Government Extension of Collective Bargaining Agreements

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Abstract

In many European countries, the government has the right to choose a collective bargaining agreement negotiated by a group of employers in an industry and, by decree, make it applicable to all firms in the industry. This paper considers a model of participation in the negotiations, allowing for both negotiating and non-negotiating firms to obey or disobey the provisions of the relevant agreement. The model is then tested on data from France in 1986. We find that French firms behave as if they believe the probability of having a contract extended to them is 0.936, which is significantly higher than the proportion of agreements in our sample that are actually extended (roughly 70 percent). Furthermore, they act as if they believe the probability of getting caught disobeying the provisions of a collective agreement or extension order is 0.992, while associated penalty, in addition to the previously unpaid back wages, is 40,800 francs per worker. We also simulated some possible policy changes to discover the most effective means of increasing participation in bargaining and obedience of collective agreements and extension orders. We found that increasing the perceived probability that an extension order will be issued by 1 percent causes the mean firm in our sample to be 95.5 percent more likely to join the employers association and participate in the bargaining. We also found that raising the probability of getting caught in disobedience of a collective agreement or extension order by 0.5 percent makes the mean firm 2.1 percent more likely to obey, while a 10 percent increase in the penalty only improves obedience by 0.3 percent.

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1. Introduction

Several countries in the European Community give the government the authority to take collective bargaining agreements that were negotiated by only a few employers and extend them to all employers in a given industry. In France, for example, 61.2 percent of all "national" agreements were extended, and even 29.3 percent of the regional and local agreements were extended by government decree[1]. In fact, 69.3 percent of all French collective agreements covering more than 10,000 workers in 1985 were extended agreements[2]. Clearly, the policy of contract extension plays an important role in these labor markets, and it is worth asking how such a policy affects the behavior of firms in these countries, not only in terms of who participates in collective bargaining, but also in terms of who actually obeys the provisions of a collective agreement.

There are two substantively interesting questions that a government's policy of extending collective bargaining agreements raises. The first is, does the presence of such a policy affect which firms participate in the negotiations? As long as the composition of the employers association that negotiates the collective agreements has an impact on the final contract and there is a positive probability of the contract being extended, one would expect to see self-selection of firms into the association. Empirically, we find this to be the case, and that an increase in the probability of extension of 1 percent will increase the probability that the average firm in our sample will join the employers association by 95.5 percent.

A second equally interesting question is, when will a firm decide to ignore an extension order, or when will it join the employers association but not pay what it "should" according to the contract that it helped to negotiate? The possibility of disobedience of an extension order and collective agreement's provisions could, in theory, negate the reputed "positive" effects (i.e. higher salaries and better benefits for employees of non-negotiating employers, a "more level playing field" among firms in an industry, etc...) of an extension order. The contracts that are negotiated by firms that consider disobedience an alternative are likely to be more favorable to employers (due to the self-selection into the employers association) than contracts negotiated by firms that would actually feel bound by its provisions.

In France, disobedience can take one of two forms. First, employers can just refuse to increase salaries[3] above the market wage. This strategy is most likely to be successful (i.e., not attract the attention of labor inspectors) in smaller firms which are less likely to be subject to unanticipated inspections[4].

For larger firms that are more likely to be selected "at random" for inspection, they may practice some form of "marginal disobedience," in which the job classifications of existing employees are changed to place them in less well-paid job categories in the collective agreement. Under U.S. labor law, such a restructuring is forbidden, since it is the job that is covered by

[1]See the ESS for a list of collective agreements, including domain of coverage (national/regional/local) and extended/not extended status.

[2]See La Base for a description of all agreements covering 10,000 or more workers.

[3]In France, the term "salary" is often applied to both salaried and wage labor. We thus do not make such a distinction here, but the term salary should be understood to include base compensation, regardless of how the amount of labor supplied is measured.

[4]This is not equivalent to saying that small firms are never inspected, since inspections are most often instigated at the request of an employee.

