

## INVOLUNTARY UNEMPLOYMENT AND NON-COMPENSATING WAGE DIFFERENTIALS IN AN EXPERIMENTAL LABOUR MARKET\*

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In this paper we report the results of a series of efficiency wage experiments. Some of the key predictions of the efficiency wage hypothesis are qualitatively confirmed by the data: (i) higher wages caused a reduction in shirking; (ii) firms offered contracts which exhibited positive job rents; (iii) firms offered systematically different wages and job rents which gave rise to non-compensating income differentials; and (iv) endogenous involuntary unemployment occurred.

There are by now many experiments which show that experimental markets converge under rather weak conditions to the competitive equilibrium (see Plott, 1989; Hey, 1991; Davis and Holt, 1993). Even if important assumptions of competitive theory are violated, for example, if agents are price makers instead of price takers or if there are relatively small numbers of traders on each side of the market, these markets ultimately converge to the competitive equilibrium.

Far fewer market experiments have been conducted in which questions of imperfectly enforceable contracts are addressed.<sup>1</sup> To our knowledge, there are only a few experiments which directly examine the issue of non-clearing markets.<sup>2</sup> In this paper we report the results of a series of labour market experiments in which markets did not clear and in which the law of one wage did not hold. In these experimental markets some workers did not get job offers while those who were employed enjoyed positive job rents. Therefore, unemployed workers would have been better off if they had been employed. In addition we observed a systematic wage and job rent hierarchy.

The advantage of an experimental approach to questions of involuntary unemployment arises from the better control of the environment in which subjects act. On the basis of the usually available field data it is very difficult to judge whether unemployment is voluntary or involuntary. Similarly, as the debate on inter-industry wage differentials reveals,<sup>3</sup> it is equally difficult to decide whether observed wages involve the payment of job rents or whether they represent the competitive returns to workers' skills or to adverse working conditions. Yet, in laboratory experiments the characteristics of jobs and workers can be better controlled. In the laboratory we can, for example,

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<sup>1</sup> See, for example, Miller and Plott (1985), DeJong *et al.* (1985).

<sup>2</sup> Recently Fehr *et al.* (1992a, 1993) have conducted a series of competitive market experiments in which fairness considerations led to prices which were significantly above the competitive – market clearing – level.

<sup>3</sup> See, for example, Krueger and Summers (1988).

unambiguously determine workers' reservation wages and, hence, whether their unemployment is voluntary or involuntary and whether – if employed – their wages exhibit job rents.

In our experiments we implemented a static model of the shirking version of the efficiency wage hypothesis.<sup>4</sup> The model generates a rich menu of testable predictions. It predicts, in particular, that higher wages and lower effort requirements reduce shirking and that involuntary unemployment and a hierarchy of job rents should occur. It is, perhaps, also worthwhile to mention that our experimental test does not only allow us to confront the aggregate market outcome (e.g. the amount of (un)employment) with the predicted outcome. In addition it allows us to test for all essential behavioural elements of the theory: Do workers behave as predicted, that is, do higher wages and lower effort requirements reduce shirking? Is this behavioural pattern sufficiently strong such that higher wages generate higher profits? Do firms recognise this pattern and do they respond with contract offers involving job rents? Do job rents vary according to firms' production technologies and contract enforcement technologies? And finally, does the interaction of workers and firms lead to involuntary unemployment? In our view the simultaneous confrontation of all predictions with the experimental data renders our experiments a strong test of the efficiency wage hypothesis.

It turns out that the key predictions of the efficiency wage model are qualitatively confirmed by the experimental data. Quantitatively, however, not all predictions are confirmed. In particular, job rents are significantly lower than predicted and high shirking rates turn out to be a persistent phenomenon although shirking should completely vanish according to our model. The high rate of shirking also gives rise to a lower market efficiency than predicted.

The remainder of this paper is organised as follows. Section I outlines our efficiency wage model and presents the numerical predictions. Section II describes the experimental design while the results are presented in Section III. Section IV closes the paper with some concluding remarks.

## I. A TESTABLE EFFICIENCY WAGE MODEL

This section outlines the model which has been implemented in the laboratory. To ease the exposition we make a number of simplifying assumptions. For a presentation of a more general model the reader is referred to Fehr *et al.* (1992*b*).

### I.1. *The Model*

Consider a static, one-period, labour market with  $m$  firms and  $n$  identical workers, where  $m < n$  holds.<sup>5</sup> Each firm can employ at most one worker. Working time is exogenously fixed and if a worker provides an effort level of  $e$

<sup>4</sup> This variant was developed by Bowles (1985), Fehr (1984 and 1986), Shapiro and Stiglitz (1984) and Stoft (1982).

<sup>5</sup> If we had, instead, implemented an infinite horizon model in the spirit of Shapiro and Stiglitz (1984) we would have encountered the problem of multiple equilibria. On this point see MacLeod and Malcolmson (1989).



she has to bear effort costs of  $c(e)$ . Effort costs are a strictly increasing and strictly convex function of  $e$  and there exists a lower bound  $e_0$  and an upper bound  $e^0$  on effort. For simplicity we assume that workers are risk neutral and have quasi-linear utility functions with (expected) income and effort as arguments. In addition  $c(e_0) = 0$ . An unemployed worker receives unemployment benefits of  $b$ . Therefore workers' reservation wages,  $w^r$ , are given by  $w^r = b + c(e)$ .

