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REGULATION WITH WAGE BARGAINING*

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In many regulated industries labour unions are strong and there is clear empirical evidence of labour rent-sharing. In this paper, we study optimal regulation in a model in which wages are determined endogenously by wage bargaining at the firm level. A seemingly robust conclusion, at least when worker bargaining power is considerable, is that incentives for cost efficiency should be stronger than in the standard case in which wages do not depend on the regulatory regime.

1. Wage Setting in Regulated Industries

Traditionally, labour unions have been strong in many regulated industries. Wages and working conditions are determined by bargaining between unions and employers. Industry regulators, who are responsible for designing pricing and transfer schemes for firms, cannot usually control wages directly. Nevertheless, the choice of regulatory policy is likely to influence the outcome of the wage bargaining process. Consider, for example, cost of service regulation under which firms are allowed a 'fair' rate of return. Based on historical costs of labour and other inputs, regulated prices are fixed at average costs. If costs are reviewed frequently, owners have little incentive to resist claims for higher wages since an increase in wages quickly leads to a corresponding increase in regulated prices. If, instead, regulatory reviews are carried out less frequently (as with price-cap regulation) the regulatory scheme becomes more 'high powered' and provides stronger incentives for cost reductions, and so firms have a stronger incentive to resist wage claims. Standard bargaining theory predicts that such a change in regulatory policy results in an outcome with lower wages.

There is a considerable empirical literature devoted to the study of labour rent-sharing in regulated industries.[1] Ehrenberg (1979), in a detailed study of New York Telephone, presents evidence suggesting that unionised workers of this company were paid a premium above non-union workers of comparable skills. Rose (1987) used the impact of deregulation on wages in the US trucking industry in the early 1980s to estimate rent-sharing in the pre-deregulation era, finding that workers had captured more than two thirds of total industry rents.[2] Of particular interest is the study by Hendricks (1975), who analysed wage settlements in electric utilities

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[1] See Hendricks (1986) for a survey, with particular emphasis on studies of the effects of deregulation on wages.

[2] As one would expect, wage premiums differ between industries, as well as between firms within a given industry. In contrast to results from the trucking industry, Card (1996) found that relative earnings of airline workers declined by 10% after deregulation and concludes that, '... taken as a whole, the evidence suggests that the rent premiums earned by airline workers in the regulatory era were relatively modest'.

in the US and found that wages were higher for utilities that expected the regulator to adjust prices following a new wage agreement.

The observation that the regulatory regime may affect industry wage levels clearly has implications for optimal policies. However, the interaction between regulation and wage determination does not seem to have received much attention in the theoretical literature. The standard approach has been to assume that the cost structure of a regulated firm is exogenous except for the level of 'effort'.[3] Based on this assumption, the theory of regulation has focused on the trade-off between providing incentives for cost-reducing efforts and rents captured by the privately informed firm; see e.g. Laffont and Tirole (1993). A fundamental insight gained from this literature is that by lowering the 'incentive power' of the regulatory scheme – that is, by accepting a higher degree of cost pass-through – the regulator may reduce rents.

In the next Section, we present a straightforward extension of the Laffont and Tirole (1993) model of optimal regulation to allow for endogenous wage determination. We assume that wages are determined by the Nash-bargaining solution with the agents' outside options as threat points. Our main result is derived in Section 3. Here we consider a game in which a regulator offers a contract to the manager (owner) of a firm, who subsequently bargains with a worker over wage and effort. It turns out that total rents (to worker and firm) are less sensitive to the power of the regulatory contract the stronger is the bargaining power of the worker. Consequently, the optimal contract yields stronger incentives for cost-reducing effort when wages are determined by bargaining at the firm level, than when they are exogenous.

In Section 4, we investigate the robustness of this result. First, we briefly discuss alternative formulations of the regulatory objective function; in particular, we show that our main result carries directly over to a procurement setting. Second, we show that the timing of effort decisions are important. When making a comparison with the case in which managerial effort is determined by bargaining with the worker, we identify conditions under which the optimal contract becomes even more high-powered. Third, lack of regulatory commitment may imply that the regulatory regime is responsive to the outcome of wage bargaining. We also consider a setup in which the contract is offered *after* wage bargaining has taken place; in this case, the firm has no incentive to resist wage claims. Section 5 concludes.