Table 1.1: Breakdown of Data by Firm Strategy and Size (Means with Std. Dev. in Parenthesis)

	IO	OO	ID	OD	Total
% of Sample	47.1	49.7	1.5	1.7	100
Number of Enterprises	1802	1901	58	66	3827
Tot. Employment (by estab.)	438.5 (1547.8)	177.7 (3497.7)	572.8 (1294.0)	102.4 (160.9)	305.2
Tot. Employment (by ent.)	4149.0 (10737.3)	3780.2 (10080.1)	154.9 (148.1)	199.1 (245.3)	3837.1

IO=(In,Obey); OO=(Out,Obey); ID=(In,Disobey); OD=(Out,Disobey);
Sources: State-La Base, Données Annuelles Salariales (DAS), Enquête sur la Structure des Salaires (ESS) and author's calculations; Total Employment (by Establishment)-ESS; Total Employment (by enterprise)-Bénéfices Industriels et Commerciaux (BIC)

the collective agreement and not the employee. Thus as long as a particular function is performed by an employee, he or she is entitled to the rates specified in the agreement for that job. In France, with the broader coverage of the collective agreements and the lack of such a regulation tying qualification categories in the agreement to specific jobs in the work place, employers are able to restructure their work forces to make them more "bottom-heavy" in terms of the collective agreement. Disobedience, in our model, encompasses both outright refusal to increase salaries and marginal disobedience. Unfortunately, marginal disobedience is much harder to detect in the data, and its detection in the real world depends largely on the expertise of the labor inspector. This problem is manifest in our empirical test, where less that 5 % of the firms in our sample can be reasonably classed as disobedient.

Table 1.1 shows how our data breaks down along the negotiating/non-negotiating (in/out) and obey/disobey dimensions. As suggested above, the disobedient firms that we are able to detect are generally the smaller firms in the sample. Despite the small sample sizes in the disobey categories, we have still managed to obtain a fairly precise estimate of the probability that a disobedient firm will get caught. As anticipated, given the arguments stated above, we find that employers believe that the probability they will get caught is 0.992, although the per worker penalty is not very steep (40,800 FF per worker, and the average firm in our sample employed 3,830 workers). We also show that if the government was able to increase firm's beliefs about the amount of the penalty by 10 percent, the percentage of negotiating disobedient firms would drop by 0.12 percent.

The paper is structured as follows. After laying out the somewhat complicated notation that will be employed in section 2, we will present the underlying model twice[5]. It first

[5]The modelling takes an approach similar to Ashenfelter and Smith (1979) [?].

appears in discrete form in section 3, where the relevant parameter (the productive efficiency of the firm) takes on one of two values. We do this primarily in order to expose the intuition underlying the model. We then reformulate the model in section 4 supposing a continuum for the efficiency parameter and a log-linear functional form for the production function and generate the equations that will actually be estimated. We discuss the data used in the estimation of the continuous model (supplied by both the French Ministry of Labor and INSEE (the French National Statistics Institute)) briefly in section 5. We then estimate our systems of equations by maximum likelihood in section 6, and present some conclusions in section 7.

2. Notation

Table 2.1 presents the notation that will be used in the rest of this paper. These definitions will be repeated when the variables reappear later.

3. The Dichotomous (Discrete) Case - Two Levels of Efficiency

In deciding what action it will take prior to the commencement of a round of collective bargaining, the firm chooses whichever of the following four strategies minimizes costs (C); i.e. it solves the problem

$$\min C = \left[(\text{out}, \text{obey}), (\text{out}, \text{disobey}), (\text{in}, \text{obey}), (\text{in}, \text{disobey})\right], \tag{3.1}$$

where

$$\begin{aligned}
(\text{out}, \text{obey}) &= \Pi_1 W_H + (1 - \Pi_1) W_L \\
(\text{out}, \text{disobey}) &= \Pi_1 \left[\Pi_2 (W_H + P) + (1 - \Pi_2) W_L\right] + (1 - \Pi_1) W_L \\
(\text{in}, \text{obey}) &= c + W_M \\
(\text{in}, \text{disobey}) &= c + \Pi_2 (W_M + P) + (1 - \Pi_2) W_L.
\end{aligned}$$