It is assumed that effort is not perfectly verifiable by a third party. There is an exogenous probability  $s$  ( $0 < s < 1$ ) that a third party will verify a worker's effort choice. To provide incentives for  $e > e_0$  firms offer the following labour contracts: they stipulate a wage  $w$ , an effort requirement  $\tilde{e}$  and a penalty  $p$  which has to be paid by the worker (to the firm) in case that a third party verifies that the actual effort chosen,  $e$ , is below  $\tilde{e}$ . If a worker provides  $\tilde{e}$  the utility from a labour contract  $(w, \tilde{e}, p)$  is given by  $u^{ns} = w - c(\tilde{e})$  where the superscript *ns* is an abbreviation of the term no-shirking. Since the payment of the fine  $p$  does not depend on the amount of shirking, that is, on  $(\tilde{e} - e)$ , a rational worker will always choose  $e_0$  once he has decided to shirk. Therefore the utility from shirking is given by  $u^s = w - sp$ . A worker will refrain if  $u^{ns} \geq u^s$ . This condition is satisfied when the expected fine  $sp$  exceeds the effort costs:

$$sp \geq c(\tilde{e}). \quad (1)$$

The profits of a firm from employing a worker who provides  $\tilde{e}$  are given by

$$\pi = q\tilde{e} - w, \quad (2)$$

where  $q$  represents the value of output produced per unit of effort. We assume that different firms face different values of  $q$ . Therefore, one should index  $q$  and all variables which are set by firms. Yet, for notational convenience, we suppress this index.

The essential feature of the shirking version of the efficiency wage hypothesis is that a wage increase is associated with a higher penalty for shirking. In the models of Bowles (1985), Fehr (1984, 1986), Shapiro and Stiglitz (1984), and Stoft (1982) higher wages deter shirking because of the threat of dismissal for shirking workers. Due to this threat a wage increase raises the expected loss from shirking. In our model we capture the relation between wages and penalties by introducing the constraint,

$$p \leq w - g, \quad (3)$$

where  $g$  represents a positive constant which is larger than  $b$  ( $g \geq b$ ).<sup>6</sup> (3) implies that in case of verified shirking a worker earns at least  $g$ . In the following constraint (3) is called the 'bounded penalty condition' (BPC). Combining (1) and (3) yields

$$w \geq g + [c(\tilde{e})/s]. \quad (4)$$

<sup>6</sup> There may be several reasons for such a constraint. It may, for example, be forbidden by law to impose penalties above  $w - g$ . Or social norms and considerations of fairness may render larger penalties infeasible. If the monitoring technology of firms is not completely reliable, diligent workers may be falsely accused of shirking which may also exert a constraining impact on penalties. And finally, our one-period efficiency wage contracts may be supported by more complicated intertemporal strategies of firms and workers in an infinitely repeated game (MacLeod and Malcolmson 1989, 1992).

Wage-effort combinations which obey (4) are enforceable in the sense that the firm can find a feasible fine  $p$  such that the worker will supply  $\tilde{e}$ . Therefore (4) is called the no-shirking condition (NSC). Of course, a rational profit maximising firm will never obey (4) as a strict inequality because, for a given  $w$ , it can always raise profits by increasing  $\tilde{e}$ . Since the profit maximising contract will obey (4) as a strict equality<sup>7</sup> we can write profits as

$$\pi = q\tilde{e} - g - [c(\tilde{e})/s]. \quad (2')$$

Setting the derivative of  $\pi$  with respect to  $\tilde{e}$  equal to zero yields

$$q = c'(\tilde{e}^*)/s \quad (5a)$$

as the first order condition for an interior solution. The profit maximising wage is then given by

$$w^* = g + [c(\tilde{e}^*)/s], \quad (5b)$$

and the fine is chosen according to

$$p^* = w^* - g. \quad (5c)$$

The job rent of a worker is defined as  $r \equiv w - w^r$  and is, therefore, given by

$$r^* = g - b + c(\tilde{e}^*) [(1-s)/s]. \quad (5d)$$

Thus, if it is profitable to demand  $\tilde{e}^* > e_0$  the firm pays an efficiency wage, that is, a positive job rent. (5a)–(5c) determine each firm's choice of the labour contract. Notice that the size of  $q$  is decisive for this choice. The higher  $q$ , the larger will be  $\tilde{e}^*$ ,  $w^*$ ,  $p^*$  and  $r^*$ . Workers in firms with a higher  $q$  enjoy higher job rents and higher utility levels.

How does the model account for endogenous involuntary unemployment? The involuntariness of unemployment follows simply from the existence of job rents and the assumption of  $m < n$ . To ensure that there are more than  $(n-m)$  unemployed one only needs some firms with sufficiently low values of  $q$ . Since maximum profits  $\pi^*$  increase monotonically with  $q$  one can always find low enough  $q$ -values which render efficiency wage contracts unprofitable. Hence, such firms will not enter the market and, therefore, labour demand is lower due to the existence of efficiency wages.

