern in the respective treatments. Moreover, as figure 3 shows, the upper bound of workers' reservation wages is much lower in the control sessions. This is a further indication that firms in the auction with effort sessions voluntarily paid higher wages because there is no reason why workers' reservation wages should be different across treatment conditions. Figure 3 finally shows that there is almost no difference between actual wages and our measure of the upper bound on workers' reservation wages

in the control sessions.²⁰ Thus, in these sessions, firms took advantage of workers' low wage offers.

Taken together, figures 2 and 3 provide strong evidence that firms voluntarily paid workers above their reservation wages in the auction with effort sessions. In contrast, in the control sessions, they took advantage of workers' underbidding and were actively pushing wages toward workers' reservation levels. This is further evidence that the competitive equilibrium exerts a strong drawing power in the control sessions, whereas in the auction with effort sessions its drawing power is severely weakened or, perhaps, even absent.

Both results—frequent underbidding and the refusal of firms to employ underbidders—confirm what different authors have found in their survey studies. Bewley (1995, 1997) finds no support for Solow's conjecture of an absence of underbidding. Agell and Lundborg (1995) report that underbidding is not “all that uncommon” (p. 298). Even though Swedish unemployment rates used to be very low, 43 percent of firms had at least once encountered underbidding blue-collar workers and 53 percent of firms had experienced underbidding white-collar workers. However, this is only part of the story. While both studies report underbidding behavior of unemployed workers, they also mention that firms *refuse to employ underbidders*. In Agell and Lundborg, for example, firms that had encountered underbidding blue-collar workers refused to accept their offers in 95 percent of the cases. Underbidding white-collar workers, on the other hand, were rejected by 82 percent of the firms.

C. Does Underbidding Cause a Wage Decrease?

Even though workers' underbidding did not seem to have an impact on wage formation in the auction with effort sessions, we cannot completely rule out that it had some wage-decreasing effect. To test for the wage-decreasing effect of underbidding, we can, however, compare our results with those of Fehr et al. (1994). Fehr et al. have reported the data of experiments that differ in one respect from our auction with effort treatment. Instead of a double auction, the wage is determined by a bilateral interaction between an exogenously matched firm-worker pair: The firm proposes a wage w . Then the

²⁰ In periods 3, 5, 8, and 9 the upper bound is slightly larger than mean contract wages because fewer than seven workers traded in these periods. Our measure of the upper bound is the *average* of the *seven* lowest values of $\min(w^a, w^o)$, whereas the mean contract wage is the average over *actually concluded contracts*. Therefore, when there are fewer than seven trades, the upper bound may exceed the mean contract wage.

worker accepts or rejects it. If he accepts it, he has to choose an effort level e ; if he rejects it, both earn nothing. Each subject is matched with 10 different subjects from the other side. Payoff functions are common knowledge and are given by equations (1) and (2) above. All parameters are set as in our auction with effort treatment. Thus, while in Fehr et al. there is no competition at all, in our double auction, both firms and workers can underbid.

By comparing the wages in Fehr et al. with wages in our auction with effort treatment, we are therefore able to check whether underbidding has any wage-decreasing effect. Figure 1 shows that wages in the bilateral treatment are, on average, close to wages in the auction with effort treatment. While they are higher during the first few periods of the sessions, they are even somewhat lower from period 5 onward. Thus, after a few periods, underbidding *has no wage-decreasing effect*. This suggests that in the auction with effort sessions the competitive equilibrium has no drawing power.

D. Why Do Firms Refuse to Hire Underbidders?

In our view, it is workers' effort behavior that explains firms' unwillingness to employ low-wage workers. As we shall see, a majority of workers made reciprocal effort choices. Yet there also was a significant minority who behaved in a completely selfish way. At the aggregate level this mixture of reciprocal and selfish effort choices gave rise to a significantly positive aggregate wage-effort relation.