2. Analytical Framework

There are three players: a regulator, a manager (or owner) and a worker. The regulator offers the manager a contract to undertake a given task, which also requires the services of the worker. Total costs of production are given by

$$C = w + \beta - e, \tag{1}$$

[3] An exception is the literature studying the interaction between regulatory policy and firms' investment incentives, see e.g., Riordan and Sappington (1989), Dalen (1995), and Tirole (1986).

where w is the worker's wage, β is an efficiency parameter, and e is the level of effort. Neither the efficiency parameter nor effort undertaken are observable to the regulator, who regards β as a random variable, continuously distributed on the interval $[\underline{\beta}, \bar{\beta}]$. The manager and the worker are both fully informed about costs. Wage is determined by bargaining between the manager and the worker (we describe the details of the bargaining technology in the next Section).

The worker's payoff is given by the wage w. The manager's payoff, when undertaking the task, depends partly on the net transfers t from the regulator and partly on the cost (or 'disutility') of effort $\psi(e)$: $\pi = t - \psi(e)$. The variable e should be thought of as encompassing those aspects of the operation of the firm over which the manager has preferences, including the organisation of production, administrative structure and expenses; that is, e measures the extent to which these aspects differ from the most-preferred mode of operation. We employ the standard assumptions that $\psi(0) = 0$, that $\psi(e)$ is thrice continuously differentiable, and that $\psi'(e)$ is positive, increasing and convex.

We limit attention to regulatory contracts that specify a linear relationship between costs of production and net transfers (see comments below). Thus, the transfer takes the form $t = a - bC$, and the manager's payoff may be written

$$\pi = a - b(w + \beta - e) - \psi(e). \tag{2}$$

The objective function of the utilitarian regulator is assumed to be given by the unweighted sum of consumer surplus S associated with the task, and the manager's and the worker's payoffs:[4]

$$SW = S - (1 + \lambda)(t + C) + \pi + w, \tag{3}$$

where $1 + \lambda$ is the (general equilibrium) costs of public funds. Inserting (1) and $t = \psi + \pi$ gives

$$SW = S - (1 + \lambda)[\beta - e + \psi(e)] - \lambda(\pi + w). \tag{4}$$

Note that, at the full-information first-best solution, $\psi'(e) = 1$.

The model has some distinguishing features that warrant comment.[5] First, we have constrained the contract set to linear contracts. As is well known, a fully optimal regulatory scheme is nonlinear, and can be represented by a *menu* of linear contracts from which the agent can choose (Laffont and Tirole, 1993). However, the fundamental trade-off, between extracting informational rents and maintaining incentives to exert effort, remains the same whether contracts are linear or not. Our main objective has been to study how wage-bargaining institutions affect such a trade-off, and how the regulator should respond to this. We assume a linear contract, which has the advantage of allowing us to capture the

[4] If the regulator had preferences over income distribution, unequal weights might apply to the utilities of the manager and the worker, respectively. However, the exact form of the objective function is not essential for our results; see the discussion in Section 4.1. below.

[5] There are other simplifying, albeit fairly standard, assumptions that could also be discussed. In a more general (multi-level principal-agent) model one could allow for asymmetric information, as well as more general bargaining procedures, at all levels of the hierarchy. While undoubtedly a great challenge, we have not attempted to overcome the fundamental difficulties in designing realistic and tractable models for more complicated settings.

power of the regulatory contract in one single parameter, in addition to making the analysis simpler. Furthermore, as shown in Dalen *et al.* (2002), the fundamental result carries over to a setting in which we allow for a menu of linear contracts (see also below).

Second, we assume that regulatory contracts are not conditional on wages. In our simplified framework, optimal regulation would involve an infinite penalty on wages above the worker's reservation wage; in effect fixing the wage at the reservation level. It is a fact that the jurisdiction of regulators typically does not include the right to set standards for wages and working conditions. Where workers (unions) have a statutory right to negotiate wages and working conditions with their employers, a regulatory contract that explicitly restricts the scope for such negotiations would probably not be considered legal. Furthermore, while compensation in our stylised model is simply a wage payment, renumeration packages are typically far more complicated, with wages tied to individual performance, position, job tasks and overtime, and with compensation being given not only in the form of wages, but also as fringe benefits such as retirement plans. It seems unlikely that an outside party could observe total compensation accurately. Also, by dictating a firm's wage policy, the regulator may create an inefficient compensation system leading to higher overall costs. Moreover, the worker's reservation wage may be determined by both individual worker characteristics and local labour market conditions, which are observed only imperfectly by the regulator. Consequently, allowing for regulatory contracts that are conditional on wage settlements would not necessarily imply that the regulator presets wages entirely.