For control purposes we have not only conducted efficiency wage experiments (EWEs) but also a so-called market clearing experiment (MCE). In the MCE we removed the incentive to pay efficiency wages by replacing the BPC (3) by the constraint  $p \leq k$ .  $k$  was chosen large enough such that all feasible effort levels were enforceable, that is,  $sk > c(e^0)$  was met. Under this constraint variations in  $p$  are not confined by variations in  $w$ . As a consequence, the no-shirking condition (4) is no longer relevant and firms will never pay more than  $w^r = b + c(\tilde{e})$ . In the MCE we should observe, thus, only compensating wage differentials and no job rents. In case of an interior solution the profit-maximising level of  $\tilde{e}$  can, therefore, be computed by substituting  $w^r$  into profit equation (2) and setting the derivative with respect to  $\tilde{e}$  equal to zero. This yields

$$q = c'(\tilde{e}) \quad (6)$$

<sup>7</sup> This holds true in the case that the firm wants to enforce  $e > e_0$ .



as the first order condition. A comparison of (6) with (5a) reveals that in the MCE firms will demand higher effort levels.

### 1.2. Parameters and Numerical Predictions

In our experiments we have implemented a discrete version of the effort cost function

$$c(e) = 0.09e^2 - 2.25 \quad (7)$$

Workers had to choose the effort level in steps of 0.25. In addition we set  $g = 15$ ,  $b = 12$ ,  $s = \frac{1}{2}$ ,  $e_0 = 5$ ,  $e^0 = 15$  and  $k = 60$ . The number of firms  $m$  varied between five and six while the number of workers varied between seven and nine. Substituting the relevant parameters into (5a), (5b) and (5d) gives us the following predictions (for an interior solution):

$$\tilde{e}^* = q/0.36, \quad (5a')$$

$$w^* = 10.5 + (q^2/0.72), \quad (5b')$$

$$r^* = 0.75 + (q^2/1.44). \quad (5d')$$

These equations show that effort requirements should be linearly related to  $q$  while  $w^*$  and  $r^*$  depend quadratically on  $q$ . Substituting the profit maximising contract values into the profit function (2') yields

$$\pi^* = (q^2/0.72) - 10.5. \quad (8)$$

In each experimental session  $q$ -values varied between 2.2 and 6. Notice that a firm which is endowed with  $q = 2.2$  would earn negative profits if it offered an incentive compatible contract. Therefore, it should not offer a contract. In each of our EWEs we implemented two rather 'low'  $q$ -values, that is, for two firms profits arising from incentive compatible contracts were either positive, but close to zero, or negative. These firms were, therefore, likely to refrain from offering contracts. However, in the MCE firms are predicted to trade at these 'low'  $q$ -values because they need not pay a job rent.

Before we describe in detail how we implemented our model experimentally, it is worthwhile to point out the behavioural assumptions of the model. First of all, the model assumes that agents behave according to the axioms of expected utility theory. Secondly, it assumes that firms are able to understand the decision problem which is faced by the workers at any given employment offer and that they anticipate that workers are expected utility maximisers. Finally, it assumes that firms – given their anticipation of expected utility maximisation by the workers – are able to deduce and will propose the terms of the profit maximising contract.

There exists by now a considerable amount of evidence from individual decision-making experiments which casts serious doubts on the assumption that people behave according to expected utility theory (see, e.g. Einhorn and Hogarth, 1986; Tversky and Kahneman, 1986; Hey and Di Cagno, 1990; Hey, 1991 (part II); Loomes, 1991; Loomes *et al.* 1991). In addition, the experimental evidence from finitely repeated Prisoner's Dilemma experiments (e.g. Selten and Stoecker, 1986), from Centipede Games (e.g. McKelvey and

Palfrey, 1992) and from multiperiod Ultimatum Games (e.g. Ochs and Roth, 1989; Güth *et al.* 1991) indicates that the backward induction outcome is rarely realised by experimental subjects. This renders the third behavioural assumption mentioned above questionable. All this seems to suggest that one cannot expect experimental subjects to choose actions which meet the predictions of our model. The situation becomes worse, if we take into account that there is no way to ensure that experimental firms know the risk preferences of experimental workers from the beginning. At least during the initial trading periods, when they have not yet gained enough experience about workers' effort choices, firms have to act without this information.

It is, however, an open question whether these behavioural 'anomalies' will also emerge in markets. In the context of competitive experimental markets the standard model seems to predict rather well. It is particularly puzzling that convergence to the competitive equilibrium seems to be reinforced by the absence of complete information about payoffs (see, e.g. Smith, 1991, p. 881). Yet, on the other hand, violations of expected utility theory have also been observed in experimental markets (e.g. Camerer, 1987). To our knowledge efficiency wage markets have so far not been tested experimentally. It is, therefore, an open question whether the deviations from economic rationality, which are observed in many individual decision-making experiments, will prevail or whether the predictive power of standard theory, as observed in competitive experimental markets, carries over to an efficiency wage environment.