To examine reciprocity at the individual level, we have computed the (nonparametric) Spearman rank correlation $\rho(w, e)$ between w and e for each worker. It turns out that 10 of 44 workers always chose the minimum effort irrespective of the wage they received. One worker always chose the maximum effort. Hence, 11 workers (25 percent) have $\rho(w, e) = 0$. On the other hand, 29 workers (66 percent) exhibit a positive correlation; for all but one of these workers $\rho(w, e) > .2$ holds. Four workers have a slightly negative correlation. Because of the small number of observations, for many workers the correlation is not significantly positive for all those with a positive ρ . Despite this, the correlation is significantly positive at the 10 percent level for 18 workers (43 percent).²¹ Taken together, these data suggest that reciprocal effort behavior is the dominant pattern at the individual level.

²¹ The small number of individual observations is due to the excess supply of workers. Notice that, by definition, $\rho(w, e)$ cannot be significant below the 5 percent level for fewer than five observations. There are, e.g., several workers with $\rho > .8$, but because $n < 5$, the correlation is not significant.

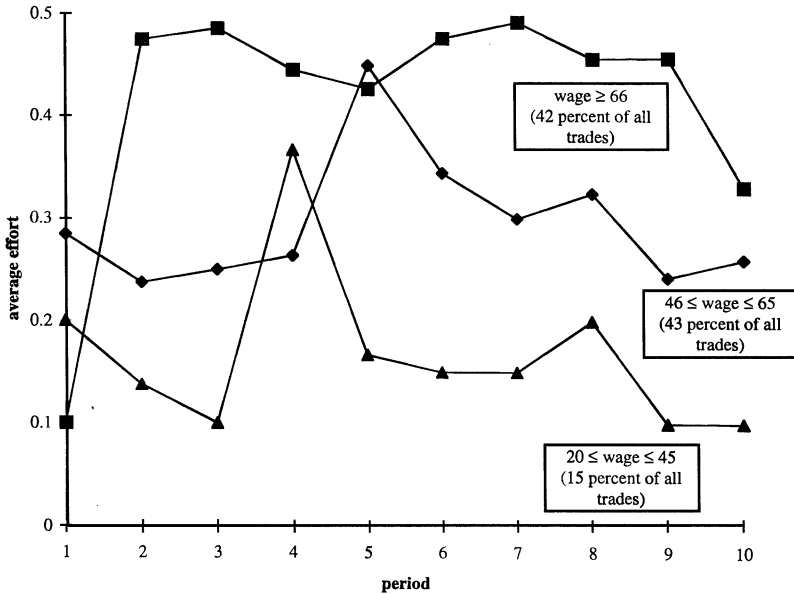


FIG. 4.—Evolution of average effort for given wage intervals

The aggregate wage-effort relation is displayed in figures 4 and 5. Figure 4 depicts the evolution of average effort over time for different wage intervals. It shows that for wages between 20 and 45, the average effort was between 0.1 and 0.2; for wages in the interval [46, 65], workers chose, on average, 0.3; whereas for wages above 65, the average effort was slightly below 0.5. In figure 5 we show a scatter plot of the wage-effort combinations in AE1–4 together with a regression line. Since there are multiple observations, for given wage-effort combinations the scatter plot exhibits different symbols, which indicate the number of observations at each combination. Figure 5 indicates that, on average, higher wages are associated with higher effort levels.

Formal evidence for the existence of a positive wage-effort relation at the aggregate level is provided by table 3, which shows the results of several two-sided censored Tobit regressions (censoring occurs because $e < 0.1$, and $e > 1$ was ruled out by the design). Regression model 1 is given by the simple equation

$$e = \begin{cases} \alpha + \beta w + \epsilon & \text{if } 0.1 < \text{RHS} < 1 \\ 0.1 & \text{if } \text{RHS} \leq 0.1 \\ 1 & \text{if } \text{RHS} \geq 1, \end{cases} \quad (5)$$