Finally, we focus on the case in which the regulator writes contracts with the manager (or firm) only, and not with the worker directly. Again, the jurisdiction of regulators typically restricts the extent to which they may apply these direct contracts. A discussion of whether such contracts would be desirable raises issues concerning the optimal boundaries of the firm, which lie outside the scope of this paper.[6]

3. Optimal contracts

In this Section we consider the following game: The regulator first offers the manager a contract. If the contract is rejected, the game ends, and both the manager and the worker obtain their reservation utilities. If the contract is accepted, the manager and the worker bargain over wage and effort. We first solve the bargaining game for a given contract $\{a, b\}$ and calculate the expected cost and the expected transfer from the regulator to the firm. We then derive the optimal regulatory scheme as the contract that maximises expected social surplus.

[6] See Tirole (1994) for a discussion of the optimal organisation of government and reasons for introducing multiple government agencies with limited jurisdiction. Laffont and Martimort (1998) demonstrate that in order to avoid collusion and side-contracting between agents, delegating incentive contracts may be optimal if communication between the upper and lower levels of a hierarchy is not limitless.

3.1. *The Bargaining Game*

We assume that the outcome of the bargaining game is given by the Nash bargaining solution. Furthermore, we apply the common assumption in the labour market literature that the relevant disagreement points are given by the agents' outside options; see for instance Pissarides (2000). We denote the worker's disagreement point by w^r and normalise the manager's disagreement point to zero. The Nash product is then

$$N = (w - w^r)^{\delta}\pi^{1-\delta} = (w - w^r)^{\delta}[a - b(\beta - e + w) - \psi(e)]^{1-\delta}, \tag{5}$$

where δ denotes the 'bargaining power' of the worker.[7] The Nash solution is given by the values of e and w that maximises the Nash product. First-order conditions for maximum may be written

$$\frac{1-\delta}{\delta} b(w - w^r) = a - b(w + \beta - e) - \psi(e), \text{ and} \tag{6}$$

$$\psi'(e) = b. \tag{7}$$

The right-hand side of (6) shows the manager's rent, which is equal to $(1 - \delta)b/\delta$ times the worker's rent $w - w^r$. Consequently, the manager's share of total rents is larger, the larger is b (the incentive-powered is the contract) and the smaller is δ, the worker's bargaining power. It is clear that the agreed wage rate is decreasing in b. Also, w increases with an increase in a; the more there is to bargain over, the higher is the wage. The same holds for a decrease in the cost parameter β.

Equation (7) defines the optimal value of effort e as an increasing and concave function of b; that is, $e^* = e(b)$, $e' > 0$, $e'' < 0$ (since ψ' is convex). Note that e^* is independent of β (this is not a general result, but follows from our linear specification of the cost function). Our findings so far can thus be summarised in the following lemma:

LEMMA 1. *The wage agreement is given by* $w^* = w(a, b, \beta, \delta, w^r)$, *where* $\partial w/\partial a > 0$, $\partial w/\partial b < 0$, $\partial w/\partial \beta < 0$, $\partial w/\partial \delta > 0$ *and* $\partial w/\partial w^r > 0$.

3.2. *The Optimal Regulatory Contract*

The optimal contract leaves no net payoff to the least efficient type. Since the right-hand side in (6) shows the manager's rent, it follows that the optimal contract yields $w = w^r$ at $\beta = \bar{\beta}$. For any given value of b, the optimal value of the constant term a is given by

$$a = b(\bar{\beta} - e^* + w^r) + \psi(e^*). \tag{8}$$

Inserting (8) into (6) gives

[7] Whether the worker receive rents in the form of higher employment or job security, or in the form of higher wages, is, from our perspective, not important. We therefore assume that worker rents are captured in one variable only, namely the wage.

$$w - w^r = \delta(\bar{\beta} - \beta). \tag{9}$$

That is, as long as the regulator makes sure that the manager and the worker of the least efficient type produce with binding participation constraints, the wage level becomes independent of the power of the incentive scheme (b). To understand this, note that an increase in b (which increases the incentive to undertake effort) has two opposing effects on the payoff of the worker. On the one hand, an increase in b increases the total rent that is allocated to the firm. On the other hand, an increase in b makes wage concessions more costly and thus reduces the share of this rent that is allocated to the worker. With our parameterisation of the model, it turns out that the two effects exactly offset each other.