## II. THE EXPERIMENTAL DESIGN

Our experiment is aimed toward testing the main implications of the efficiency wage model described in the previous section. Each trading period consisted of two stages. At the first stage firms unilaterally offered contracts  $(w, \tilde{e}, p)$ . At the second stage workers who had accepted the terms of a contract chose their effort levels  $e$ . For  $e < \tilde{e}$  a random mechanism determined with probability  $s = \frac{1}{2}$  whether the penalty  $p$  has to be paid or not. The first stage of a period was organised as a posted bid market with firms as contract makers. Each firm could buy one unit of the good (offer one contract) per period. Firms were, however, not forced to trade, i.e. they could refrain from making offers.

The procedural details of our experiment are as follows.<sup>8</sup> The contract offers were made simultaneously. When each firm had determined its contract the experimenter made all offers public by writing them on the blackboard. In addition, the experimenters transmitted the offers by telephone to the workers who were located in a different room.

After the contract offers were written on the blackboard in the workers' room a random mechanism determined the order in which workers could choose among the available offers. When a contract was accepted the worker chose his effort level, which was transmitted to 'his' firm. No other experimental subject was informed about the effort choice. To rule out the possibility of reputation

<sup>8</sup> The instructions are available on request.



formation firms did not know the identity of 'their' workers nor were workers informed about the identity of 'their' firm.

In total we organised six experimental sessions.<sup>9</sup> The first five sessions were efficiency wage experiments (EWEs). They comprised 16 periods. The last session was a market clearing experiment (MCE), that is, condition (3) was replaced by the constraint  $p \leq k$ . It had only 13 periods.

The information structure of the experiments was as follows. The  $q$ -values were private information. The effort cost schedule and the cost of trading of  $b = 12$  were, however, common knowledge. Workers did not know that firms faced a constraint on the penalty nor did they possess information about the exact effect of their effort choices on the firms' profits. They were, however, told that the higher their effort chosen the larger would be the profit of 'their' firm.

### III. EXPERIMENTAL RESULTS

In this section we present the empirical results and relate them to the predictions of Section I.2. In all five EWEs firms could offer 448 employment contracts. In 100 cases they preferred to make no offers. Therefore, in total 348 contracts were offered; all of them have been accepted by workers. In the MCE firms exhausted the number of potential contract offers. They offered 78 contracts out of which two were rejected by workers. These facts are already an indication for the existence of endogenous unemployment in the EWEs.

#### III.1. *Firms' Penalty Choices*

Our choice of the parameters in the EWEs ensures that in equilibrium, the BPC is binding for all  $\tilde{e} > e_0$ . Therefore,  $p$  should obey the equation  $p = w - 15$ . Except for a few cases this prediction was confirmed by actual behaviour. In all five EWEs 87.1% of all offers strictly satisfied the BPC. During the last four periods this percentage increased to 93.8%. In the MCE the BPC was replaced by the constraint  $p \leq 60$ . When firms expect workers to be risk neutral the expected penalty  $sp$  should be at least as large as the cost of providing  $\tilde{e}$ :  $\frac{1}{2}p \geq c(\tilde{e})$ . In total firms offered 78 contracts in the MCE. Only eight of them stipulated penalties below  $2c(\tilde{e})$ . During the last four periods only two out of 24 contract offers stipulated  $p < 2c(\tilde{e})$  whereas 18 even set  $p > 3c(\tilde{e})$ . These data provide fairly convincing evidence that firms' penalty behaviour was rational.

#### III.2. *Workers' Behaviour*

Since the expected penalty,  $sp$ , does not vary with the size of the effort deviation,  $\tilde{e} - e$ , a rational worker should either choose  $\tilde{e}$  or  $e_0$ . This prediction was confirmed by actual behaviour in more than 97% of the cases. Although this aspect of workers' behaviour conforms to the predictions of our model other

<sup>9</sup> All sessions were conducted between March and May 1992. Sessions 1-5 lasted approximately 3.5 hours while session 6 lasted only 3 hours. On average subjects earned ATS 250 (approximately \$25) per session. No subject was allowed to participate in more than one session. Our subjects were students of the University of Technology in Vienna. The large majority of them had never taken a course in economics. A few of them (< 10%) had some knowledge of introductory microeconomics. None of them had knowledge about experimental economics or game theory.

aspects do not. If a worker consistently behaves in a risk neutral manner he should supply  $\tilde{e}$  when  $u^{ns} - u^s \geq 0$  and shirk when  $u^{ns} - u^s < 0$ . Yet, in all our EWEs workers exhibited a lot of risk aversion. There were many trades in which workers did not shirk although  $u^{ns} - u^s$  was negative.<sup>10</sup> If a worker behaves as if he has a utility function with a constant degree of risk aversion the switch to non-shirking occurs already at  $u^{ns} - u^s < 0$ . However, in general workers' choices were not compatible with a constant degree of risk aversion, either. They shirked, for example, when  $u^{ns} - u^s = -2$  but supplied  $\tilde{e}$  when  $u^{ns} - u^s = -6$ . This raises doubts whether workers' behaviour conformed to the axioms of expected utility theory.