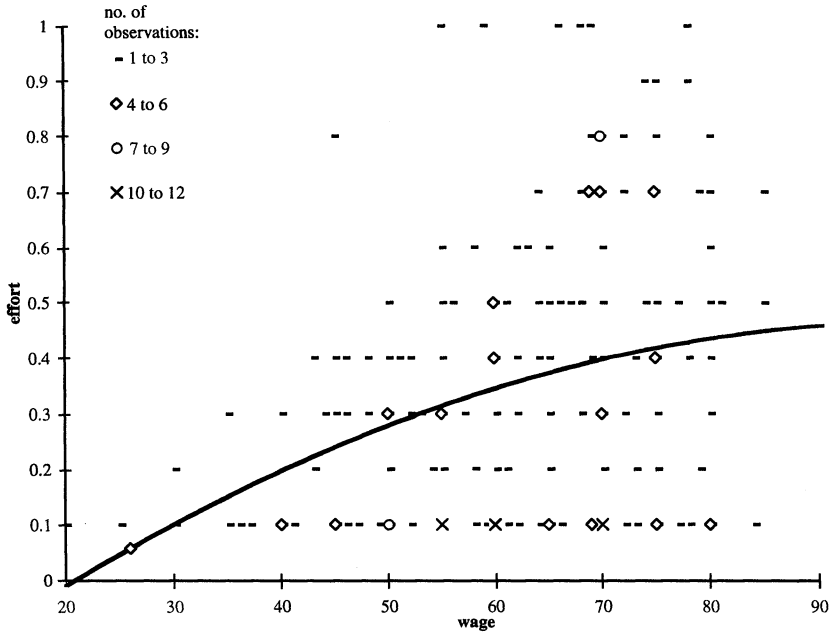


FIG. 5.—The effort-wage relation: scatter plot and regression line (model 2)

TABLE 3
 TOBIT REGRESSION RESULTS FOR AUCTION WITH EFFORT SESSIONS 1-4

Independent Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-.0522 (.0653)	-.2744 (.1833)	-.2892 (.1849)		
Wage	.00640 (.0010)	.0147 (.0065)	.0149 (.0065)	.0051 (.0005)	.0056 (.0011)
Wage squared		-.000073 (.000056)	-.000076 (.000056)		
Period			.0030 (.0052)	.00061 (.0025)	
Wald statistic				10E+10	8.29
$p(W)$.0000	.6000

NOTE.—Dependent variable is effort. The Wald statistic refers to the null hypothesis that all dummy variables in model 4 or model 5, respectively, are equal to the constant in a model without dummies. Model 4 allows for individual fixed effects, and model 5 includes period-dependent intercepts. $p(W)$ is the p -value for the corresponding Wald statistics. The number of observations is 280. Standard errors are in parentheses.

where ϵ denotes the normally distributed error term, and RHS (right-hand side) is defined as $\text{RHS} = \alpha + \beta w + \epsilon$. Model 2 adds squared wages to equation (5). Model 3 includes, in addition, the period of observation as an explanatory variable. Since w^2 always turned out to be highly insignificant, we did not include it in models 4 and 5. Model 4 allows for individual fixed effects, whereas model 5 allows for period-dependent intercepts.

The most important result of table 3 is that the coefficient on wages is always highly significant and positive. In addition, the regressions suggest that the positive wage-effort relation is not weakened over time. This follows from the fact that the coefficient on the period is always nonnegative and insignificant. Moreover, the Wald statistic for H_0 that all period-dependent intercepts in model 5 are equal to the constant in model 1 does not reject H_0 (see col. 5 in table 3). This also indicates that the position of the wage-effort schedule does not change over time. Model 4 allows us to test for individual differences. The p -value of the Wald statistic for H_0 that all individual intercepts are equal to the constant in an equation without individual dummies is below .001. Thus H_0 is clearly rejected, which indicates individual differences in effort choices.