In these expressions, Π_1 refers to the probability that the collective agreement will be extended[6]. Π_2 is the probability that a firm that decides to disobey the provisions of the collective agreement will be caught, regardless of whether it participated in the negotiations or had the agreement extended to cover it. P is the amount of the monetary penalty assessed to firms that are caught disobeying the relevant contract, in addition to having to make up the difference in wages that were not paid while the firm was disobedient. c is the cost of membership in the employers association and W_L is the lowest possible wage that can be paid, equivalent to the opportunity wage x faced by the workers employed by a given firm. W_H and W_M are negotiated wages, the definitions of which are derived below.

[6] In France, the country to which these models will be applied, most collective agreements are not restricted to single firms or narrowly defined industries. Some agreements cover firms participating in an extremely broad range of product markets (such as the metallurgy agreements or the buildings and public works agreements). Others are designed to apply to certain levels in the hierarchy of a firm regardless of sector, most notably the "cadres", or managers and supervisors agreements. For this reason, we discount the possibility that firms participate in the negotiations with the end goal of using a uniform input price to facilitate product market collusion among association members. Instead, we treat all firms as price takers with the objective of cost minimization.

Table 2.1: List of Notation

Variable	Interpretation
C	Expected compensation cost (prior to bargaining)
c	Cost of membership in the employers association (per worker)
Π_1	Probability that the collective agreement will be extended
Π_2	Probability that a firm that disobeys is caught
P	Penalty charged to the firm, over and above back wages, if it is caught disobeying the extension order (in currency units per worker)
W_L	Market wage rate
W_H	Negotiated wage rate when the employers association consists of exclusively efficient firms
W_M	Negotiated wage rate when the employers association consists of both efficient and inefficient firms
x	Opportunity (outside firm) wage rate
L	Amount of labor input (Employment within the firm)
y	Index of market conditions and macroeconomic variables
α	Efficiency parameter
γ	Union's bargaining power

Table 2.1: (continued)

Variable	Interpretation
ψ	Average revenue product of labor
$\tilde{\psi}$	Average revenue product of labor for an employers association member
θ	Proportion of "more efficient" firms in the industry (dichotomous model)
τ	Proportion of "more efficient" firms in the employers association (dichotomous model)
Ω	Total number of firms in the employers association (dichotomous model)
r	Rental cost of a unit of capital (continuous model)
K	Amount of capital input (continuous model)
s	Productivity parameter (continuous model)
ξ	Mean of the support of the uniform distribution of the efficiency parameter (continuous model)
β	Spread of the support (b-a) of the uniform distribution of the efficiency parameter (continuous model)

The first expression in equation (3.1) corresponds to the firm's expected compensation cost if it chooses the strategy (out,obey); i.e. the firm decides not to be in the employers association, but if the contract is extended, it will obey the extension order and implement the negotiated contract. The second expression represents the firm's expected compensation costs if it follows the strategy (out,disobey); i.e. it does not partake in the bargaining and will disobey the extension order if the collective agreement is extended, risking the possibility of having to make up back wages at the negotiated level and pay a fine (P). The third expression (in,obey) represents the standard case of a firm that participates in bargaining and implements the resulting contract. The last alternative (in,disobey) represents the case where a firm decides to participate in the negotiations (with the intention of lowering the collectively bargained wage) but does not implement the contract resulting from the bargaining and risks having to pay the (lower negotiated) back wages plus the penalty[7]. The derivations of these expressions will be developed in the rest of this section.