Our theoretical efficiency wage model with complete information predicts that shirking will never occur because rational firms will obey the NSC. But since firms did not know the risk preferences and, hence, the NSC of heterogenous workers one can hardly expect that shirking is absent from the beginning. But if firms learn in the course of the experiment how workers respond to different wage contracts, a declining rate of shirking might be expected over time. The data show, however, a different picture. On average workers chose  $e < \tilde{e}$  in 42% of all cases in the EWEs. Yet, during the last four periods the percentage of shirking rose even to 45%. This contrasts sharply with worker's behaviour in the MCE in which  $e < \tilde{e}$  occurred only in 21% of all cases. Moreover, contrary to the EWEs the percentage of shirking fell from 21 to 17% in the last four periods of the MCE. This decrease is likely to be due to the increase in penalties (see Section III.1). According to the NSC higher wages and lower effort (cost) requirements should increase the probability of non-shirking in the EWEs. We tested this prediction by regressing this probability on wages and the costs of effort demanded  $c(\tilde{e})$ . In the MCE the wage should, however, play no role in determining workers' effort choices. Instead the penalty and  $c(\tilde{e})$  can be expected to affect workers' behaviour in the MCE. Table 1 reports the results of our probit regressions.<sup>11</sup>

All regressions coefficients have the predicted sign and are significant at the 5% level. Table 1 provides, therefore, support for a core element of the efficiency wage hypothesis: the higher the wage the less likely shirking will occur. In addition it shows that an increase in effort demanded increases the probability of shirking. Yet, due to the experimental evidence provided by the MCE-data the critics of the efficiency wage hypothesis will also be satisfied: if one removes the wage-dependent upper bound on the penalty the wage loses its role as an incentive device and the penalty alone takes over the role of deterring shirking. What is interesting here is that our results provide evidence in favour of a central prediction of the efficiency wage hypothesis although one can have doubts whether, at the individual level, workers' behaviour conformed to expected utility theory.

<sup>10</sup> There were 268 trades with contracts that implied  $u^{ns} - u^s < 0$ . Workers did not shirk in 53% of these trades. In contrast, there were only 80 trades for which  $u^{ns} - u^s \geq 0$ ; in only 12 of these cases workers shirked.

<sup>11</sup> Since there were considerable behavioural differences among workers we included dummies for workers into the regression.



Table 1  
*Determinants of Probability of Non-shirking (Probit Regression)*

Variable	Experiment					MCE†
	EWE 1*	EWE 2	EWE 3	EWE 4	EWE 5	
Waged offered	0.476 (2.992)‡	0.156 (2.678)	0.161 (2.947)	0.166 (3.297)	0.189 (3.657)	
Costs of effort demanded	-0.513 (-2.342)	-0.318 (-2.441)	-0.344 (-2.658)	-0.321 (-3.460)	-0.245 (-2.596)	-0.208 (-2.426)
Penalty						0.085 (2.797)
§ Pseudo-R <sup>2</sup>	0.66	0.34	0.44	0.33	0.51	0.47
Observations	65	60	59	69	79	76

\* Regression for the EWEs:  $y = \alpha w + \beta c(\bar{e}) + \sum \gamma_i d_i + \epsilon$ .

† Regression for the MCE:  $y = \beta c(\bar{e}) + \delta p + \sum \gamma_i d_i + \epsilon$ .

\*, †  $y = 1$  ( $y = 0$ ) in case of non-shirking (shirking) and  $d_i = 1$  ( $d_i = 0$ ) if worker  $i$  was involved (not involved) in the trade.

‡ † values in parentheses.

§ See McFadden (1974).

### III.3. *Firms' Effort and Wage Choices*

In each EWE we implemented two classes of redemption values. 'Low' redemption values varied between 2.2 and 2.7. At these values profits arising from incentive compatible contracts are positive but close to zero or negative. 'High' redemption values varied between 3.5 and 6. The equilibrium profit for these values is substantially above zero, that is, firms with those  $q$ -values are predicted to trade. This prediction has been confirmed by the data. In total firms could make 288 contract offers at 'high' redemption values in all five EWEs. They offered 285 contracts all of which were accepted by the workers. Fig. 1 exhibits the wage and effort behaviour of firms with 'high' redemption values in the last four periods.<sup>12</sup> It compares the predicted average effort and the predicted average wage with the actual average effort and the actual average wage. As Fig. 1 reveals there was a clear tendency to offer wages and demand effort levels below the predicted values. This holds true for the EWEs (see Fig. 1a) as well as for the MCE (see Fig. 1b) although the tendency is much more pronounced in the EWEs. In fact, in the last MCE period wages and effort came very close to their predicted values while in the EWEs they remained significantly below the predicted values.

How did firms' wage and effort behaviour affect job rents? In Fig. 2 we have depicted average job rents at 'high' redemption values for the EWEs and the MCE. Whether we take the average over all periods or only over the last four periods, as in Fig. 2, job rents in the EWEs were below their predicted values.<sup>13</sup> This holds true for each of the 'high' redemption values. Although job rents

<sup>12</sup> We have taken the last four periods because they are likely to include potential learning effects. Yet, Fig. 1 would look very similar if we had included the data of earlier periods.

<sup>13</sup> The hypothesis that job rents are equal to their predicted values can be rejected at a significance level of 0.5%.