Firms that believe and experience that there is a positive relation between wages and effort have a reason to pay high wages. It is therefore a natural question whether firms' wage policy was optimal, *given workers' effort behavior*. Figure 6 provides the relevant information to answer this question. It shows firms' average profits and the relative frequency of trades in different wage intervals. Most important, the fact that many workers responded reciprocally to the actual wage payment made it profitable for firms not to enforce wages in the interval [20, 35]. If firms paid wages in this interval, they received effort levels close to $e = 0.1$. Their profit was, therefore, little higher than 10. Notice that only 6 percent of all trades took place in this interval. Yet if they paid wages in the interval [66, 75], they earned, on average, more than 20, which is more than twice the competitive equilibrium payoff of 10. Figure 6 shows that firms did pretty well in maximizing their payoff: 32 percent of the observations are in the profit-maximizing wage interval [66, 75] and 23 percent are in the next-best interval [56, 65]. Moreover, the relative frequency of trades decreases the lower the average profit earned in an interval.²² This evidence suggests that firms' behavior was quite rational.

²² The Spearman rank correlation between average profits in a given wage interval and the relative frequency of trades in this interval is .964 ($p < .0001$).

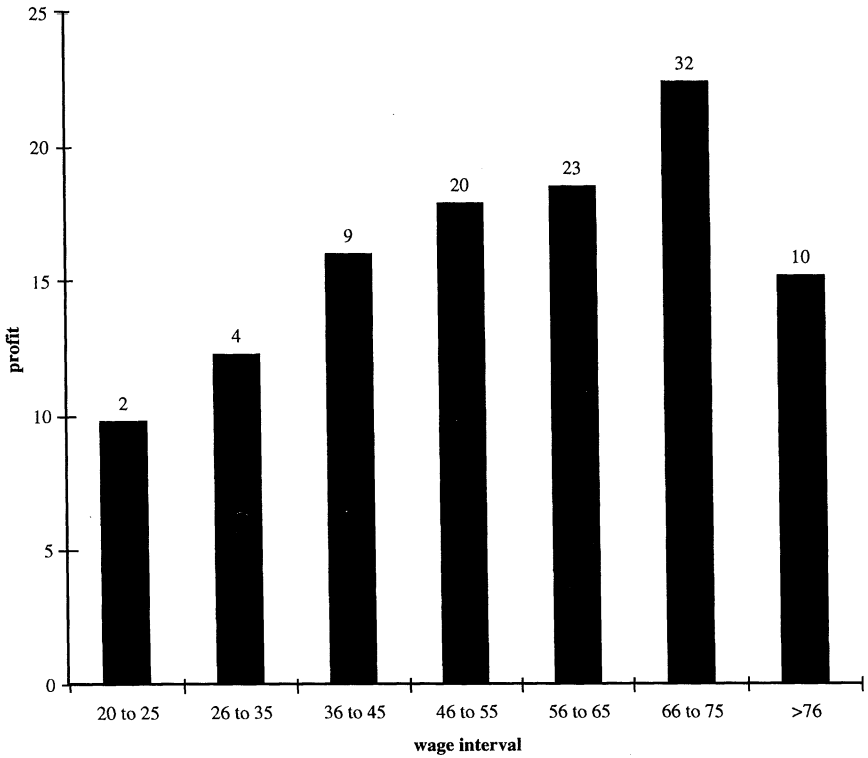


FIG. 6.—Wage-profit relation (relative frequency of observations above bars)

E. Wage Formation under Negative Reciprocity

So far our examination has focused on the impact of positive reciprocity on wage formation. Since positive reciprocity affects workers' cooperative attitudes, it is likely to be important under conditions of incomplete labor contracts and weak performance incentives. Such conditions arise if firms face the difficulties of measuring and verifying workers' performance in a multitask environment (Holmström and Milgrom 1991; Baker 1992). The impact of reciprocity motives on wage formation is, however, not necessarily confined to this environment. Negative reciprocity, in particular, may also be important in an environment in which firms are endowed with a relatively powerful enforcement technology. Remember that negative reciprocity means that somebody is even willing to bear some cost to punish actions that are viewed as hostile. The language used by the managers in Bewley's interview study indicates that they were afraid of workers' negative reciprocity. They feared that wage cuts "express hostil-

TABLE 4

COST ASSOCIATED WITH DIFFERENT EFFORT LEVELS IN THE MODIFIED DESIGN

	EFFORT LEVEL e									
	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
Effort cost $c(e)$	18	15	12	10	8	6	4	2	1	0

ity to the work force” and are “interpreted as an insult” by the workers, which in turn triggers their hostility.