Combining (2) and (6) gives $\pi = b(w - w^r)(1 - \delta)/\delta$. Inserting for w from (9), then gives

$$\pi = b(1 - \delta)(\bar{\beta} - \beta). \tag{10}$$

The combined rent obtained by the manager and the worker equals

$$\pi + w - w^r = [b(1 - \delta) + \delta](\bar{\beta} - \beta). \tag{11}$$

Total rent is thus increasing in b, but less than proportionally, as long as the worker has any bargaining power.

The regulator sets b so as to maximise expected social welfare. Substituting (11) into (4) and taking expectations with respect to β, we find that the regulator's problem is to maximise

$$\mathrm{E}\,SW = S - (1 + \lambda)[\mathrm{E}\beta - e + \psi(e)] - \lambda[b(1 - \delta) + \delta](\bar{\beta} - \mathrm{E}\beta) - \lambda w^r, \tag{12}$$

where $e = e(b)$ is given implicitly by (7). The first-order condition becomes

$$(1 - b)e'(b) = \frac{\lambda}{1 + \lambda}(1 - \delta)(\bar{\beta} - \mathrm{E}\beta). \tag{13}$$

Since, by assumption, $\psi'''(e) \geq 0$, $e''(b) \leq 0$. It follows that the left-hand side of (13) is decreasing in b. Consequently, since the right-hand side is independent of b, the solution is unique. Furthermore, a higher value of the right-hand side implies a lower value of b. Note that when $\delta = 1$, the optimal contract is to set $b = 1$. In this case, managerial rent is always zero. Since the wage is independent of b, there is no trade-off between efficiency and rent in this case, and the firm (in effect, the worker) is the residual claimant. Generally, the optimal contract will be monotonically increasing in δ.

We want to compare the contract derived above with the optimal scheme in the case in which wages are set independently of the regulatory contract (say, by wage bargaining at the industry, or economy, level) and thus regarded as exogenous by the regulator. This can be seen as a special case of our model obtained in the limit when $\delta \to 0$. Consequently, from (13), we have the following result:

PROPOSITION 1. *Compared to the optimal regulatory contract when wages are exogenous, the optimal regulatory contract with wages determined by bargaining at the firm level yields stronger incentives for efficiency* (*i.e., a higher* b).

Both with exogenous and with endogenous wages the regulator faces a trade-off between incentives and rent extraction. A high-powered incentive scheme leads to high effort and a low degree of rent extraction. However, when the wage level is endogenous, the b parameter also affects wage settlement. In particular, a higher b makes it more costly for the manager to accept wage claims and hence reduces the worker's bargaining position. Consequently, when wages are determined by bargaining at the firm level, the rent extraction effect of lowering incentives becomes weaker.

As it turns out, this weakening of the rent extraction effect is independent of our restriction to linear contracts, and so, as shown in Dalen *et al.* (2002), similar results are also obtained with a more general contract space.

4. Robustness

In the previous two Sections we presented an extension of a standard model of optimal regulation by allowing for endogenous wage determination. In this Section we investigate the robustness of the results derived by considering some alternative modelling formulations. We first consider a different regulatory objective function, corresponding to a procurement setting. We then investigate the robustness of results with respect to the time structure of the game. We demonstrate that the timing of effort decisions are important and identify conditions under which the optimal contract becomes even more high powered. Lastly, we consider a setup in which the regulatory contract is offered *after* wage bargaining has taken place, and show that in this case the manager has no incentive to resist wage claims.