We now need some sense of firm profits under the different alternative strategies (i.e. payoffs to the firm). That means we need to know W_H and W_M (W_L is equal to the opportunity wage x), as well as Π_1, Π_2 and P. In this model, we take revenue $R(y, \alpha, L)$ to be a function of the amount of labor input (L), market conditions (y) and a parameter that reflects the efficiency of the firm (α), where a high α implies a more efficient production process and a low α implies a less efficient one. R is also assumed to be increasing in labor at a decreasing rate, i.e. $\frac{\partial R}{\partial L} \geq 0$ and $\frac{\partial^2 R}{(\partial L)^2} \leq 0$. We assume that the negotiated contracts are strongly efficient[8], which implies that the amount of labor employed is independent of the wage resulting from the bargaining; the firm employs whatever level of labor equates marginal revenue product of labor with the opportunity wage rate. Call this amount of labor input $\widehat{L}_\alpha$ (since it is different for different α 's) and the revenue that corresponds to employing $\widehat{L}_\alpha$ units of labor $\widehat{R}_\alpha$. Given that $\widehat{L}_\alpha$ is the efficient labor input, we know that the contract wage must fall within the range $x \leq W \leq \frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c$, since any wage below x would be refused by the union (its members can always opt for the opportunity wage) and any wage above $\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c$ will be rejected by the firm (it would be earning negative profits)[9]. The actual agreed-upon wage depends on the bargaining power of the union (γ)[10] and on the composition of the employers association[11]. A union with bargaining power γ can extract γ

[7] We are assuming that the penalty for disobeying an extension order and the penalty for not implementing a contract to which one was a signatory are identical, although for a risk neutral firm this need only be true in expectation.

[8] For tests of the empirical validity of strongly efficient contracting, see Brown and Ashenfelter (1986) [?] and MaCurdy and Pencavel (1986) [?].

[9] Also implicit here is the assumption that $x \leq \frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c$ for all relevant α. This seems to be a reasonable assumption, since if $x > \frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c$, there is no way that the firm could continue to produce inside the employers association and still make non-negative profits. We can interpret this as a constraint on c.

[10] Although much effort has been devoted to estimating bargaining power (γ) (See, for example, Rose (1987) [?], Card (1986) [?]), surprisingly little attention has been paid to how this bargaining power is derived. Svejnar's (1986) [?] model is perhaps the most well known. In this paper, we will take the standard approach and ignore the sources of bargaining power, concentrating primarily on its measurement and implications for bargaining outcomes within the context of our model.

[11] We are assuming that the union is naive in the sense that, when it negotiates, it believes that all firms in the employers association with which it is negotiating are bargaining in good faith. In other words, the

percent of the available quasi rents per worker; that is to say that it receives the opportunity wage (x) plus γ times the difference between $\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c$ and x, or

$$W = x + \gamma\left(\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c - x\right) = (1-\gamma)x + \gamma\left(\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c\right). \tag{3.2}$$

As mentioned above, more and less efficient firms are distinguished by the parameter α. As long as $\frac{\partial^2 R}{(\partial L)^2} < 0$, there will be a one-to-one relationship between α and the average revenue product of labor, i.e. $\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha}$, and an analogous one-to-one relationship between α and $\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c$, which is the average revenue product of labor after having accounted for the membership cost of the employers association[12]. In other words, those firms for which $\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha}$ (and thus $\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c$) is in some sense "large" are regarded as more efficient; those for which $\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha}$ (and thus $\frac{\widehat{R}_\alpha}{\widehat{L}_\alpha} - c$) is in some sense "small" are regarded as less efficient. Since we assume that there are only two levels of efficiency, this corresponds to two different αs, and thus to two different average revenue products of labor and two different corresponding ex membership cost average revenue products of labor[13]. Denoting more and less efficient firms as HI and LO respectively, we also introduce the notation $\psi = \frac{\hat{R}}{\hat{L}}$ and $\tilde{\psi} = \frac{\hat{R}}{\hat{L}} - c$. Thus, for example, the ex membership cost average revenue product of labor of a more efficient firm will be written as $\tilde{\psi}^{HI}$, the average revenue product of labor at a less efficient firm will be ψ^{LO}, and so on.