To examine the impact of negative reciprocity on wage formation, we conducted double auctions with a modified cost function. In contrast to the previous design, the costs associated with a worker’s effort are now lowest at the *maximum* effort level (see table 4). Consequently, a money-maximizing worker will always choose the maximum effort.

This cost function can be interpreted as follows: It not only represents a worker’s “subjective” effort cost but incorporates, in addition, firms’ enforcement technology. This enforcement technology renders the choice of the maximum effort optimal for a nonreciprocal, money-maximizing subject and imposes increasing pecuniary costs on shirking workers.²³

To isolate the impact of negative reciprocity on wage formation, we compared a modified main treatment in which effort was endogenous with a control treatment in which effort was no choice variable. In the modified main treatment, monetary payoffs from a trade were given by $\pi = ve - w$ and $U = w - c(e) - 20$, with $v = 120$ and $c(e)$ as given in table 4. In the control treatment, the payoff functions were the same but e was fixed at the maximum level of $e = 1$. As in the previous design, there was an excess supply of four workers, and the same information conditions prevailed. In total we conducted two experimental sessions for each treatment condition.

²³ A simple example may illustrate how this cost function can be constructed. Suppose that a worker’s subjective effort cost $x(e)$ is a convex and increasing function of e and that the probability of being caught performing below the maximum effort e^0 , $\sigma(e^0 - e)$, is a rising and strictly convex function of the deviation $e^0 - e$, with $\sigma(0) = 0$ and $\sigma'(0) > 0$. Suppose further that $f > 0$ is the pecuniary loss imposed on the worker if he is caught shirking. The *total* expected costs $c(e)$ associated with e are then given by $c(e) = x(e) + \sigma(e^0 - e)f$. If $c'(e^0) = x'(e^0) - \sigma'(0)f < 0$, an expected cost function with the same qualitative properties as the function in table 4 emerges. Instead of having a fixed penalty f , one could also assume that f increases with $e^0 - e$. Notice that in the experiments we did not implement a probabilistic cost function. This has the advantage that $e < e^0$ causes a *sure* loss. Therefore, the choice of $e < e^0$ cannot be attributed to risk seeking but is a clean expression of negative reciprocity.

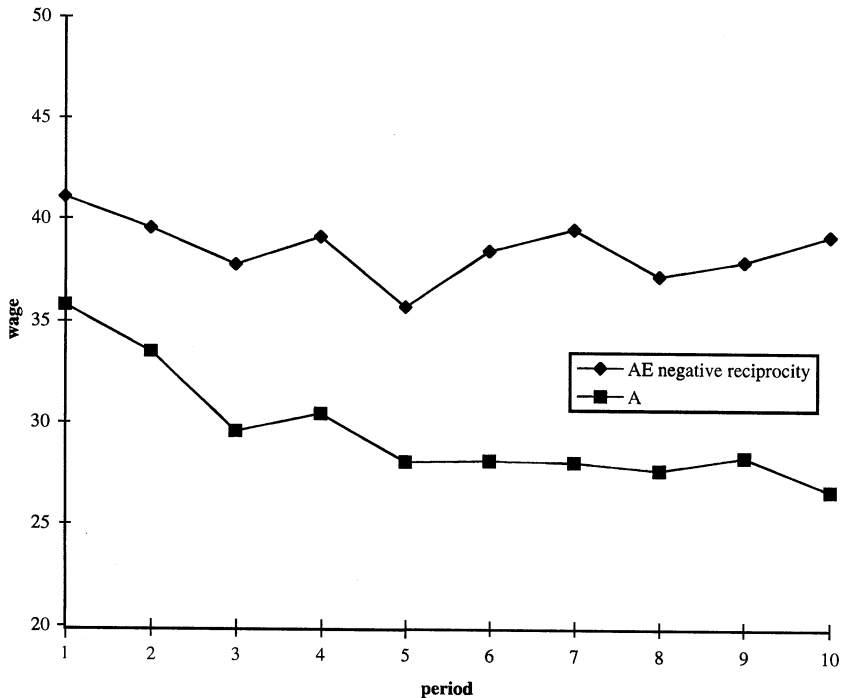


FIG. 7.—Evolution of average wages in the auction with effort sessions with negative reciprocity and in the auction without effort sessions.