4.1. *Procurement*

Above, the objective function of the regulator was assumed to equal the unweighted sum of consumer surplus and the manager's and the worker's payoffs. Alternatively we could consider private procurement, in which case the objective (of the procurer) is to maximise private surplus $PS = S - (C + t)$. Substituting for t, private surplus may be written

$$PS = S - [\beta - e + \psi(e)] - (\pi + w).$$

Since the outcome of the wage-bargaining game will be the same (for any given contract), the procurement problem is to maximise

$$\mathrm{E}\,PS = S - [\mathrm{E}\beta - e + \psi(e)] - [b(1-\delta) + \delta]\left(\bar{\beta} - \mathrm{E}\beta\right) - w^r, \tag{14}$$

where $e(b)$ is given implicitly by $\psi'(e) = b$, as in Section 3. The first-order condition for this problem is $(1 - b)\,e'(b) = (1 - \delta)\left(\bar{\beta} - \mathrm{E}\beta\right)$.

Consequently, the result stated in Proposition 1 carries over to the private procurement case. This confirms that our result does not depend critically on the exact form of the objective function of the regulator; what is important is that the regulator dislikes leaving rents to firms and workers.

4.2. *Effort Decisions*

In Sections 2 and 3, the effort level of the manager was assumed to be determined jointly with wages in a bargaining process involving the manager and the worker. This assumption may not be unreasonable. Both the manager and the worker have preferences over e (the worker indirectly, as effort influences wages), and efficient bargaining generally requires that all aspects that parties have preferences over are included in the negotiations. Nevertheless, assuming that the manager has discretion with respect to his own effort level would be in line with the 'right to manage' assumption often made in the labour market literature (see Layard *et al.* 1991).

It turns out that managerial discretion over effort decisions does not change the results obtained above, as long as the manager's effort level is decided upon *after* the wage is determined.[8] To see this, suppose w is the negotiated wage. Then the firm chooses e so as to maximise $\pi = a - b(w + \beta - e) - \psi(e)$, and, as w is preset at this point, e is determined by the first-order condition $\psi'(e) = b$. This is the same condition as in (7). When bargaining over wages, this effort level is anticipated by the parties, and so the wage is determined by (6), as before. Therefore, for any given contract, the effort level and the wage level are the same as when agents bargain over effort and it follows that the optimal contract is unaltered as well. The reason for this equivalence result is that when wage is set before effort is exerted, the manager in effect becomes the residual claimant to the information rent. Consequently, from the point of view of the worker and the manager, and given the regulatory contract, the manager chooses e efficiently, just as e is set optimally in the Nash bargaining solution. Note that this result is independent of the assumed linearity of costs.

This is different if effort is decided upon *before* wage is determined. Consider now the following move structure. First, the regulator offers a contract to the manager. If the manager accepts, he has to decide on the amount of effort to be exerted. Last, wage is determined by the Nash bargaining solution.

It is assumed that costs of effort are sunk when the bargaining game takes place, and that the manager's outside option is independent of the effort level. Consequently, the cost of effort does not enter the Nash maximand, which now reads (with the normalisation $w^r = 0$)

$$N = w^{\delta}[a - b(w + \beta - e)]^{1-\delta}. \tag{15}$$

[8] The same holds true in our setup if effort is determined before the wage is set, as long as the disutility of effort is felt only after wage negotiations are successfully completed. Then the wage is determined by the same condition as in the previous Section. Furthermore, it can be shown that the first-order condition for the manager's choice of effort reduces to $\psi'(e) = b$. Note that this result does not carry over to models with more general cost functions.

The first-order condition for the Nash solution becomes

$$\frac{1-\delta}{\delta} bw = a - b(w + \beta - e), \tag{16}$$

which yields

$$w = \delta\left(\frac{a}{b} - \beta + e\right). \tag{17}$$

In the second stage, the manager maximises $a - b(w + \beta - e) - \psi(e)$, where w is given by (17). The first-order condition for this problem becomes

$$\psi'(e) = (1-\delta)b. \tag{18}$$

Comparing (18) with (7), we obtain the following result:

LEMMA 2. *For a given regulatory contract and as long as the worker has any bargaining power (i.e., $\delta > 0$), the level of effort exerted is lower in the case in which effort is set before wage bargaining takes place, than when it is determined either in or after the bargaining process.*

This result reflects the 'hold-up' character of the game: the manager carries the full share of the costs of effort while the worker obtains a strictly positive share of the return. Consequently, the manager has less incentive to exert effort in this case than in the model analysed above. Two new effects are introduced that the regulator will have to consider when constructing an optimal contract. On the one hand, since less cost-reducing effort is undertaken, it becomes more important to provide incentives for effort. On the other hand, the marginal effect of increasing the power of the incentive scheme is smaller.