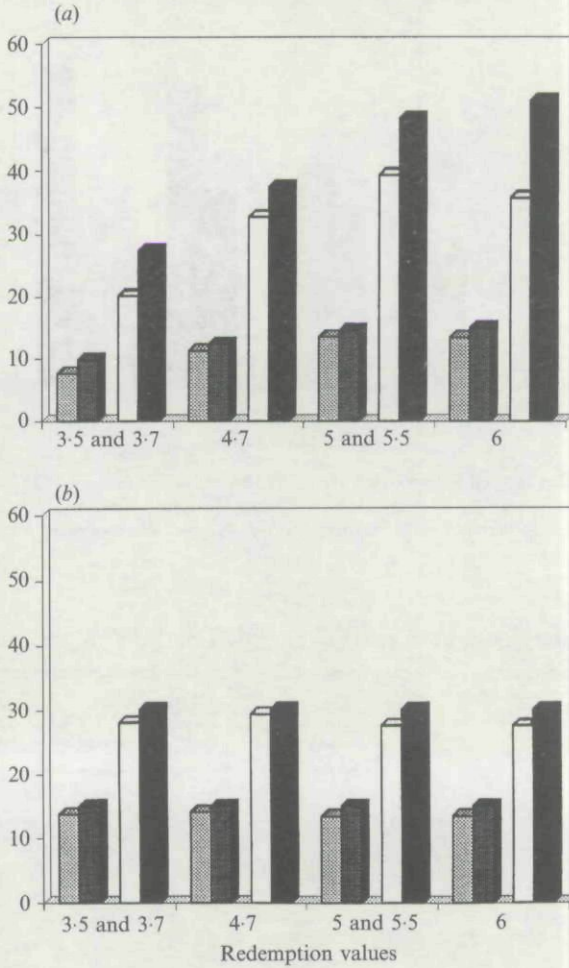


Fig. 1. Average values and predicted values for effort and wages for the last four trading periods. (a) All EWEs. (b) MCE. ■, Average effort; ■, predicted effort; □, average wage; ■, predicted wage.

were lower than predicted in the EWEs they were significantly higher than in the MCE. This difference is particularly pronounced during the last four periods. While job rents in the MCE converged close to zero they remained significantly positive in the EWEs.

The fact that in the MCE job rents tended to vanish while in the EWEs they persisted can be taken as a first indication that the efficiency wage mechanism was operative: by paying a positive job rent firms tried to induce workers to refrain from shirking. Yet, if it is indeed the efficiency wage mechanism which causes positive job rents the data should exhibit three further regularities. According to our numerical predictions in equation (5a'), (5b') and (5d') wages, effort demanded and job rents should be increasing in redemption values or squared redemption values, respectively. To examine this prediction we ran



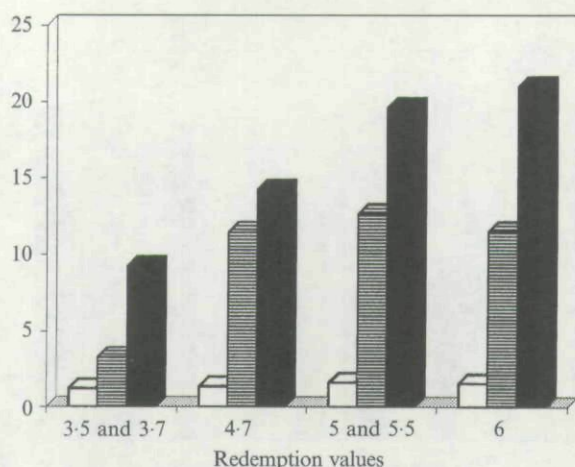


Fig. 2. Average and predicted values of job rents per contract offer in the EWEs and the MCE for the last four trading periods. □, Average job rent in the last four periods of the MCE; ▨, average job rent in the last four periods of all five EWEs; ■, predicted job rent for the EWEs.

Table 2

*The Impact of Redemption Values on Wages, Effort and Job Rents (OLS Regression)*

Variable		Experiment					
		EWE 1	EWE 2	EWE 3	EWE 4	EWE 5	EWE 1-5
Wage equation*	Squared redemption value	0.695 (8.635)§	0.587 (3.535)	0.714 (5.567)	0.543 (6.875)	0.623 (9.139)	0.635 (13.524)
	Adjusted-R <sup>2</sup>	0.58	0.26	0.61	0.47	0.54	0.49
Effort equation†	Redemption value	1.012 (6.162)	0.687 (1.912)	1.026 (3.239)	0.641 (2.649)	0.692 (4.219)	0.807 (8.104)
	Adjusted-R <sup>2</sup>	0.35	0.10	0.41	0.22	0.25	0.30
Job rent equation‡	Squared redemption value	0.431 (8.211)	0.405 (4.368)	0.49 (7.425)	0.457 (8.63)	0.455 (6.938)	0.447 (16.014)
	Adjusted-R <sup>2</sup>	0.60	0.35	0.71	0.49	0.49	0.53
Observations		65	64	69	71	79	348

\* Wage equation:  $w = \beta_w q^2 + \sum \gamma_i d_i + \epsilon$ .

† Effort equation:  $e = \beta_e q + \sum \gamma_i d_i + \epsilon$ .