In the presence of money-maximizing subjects the predictions for both treatment conditions are again straightforward. Since workers will always choose the maximum effort in the modified main treatment, the wage outcome in both treatment conditions should be the same. However, if wage cuts are indeed interpreted as an insult triggering workers' hostility, we should observe submaximal effort levels at low wages in the modified main treatment. As a consequence, firms may constrain wage cutting. Figure 7 indicates that this in fact happened. If workers had the opportunity to choose submaximal effort levels, average wages were substantially higher in *each* period. The difference in the average wage is significant according to the nonparametric Mann-Whitney and median tests at all conventional significance levels ($p < .0001$). Moreover, while in the control condition there is a downward trend in wages over time, no such trend can be observed in the main treatment: wages in period 10 are as high as wages in period 1.

Space limitations prevent us from presenting the results of the modified experiments in the same detail as the results of the previous design. However, apart from the fact that it is now negative reci-

procuity that drives the results, the qualitative data pattern is very similar. Tobit and ordinary least squares regressions of effort on wages show that there is a significantly positive wage-effort relation. This relation is stable across periods, and as in the previous design, there are significant individual differences. In the main treatment we again observe much underbidding by the workers, but in the face of reciprocal effort choices, firms refuse to accept low wage offers. In the control treatment, however, firms make wage bids close to the competitive equilibrium wage and do not hesitate to accept workers' low offers. These regularities suggest that workers' negative reciprocity generates downwardly rigid wages in the main treatment, whereas no such rigidity is present in the control treatment.

V. Concluding Remarks

Labor relations are frequently characterized by incomplete labor contracts and weak performance incentives. The absence of explicit performance incentives can be viewed as a rational response of firms to the difficulties of measuring and verifying performance in a multitask environment. In practice, incomplete labor contracts often take the form of a fixed-wage contract without explicit performance incentives and a considerable degree of workers' discretion over their work effort. Under these conditions, workers have many opportunities to take advantage of employers, and therefore, firms have an interest in creating and maintaining a generally cooperative attitude among the workers. It is hypothesized that fairness and reciprocity considerations are an important determinant of workers' propensity to cooperate and that wage cuts may cause a significant decrease in workers' willingness to cooperate with the firm. As a consequence, firms may be reluctant to cut wages even if they face an excess supply of workers.

To examine whether people's willingness to cooperate is indeed affected by the wage level, we have conducted experimental double auctions with complete *and* incomplete contracts. Double auctions are well known for their striking competitive properties. They constitute, therefore, a particularly hostile environment for the emergence of reciprocity effects. By comparing the wages in markets with complete labor contracts with wages in markets with incomplete labor contracts, we are able to isolate the impact of reciprocation opportunities on wage formation.

It turns out that workers' effort levels are indeed positively related to the wages paid. This positive wage-effort relation prevails when there are weak *and* when there are strong pecuniary performance incentives. As a consequence, firms face a cost when they reduce their wages, which gives rise to downwardly rigid wages in the market

with incomplete contracts. Despite the fact that there is an immense amount of underbidding on the workers' side, firms refuse to accept workers' low wage offers in this market. The positive wage-effort relation also implies that higher wages increase the total gains from trade. Therefore, the refusal to cut wages is efficiency enhancing for those who are involved in the trade. In the market with complete contracts, however, firms accept workers' underbidding so that wages come close to the competitive level. Our analysis thus suggests that in the absence of complete labor contracts, reciprocity motives become important in two ways: First, they severely restrict the impact of underbidding on wage formation, and, second, they are a determinant of the total gains from trade for those who are involved in the trade.

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