From (15) we see that since the costs of effort are sunk, they are not included in the Nash maximand. As even the least productive type must be compensated for his effort cost, it follows that the worker and the manager always bargain over a positive value. Consequently, the wage will always exceed the reservation wage. We can then derive the optimal contract by a similar procedure, as in the previous Section. As shown in the Appendix, expected social welfare (from (4)) becomes

$$\begin{aligned} \mathrm{E}SW = S &- (1+\lambda)[\mathrm{E}\beta - e + \psi(e)] \\ &- \lambda\left\{[b(1-\delta)+\delta](\bar{\beta} - \mathrm{E}\beta) + \frac{\delta\psi(e)}{(1-\delta)b}\right\}, \end{aligned} \tag{19}$$

where $e = e(b)$ is given implicitly by (18). When comparing this with the expression in (12), we find that there is a new term, indicating that the worker in this model always obtains positive rents. Furthermore, the relationship between effort and the power of the regulatory contract differs. Both the higher wage and the lower effort tend to reduce social welfare. Therefore, for any given value of b, social welfare is lower in this case than in the model considered in the previous Sections. Since this is true for all b, we have the following result:

PROPOSITION 2. *Social welfare is lower in the case in which effort is set before bargaining between the manager and the worker takes place, than when it is determined either during or after the bargaining process.*

The first-order condition for the regulator's maximisation problem is given by

$$(1+\lambda)(1-\psi')e'(b) - \lambda(1-\delta)(\bar{\beta} - \mathrm{E}\beta) - \lambda\frac{\delta}{1-\delta}\left[\frac{\psi' e'(b)}{b} - \frac{\psi}{b^2}\right] = 0. \qquad (20)$$

We now want to compare this contract (denoted by b^M) and the corresponding effort level (denoted by e^M) with the contract derived in Section 3, in which effort is determined by bargaining (denoted by b^B and e^B, respectively). It appears that, depending on parameter values, effort, as well as the power of the regulatory contract, may be both lower and higher than in the effort-bargaining case (see the Appendix). Intuitively, perhaps the most reasonable outcome is that, since gains from effort must be shared, the level of effort will be lower (i.e., $e^M < e^B$) and, furthermore, that this disincentive will be countered by the regulator offering a more high-powered incentive contract (i.e., $b^M > b^B$). This intuition is confirmed in the case in which the effort-cost function is quadratic and the worker has sufficiently strong bargaining power:

Proposition 3. *Assume $\psi(e) = Ae^2$. Then $e^M < e^B$. Furthermore, $b^M > b^B$ for δ sufficiently close to 1.*

Proof. See the Appendix. □

As mentioned above, the hold-up character of the game when cost of effort is sunk at the bargaining stage leads to something akin to an underinvestment result. Consequently, as the marginal value of effort is increasing, providing incentives for effort becomes more important. This direct effect on the incentive schemes is, however, dampened by the fact that the marginal impact on effort of increasing the power of the contract is smaller. Nevertheless, at least in the case in which the effort-cost function is quadratic, the direct effect dominates, further enhancing the result of Section 3: that when wages are endogenously determined the optimal regulatory contract should be more high powered than when wages are exogenous.

4.3. *Strategic Wage Setting*

So far we have considered cases in which the regulator offers contracts before the wage level is determined, in effect assuming that the regulator can commit to a regulatory scheme that is independent of the outcome of the bargaining process, and that he will not respond to new wage agreements. In some circumstances such an assumption is unreasonable. The government often lacks the power, or is unwilling, to enter into long-term contracts. A government usually has limited ability to bind future governments. And even if such commitments were possible, the risk of regulatory failure or incompetence, and the necessity of allowing policies to be adjusted in the light of new information or unforeseen contingencies, may imply that they are unacceptable.

If the regulatory regime is frequently revised, firms and their workers may use wage setting strategically to influence the regulatory scheme; see the finding of Hendricks (1975) that wages were higher for utilities that expected the regulator to adjust prices following a new wage agreement.