Let the proportion of more efficient firms in the industry be called θ. If only the more efficient firms negotiate, the contract wage will be (using (3.2) and the notation from above)

$$W_H = (1-\gamma)x + \gamma\tilde{\psi}^{HI} \tag{3.3}$$

whereas if all of the less efficient firms join the employers association[14] and the ceiling on acceptable wage offers declines to the mean of the ex membership cost average revenue product of labor of the member firms in the association, then the contract wage will be

union believes that the negotiated contract will be implemented by all of the signatories and does not take into account during negotiations the fact that some firms may disobey the provisions of the contract. In the real world, this assumption is reflected in the fact that by far the majority of visits by labor inspectors are the result of complaints by union members, union delegates and personnel delegates. Thus, unions can be viewed as relying upon their members (and other employees) to guarantee compliance. In a country with union membership rates as low as those of France (under 15 percent by most estimates), this may result in unions negotiating in good faith and firms negotiating with the knowledge that they can always decide to disobey the provisions of the collective agreement.

[12]This is a sufficient, although not a necessary, condition.

[13]Recall that, in strongly efficient contracting models, the average revenue product of labor less the opportunity wage (x) is the same as the quasi rent per worker of a firm that does not belong to an employers association. Similarly, the ex membership cost average revenue product of labor less the opportunity wage (x) is the same as the quasi rent per worker of a firm that is a member of the employers association.

[14]Abowd and Kramarz (1992) [**?**] show that, in France, the presence of a firm level agreement is associated with significantly higher quasi rents and quasi rents per worker, both of which are positively correlated with efficiency. The most efficient firms are also the firms that have the most to lose in the event of a strike or slowdown. Thus we assume that the employers association consists of a core of efficient firms that have overriding reasons to participate in the negotiations, plus however many inefficient firms decide to join. When we derive the systems of equations to be estimated for the continuous model (at the end of section 4),

$$W_M = (1-\gamma)x + \gamma\left(\theta\tilde{\psi}^{HI} + (1-\theta)\tilde{\psi}^{LO}\right). \tag{3.4}$$

This expression is the result of the distribution of $\tilde{\psi}$s of firms in the association being binomial, so the expectation of the association's $\tilde{\psi}$ is just a linear combination of the $\tilde{\psi}$s of the member firms, with the weight placed on each type corresponding to the proportion of the association that is actually comprised of that type[15].

Of course, there is no reason to assume a priori that all less efficient firms will necessarily join the employers association at the same time. Less efficient firms should join until the marginal expected compensation cost associated with being in the association and the marginal expected compensation cost associated with taking the best of the two alternatives that involve not joining the association are equal. However, it should be apparent that after each less efficient firm joins the association, the marginal cost to the next firm of joining the association *decreases* as the contract curve shortens[16], and it continues to shrink with each firm that joins. Meanwhile, since the probability of extension is assumed to be independent of the size and composition of the association and is less than or equal to 1, and since $\Pi_2 \leq 1$, the cost associated with not joining decreases at best as fast as (when $\Pi_1 = 1$ and $\Pi_2 = 1$), and most likely slower than (when $\Pi_1 < 1$ and/or $\Pi_2 < 1$), the cost associated with joining does for the same increase in the share of less efficient firms than the cost associated with joining. Given these facts and the within-α group homogeneity of the firms, we have a knife-edge situation, where if one less efficient firm finds it beneficial to join, all less efficient firms will join, and we can talk about there being only two bargained wages, W_H and W_M, as expressed in (3.3) and (3.4) above.