‡ Job rent equation:  $r = \beta_r q^2 + \sum \gamma_i d_i + \epsilon$ .

\*, †, ‡  $d_i = 1$  ( $d_i = 0$ ) if firm  $i$  made the offer (made not the offer).

§ t values in parentheses.

several OLS and Tobit regressions of  $w$ ,  $\tilde{e}$  and  $r$  on (squared) redemption values.<sup>14</sup>

Table 2 shows that all estimated coefficients have the expected positive sign. All but one of the coefficients (for the effort-equation in EWE 2) are significant

<sup>14</sup> The reason for performing OLS- as well as Tobit-regressions was that both  $w$  and  $\tilde{e}$  are censored variables. In Table 2 we report, however, only the estimated coefficients of the OLS-regressions because the Tobit-regressions yield essentially the same results: the size of all Tobit-estimated coefficients is very close to the size of the OLS-estimations and all 'Tobit-coefficients' are statistically significant at the 5% level.

at the 5% level. In general, the redemption value explains a considerable part of the variation of wages, effort demanded and the job rent. The wage and job rent equations in Table 2 also indicate the existence of non-compensating wage differentials, i.e. firms with higher  $q$ -values paid higher wages and job rents. Therefore, in our view, the results reported in Tables 1 and 2 provide considerable evidence that job rents were indeed caused by the efficiency wage mechanism.

#### III.4. *Unemployment and Efficiency*

In all experiments there were more workers than firms. Thus, unemployment would have occurred in any case. But the relevant question here is whether the payment of positive job rents causes some additional unemployment. In the MCE there were 78 potential trades. In total, 76 trades occurred. In two cases no contracts were concluded<sup>15</sup> because firms' offers were below  $w^r$ .

Whereas the reason for not trading in the MCE was low offers, which were below workers' reservation wage because of a mistake, the reason for not trading in the EWEs was different. In all cases in which firms did not trade they did not make contract offers. In all five EWEs firms with 'low' redemption values could make 160 offers. Yet in 97 cases they preferred not to propose any contract. Recall that firms with 'high' redemption values withdrew from trade in only three cases. According to our parameterisation trade at redemption values smaller than 2.4 is unprofitable.<sup>16</sup> In EWE 3-5 the 'low' redemption values were below 2.4. In the last four periods of these three EWEs the number of potential offers at these  $q$ -values was 24. Yet, firms made only two offers. We take this as evidence that the unemployment prediction of our efficiency wage model has been confirmed by the data.

In EWEs 1 and 2 firms could make small equilibrium profits at low  $q$ -values. Yet, out of 64 potential contracts only 33 offers were made at these redemption values. In the last four periods only six out of 16 potential trades were realised. This may be taken as evidence that many firms considered the achievable profits as too low. As a result, unemployment was above the predicted level in these EWEs.

The total gains from an employment contract are given by  $S \equiv qe - c(e)$ .  $S$  is maximised if  $q = c'(e)$  holds. This is exactly the condition for the profit maximising choice of  $e$  in the MCE (see equation (6)). Therefore, in the equilibrium of the MCE all gains from trade are exhausted. In the EWEs this first best efficiency level cannot be attained in equilibrium because effort will be lower and unemployment will in general be higher than in the equilibrium of the MCE. In Fig. 3 we have depicted the evolution of aggregate efficiency over time in all five EWEs and the MCE. Aggregate Efficiency is defined as the

<sup>15</sup> Due to time limitations these firms were in a hurry when making their offers which caused them to make a mistake.

<sup>16</sup> According to (8) profits arising from an incentive compatible contract are negative if  $q$  is below 2.74. Notice, however, that this presupposes that  $\bar{z} = 7.6$  and that the wage obeys the NSC. An alternative strategy is to propose  $(w, \bar{z}) = (12, 5)$ . In this case the worker cannot shirk because  $\bar{z} = \epsilon_0 = 5$  and, hence, the NSC need not be met. The alternative strategy yields therefore strictly positive profits. For  $q < 2.4$  this strategy generates negative profits, too.