Consider again the model described in Section 2, but assume wage bargaining takes place prior to the issuing of the regulatory contract. Denote the resulting wage by w^s. At the time when the regulator designs the contract, the wage is given and, consequently, the optimal contract will be the same as in the model with exogenous wages, with $\bar{w}$ set equal to w^s. The profit of the firm and the optimal value of b will be given by (13) (setting $\delta = 0$), independently of w^s. It follows that the manager is indifferent with respect to the wage level.

Assume also that there is an upper limit $\hat{w}$ on wages that the regulator accepts and that he refuses to offer a contract if the wage exceeds this level. It is easy to see that the equilibrium wage in the bargaining game between the worker and the firm is $\hat{w}$. Supposing equilibrium wage w^s were below $\hat{w}$. Then an increase in wage up to $\hat{w}$ results in a Pareto improvement for the parties to the wage bargaining, as it makes the manager just as well off and the worker better off. Since the Nash solution is Pareto efficient, w^s cannot be the Nash solution; it would be a contradiction. We have thus shown the following proposition:

PROPOSITION 4. *Assume wages are determined by Nash bargaining before the regulatory contract is in place. Assume also that there is an upper limit* $\hat{w}$ *on the wages that the regulator accepts. Then the equilibrium wage is equal to* $\hat{w}$.

The reason why the manager is indifferent with respect to the level of wages is that he, in effect, passes on to the regulator any increase in wage costs. However, the possibility of committing to a wage level prior to the design of the regulatory contract may have other strategic effects, which the assumed (linear) cost structure is not rich enough to capture. For instance, suppose that labour and effort are alternative factors of production in the sense that higher effort means less use of labour. In such a situation the value of effort is increasing in the wage level. This introduces a *strategic effect* of wage determination. A robust result from the theory of regulation is that the information rent of a privately informed firm increases if the incentive contract becomes more high powered (10). By accepting a high wage level, a firm may trigger a more high-powered regulatory regime: see Dalen *et al.* (2002) for an illustration of this point.

5. Conclusion

In this paper we have provided an analysis of how optimal regulatory contracts should be modified if wages are endogenously determined. The main message is that optimal regulation provides stronger incentives for cost efficiency when wages are determined by wage bargaining at the firm level, and thus influenced by the regulatory regime, than if wages are exogenously determined.

We considered first a set up in which both wage and effort are determined by bargaining between worker and firm. Increasing the power of the regulatory contract strengthens management's incentive to resist high wage claims and hence reduces costly transfers to the firm. If, instead, managerial effort is determined before wage bargaining takes place, a hold-up problem arises and the manager's incentives to provide effort falls. This may provide additional stimulus for increasing the incentive power of the contract.

Admittedly, our analysis has been conducted in a highly simplified framework. While we do not believe our main conclusions depend critically on the assumptions made, it would nevertheless be interesting to broaden the analysis in various directions. Extending the framework in the following directions could be particularly interesting:

- While we have noted that regulated firms may strategically exploit wage setting to influence rents (see Section 4.3), there are also strong incentives to reduce the extent to which rents are shared with labour. This raises the question of how regulation may affect firms' choices of technology. One conjecture is that regulated firms may have incentives to substitute labour for fixed-priced inputs. This incentive may be enhanced if unions bargain for slack (low effort, over-manning) as well as wages.
- Regulation may not only affect the outcome of wage bargaining directly, but also indirectly, by influencing the degree of unionisation. A common conjecture is that regulation raises industry rents and hence increases incentives for labour to organise (Hendricks, 1986). An analysis of this issue would require a more developed model of the labour market in which firms operate.[9]

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Appendix

A. Effort Set before Bargaining

Inserting w from (17) into the expression for π in (2) gives $\pi = (1-\delta)a - b(1-\delta)(\beta - e) - \psi(e)$, and we may solve the condition $\pi(\bar{\beta}) = 0$ to find that the optimal a is given by

$$a = b(\bar{\beta} - e) + \frac{\psi(e)}{1-\delta}. \tag{A.1}$$

Inserting (A.1) in the expressions for profit π and wage rate (17) gives

$$\pi = b(1-\delta)(\bar{\beta} - \beta), \tag{A.2}$$

$$w = \delta(\bar{\beta} - \beta) + \frac{\delta}{1-\delta}\frac{\psi(e)}{b}, \tag{A.3}$$

$$\pi + w = [b(1-\delta) + \delta](\bar{\beta} - \beta) + \frac{\delta}{1-\delta}\frac{\psi(e)}{b}. \tag{A.4}$$

Consequently, for given b, the manager's rent is the same as in the model of Section 3, while the wage is always strictly greater than zero. Note that, unlike in Section 3, where

[9] One approach could be developed along the lines suggested in Moen (1997).

the equilibrium wage was independent of b, here the wage level typically depends on the power of the regulatory contract. Inserting into the expression for social welfare, we derive (19).