We can now discuss some implications for policy that can be drawn from the model developed so far. It can be shown that if the government wants to prevent firms from dis-

we operationalize this assumption by introducing two variables. The first, b, represents the efficiency level (α) of the most efficient firm in the association. The second, a, represents the ratio of the α of the least efficient firm in the association (who is a member by choice) to that of the most efficient firm, who is not necessarily negotiating for the same reasons.

[15] In fact, a better way of weighting the firms in the association when calculating expected quasi rents per worker from the point of view of the union (one should always have a basic strike model at the back of one's mind) might be to weight by employment (i.e. multiply each firm's $\tilde{\psi}$ by its share of total covered employment), since that should also play a role in the union's objective function. If this were to be done, since more efficient firms employ more workers (under the assumed conditions on the revenue function), the negotiated W_M would put more weight on the more efficient firms' $\tilde{\psi}$. The result would be a $\widehat{W_M}$ which would be at least as large as W_M above, but would depend explicitly on the R selected. In the continuous case (section 4), we choose a particular functional form for R, and thus we can derive the "properly" weighted expectation.

[16] Recall that in efficient contracting models, the negotiated agreement lies on the contract curve. That means that the contract's wage-employment combination must be Pareto optimal or, in the case of an interior solution, the marginal rates of substitution between employment and wages for both parties must be equal for any negotiated contract. It also means that the negotiated contract must lie along the contract curve between the union's and the employers association's threat points. When more inefficient firms join the association, the wage rate necessary to drive the mean firm's profits to zero declines. Under strongly efficient contracting, this implies that the employers association's threat point decreases, while that of the union rests unchanged. Hence, the two contract curves share a common lower end point, but the one relevant to the association containing more inefficient firms has a lower upper end point, and giving the union γ of this (smaller) surplus, assuming that γ does not change, means that the negotiated wage will be lower.

obeying the extension order (i.e. make obeying the law incentive compatible), the following statement must be true[17]:

$$\gamma\left(\tilde{\psi}^{HI}-x\right) \leq \left[\frac{\Pi_2}{1-\Pi_2}\right] P. \tag{3.5}$$

Note that nothing on the left-hand side of the expression is explicitly under the control of the government (although in some sectors the government is practically a monopsonist and thus might impact R, and its control over the minimum wage and unemployment benefits may also have some influence on x). However, by hiring more labor inspectors it can (in theory) increase Π_2, and by increasing penalties for firms caught disobeying extension orders and not implementing contracts it increases P. Which of these alternatives it might choose to inspire compliance depends upon both the costs of each alternative and the level of its complement (the iso-expected penalty curves are conic sections).

The less efficient firm must select one of the four alternatives presented in (3.1) above. Given what we know from (3.3) and (3.4) and using the following substitutions:

$$\Delta^1 = \tilde{\psi}^{HI} - x$$

$$\Delta^2 = \tilde{\psi}^{HI} - \tilde{\psi}^{LO}$$

$$\Delta^3 = \tilde{\psi}^{LO} - x,$$

we can derive the following sets of criteria that, when satisfied, determine which strategy the less efficient firm will select.

$$\underline{(\text{in}, \text{obey})}$$

$$\begin{array}{rcrrr} -c & + & \Pi_1\gamma\Delta^1 - & \theta\gamma\Delta^2 - & \gamma\Delta^3 \geq \\ (\Pi_1\Pi_2 P - c) & + & \Pi_1\Pi_2\gamma\Delta^1 - & \theta\gamma\Delta^2 - & \gamma\Delta^3 \geq \\ \Pi_2 P & + & 0\gamma\Delta^1 - & \theta\,(1-\Pi_2)\gamma\Delta^2 - & (1-\Pi_2)\gamma\Delta^3 \geq \end{array} \tag{3.6}$$

$$\underline{(\text{in}, \text{disobey})}$$

$$\begin{array}{rcrrr} c + \Pi_2 P & - & \Pi_1\gamma\Delta^1 + & \Pi_2\theta\gamma\Delta^2 + & \Pi_2\gamma\Delta^3 < \\ c + (1-\Pi_1)\,\Pi_2 P & - & \Pi_1\Pi_2\gamma\Delta^1 + & \theta\Pi_2\gamma\Delta^2 + & \Pi_2\gamma\Delta^3 < \\ \Pi_2 P & + & 0\gamma\Delta^1 - & \theta\,(1-\Pi_2)\gamma\Delta^2 - & (1-\Pi_2)\gamma\Delta^3 < \end{array} \tag{3.7}$$