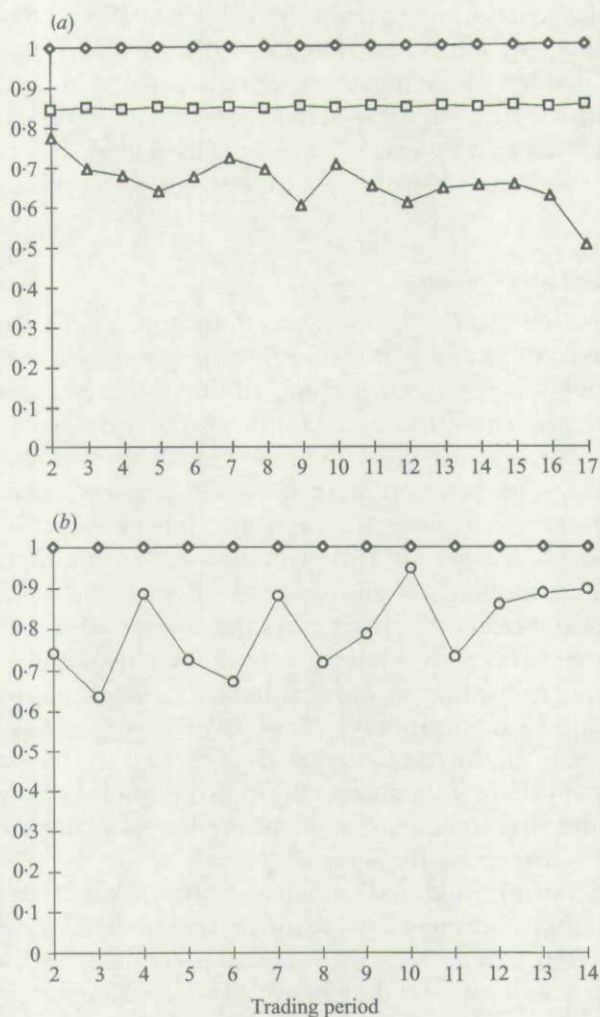


Fig. 3. Efficiency comparison. (a) All EWEs. —◇—, first best efficiency (= predicted efficiency in the MCE); —□—, predicted efficiency in the EWEs; —△—, actual efficiency in the EWEs. (b) MCE. —◇—, first best efficiency (= predicted efficiency in the MCE); —○—, actual efficiency in MCE.

aggregate gains over all labour contracts concluded divided by the maximum attainable aggregate gains.

Due to shirking in both, the EWEs and the MCE, aggregate efficiency is well below the predicted level. In the EWEs the efficiency reducing effect of shirking is reinforced by the fact that  $\bar{z}$  is in general below its predicted value. Moreover, while in the MCE there is a weak upwards trend over time the opposite holds true in the EWEs. These results indicate that the efficiency losses due to incomplete verifiability of effort may be considerable.

## IV. INTERPRETATION AND CONCLUDING REMARKS

In this paper we have constructed an efficiency wage model which was then subjected to an experimental investigation. The results of our analysis are somewhat mixed. On one hand the key predictions of the model are qualitatively confirmed by the data: a rise in wages reduces the probability of shirking and firms pay significantly positive job rents. Moreover, some workers remain involuntarily unemployed because they do not get job offers. In addition, different firms pay different wages which gives rise to non-compensating wage differentials. However, on the other hand, job rents are in general significantly below the predicted values. Moreover, contrary to the predictions, shirking is a persistent phenomenon. Therefore, the efficiency of the market is considerably below the predicted efficiency.

How can the deviations from the predicted outcomes be explained? In our view, understanding of the behaviour of firms is key. As our analysis of workers' behaviour indicates firms could have deterred shirking by offering higher job rents. Therefore, the question arises why they did not pay higher job rents. A first possible answer to this question is that 16 periods do not provide enough time for learning. Although we cannot rule out this explanation we doubt it because, on average, job rents were fairly stable during the latter periods of our EWEs. A second explanation could be that at least some firms were unable to meet the behavioural rational choice assumptions of our model. A third reason might be that the posted contract institution leads to a downwards pressure on job rents. From market experiments in which sellers have the power to post prices it is well known (see, e.g. Davis and Holt, 1993, chapter 4) that this power tends to raise prices. Likewise the power of firms to post contracts in our experiments might tend to reduce job rents.

The fourth reason is related to the possibility that firms were risk averse. At least during the initial trading periods firms did not know workers' risk preferences and, hence, the exact location of the no-shirking condition (NSC). There was, therefore, always the danger that their  $(w, \tilde{e})$ -combination was below the NSC of the worker with whom they were matched. In addition, if shirking turned out to be not verifiable, firms' losses were the larger the higher was  $w$ .<sup>17</sup> It seems possible that risk averse firms reduced  $w$  to reduce the losses in case of unverifiable shirking. But if they set  $w$  at a lower level they also had to reduce  $\tilde{e}$  because otherwise there would have been an increase in the probability of shirking. Therefore, they reduced  $\tilde{e}$ , too. This story seems to be compatible with the data exhibited in Fig. 1 which show that both average wages and average effort were below their predicted values.

That firms' incomplete information about the position of the NSC and, hence, their risk preferences were a relevant factor in the EWEs is also compatible with the fact that in the MCE the market converges close to the predicted values. In the MCE the NSC was no longer relevant because the

<sup>17</sup> For example, a firm with  $q = 6$  which offers the contract  $(w, \tilde{e}, p) = (45, 15, 30)$ , earns  $\pi = (6 \cdot 5) - 45 = -15$  if shirking is not verified. But if it offers  $(58, 15, 43)$ , its profit is  $(6 \cdot 5) - 58 = -28$  in case of unverifiable shirking.



constraint on  $p$  was much weaker. Instead, the reservation wage constraint became relevant. But this constraint was the same for all workers and known to the firms. Therefore, by imposing large penalties, firms could reduce the uncertainty about workers' behaviour to a considerable extent which in turn lowered the impact of their risk preferences on their  $w$ - and  $\tilde{e}$ -choices. This could be the reason why firms' behaviour was much closer to our risk neutral (complete information) prediction in the MCE. Although we are inclined to give the last explanation the most credit we have to admit that we cannot rule out the other explanations at the present stage of our research. It remains a task for future research to investigate these potential reasons in more detail.

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