We can now compare contract and effort derived from the first-order condition (20), denoted b^M and e^M, with b^B, e^B (from the case in which effort is determined by bargaining, as in Section 3) and b^E, e^E (from the case in which the wage rate is exogenous) derived above (evaluated at (b^M, e^M)). Using (18) (i.e., $\psi' = (1-\delta)b$, which implies $e'(b) = (1-\delta)/\psi''$), we can re-write the first-order condition (20) as

$$(1-\psi')\frac{1}{\psi''} = \frac{\lambda}{1+\lambda}\left[\bar{\beta} - \mathrm{E}\beta + \frac{\delta}{\psi''}\left(1 - \frac{\psi''}{\psi'}\frac{\psi}{\psi'}\right)\right].$$

The left-hand side is decreasing in e. Consequently, when comparing this expression with the first-order condition (13), and noting that $\delta = 0$ in (13) gives the contract with exogenous wage, we obtain:

$$e^M \lesseqgtr e^E \iff 1 - \frac{\psi''}{\psi'}\frac{\psi}{\psi'} \gtreqless 0 \tag{A.5}$$

$$e^M \lesseqgtr e^B \iff \bar{\beta} - \mathrm{E}\beta + \frac{1}{\psi''}\left(1 - \frac{\psi''}{\psi'}\frac{\psi}{\psi'}\right) \gtreqless 0. \tag{A.6}$$

In order to compare the incentive power of the contracts, we substitute $\psi' = (1-\delta)b$ back into (20) and get

$$(1-b)\frac{1}{\psi''} = \frac{\lambda}{1+\lambda}\left[\bar{\beta} - \mathrm{E}\beta + \frac{\delta}{\psi''}\left(1 - \frac{\psi''}{\psi'}\frac{\psi}{\psi'}\right)\right] - \delta\frac{b}{\psi''}.$$

Noting that the left-hand side is decreasing in b, we again compare this first-order condition with the first-order condition (13) to obtain

$$b^M \lesseqgtr b^E \iff \frac{\lambda}{1+\lambda}\left(1 - \frac{\psi''}{\psi'}\frac{\psi}{\psi'}\right) - b \gtreqless 0 \tag{A.7}$$

$$b^M \lesseqgtr b^B \iff \frac{\lambda}{1+\lambda}\left[\bar{\beta} - \mathrm{E}\beta + \frac{1}{\psi''}\left(1 - \frac{\psi''}{\psi'}\frac{\psi}{\psi'}\right)\right] - \frac{b}{\psi''} \gtreqless 0. \tag{A.8}$$

B. Proof of Proposition 3

Assuming $\psi(e) = Ae^2$, we get

$$1 - \frac{\psi''}{\psi'}\frac{\psi}{\psi'} = \frac{1}{2}, \tag{B.1}$$

which, from (A.6), implies $e^M < e^B$. Furthermore, the left-hand side of (A.6) reduces to

$$\frac{\lambda}{1+\lambda}\left(\bar{\beta} - \mathrm{E}\beta + \frac{1}{4A}\right) - \frac{1}{2A(1-\delta)}\left[1 - \frac{2A\lambda}{1+\lambda}\left(\bar{\beta} - \mathrm{E}\beta + \frac{\delta}{4A}\right)\right]. \tag{B.2}$$

Using (18) and (20) we find

$$e^M = (1-\delta)b^M = 1 - \frac{2A\lambda}{1+\lambda}\left(\bar{\beta} - \mathrm{E}\beta + \frac{\delta}{4A}\right). \tag{B.3}$$

Therefore, so long as parameters are such that problems are well defined (in particular, the left-hand side of (B.3) is strictly positive), (B.2) becomes negative for δ sufficiently close to 1.

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