[17] In fact, this is one of two conditions on P, but it is the only binding one. This condition represents the decision between (out, obey) and (out, disobey). The condition that represents the decision between (in, obey) and (in, disobey) is

$$\gamma\left(\theta\psi^{HI} + (1-\theta)\psi^{LO} - c - x\right) \leq \left[\frac{\Pi_2}{1-\Pi_2}\right] P,$$

but for all $\theta < 1$, the left-hand side of this expression is smaller than the left-hand side of (3.5) above, and for $\theta = 1$, the two expressions are identical.

$$\underline{(\text{out, disobey})}$$

$$\begin{array}{rcrrr} \Pi_2 P & - & (1-\Pi_2)\gamma\Delta^1 + & 0\gamma\Delta^2 + & 0\gamma\Delta^3 < \\ (\Pi_1\Pi_2 P - c) & + & \Pi_1\Pi_2\gamma\Delta^1 - & \theta\gamma\Delta^2 - & \gamma\Delta^3 < \\ c + (1-\Pi_1)\,\Pi_2 P & - & \Pi_1\Pi_2\gamma\Delta^1 + & \theta\Pi_2\gamma\Delta^2 + & \Pi_2\gamma\Delta^3 \geq \end{array} \tag{3.8}$$

$$\underline{(\text{out, obey})}$$

$$\begin{array}{rcrrr} \Pi_2 P & - & (1-\Pi_2)\gamma\Delta^1 + & 0\gamma\Delta^2 + & 0\gamma\Delta^3 \geq \\ -c & + & \Pi_1\gamma\Delta^1 - & \theta\gamma\Delta^2 - & \gamma\Delta^3 < \\ c + \Pi_2 P & - & \Pi_1\gamma\Delta^1 + & \Pi_2\theta\gamma\Delta^2 + & \Pi_2\gamma\Delta^3 \geq \end{array} \tag{3.9}$$

4. The Case with a Continuum of Levels of Efficiency

Now let us consider the case where the firms in the industry have their efficiency parameters distributed uniformly over the interval $\left[\xi - \frac{\beta}{2}, \xi + \frac{\beta}{2}\right]$, and firms in the employers association have their efficiency parameters distributed uniformly over the interval $\left[\tilde{\xi} - \frac{\tilde{\beta}}{2}, \tilde{\xi} + \frac{\tilde{\beta}}{2}\right]$. For the sake of concreteness, we shall assume that all firms have log linear production functions in capital (K) and labor (L) with marginal products determined by s and the efficiency parameter α, i.e. $Q(L,K,\alpha) = \alpha s \log(L) + \alpha(1-s)\log(K)$. Hence, the revenue function can be written as

$$R(y,L,K,\alpha) = y\left[\alpha s \log(L) + \alpha(1-s)\log(K)\right].$$

This revenue function has the properties that $\frac{\partial R}{\partial L} > 0$ and $\frac{\partial^2 R}{(\partial L)^2} < 0$, for all $L > 0$ when y and α are strictly positive. Furthermore, this parameterization allows one to interpret the efficiency parameter α as being related to returns to scale. The parameter s can be interpreted as showing which factor, labor or capital, contributes the most in terms of marginal productivity to the production process. Given this revenue function, firm quasi rents (where r is the rental cost of a unit of capital) can be written as

$$\text{Quasi Rents} = y\left[\alpha s \log(L) + \alpha(1-s)\log(K)\right] - xL - rK - cL.$$

The efficient labor input, for each firm, is

$$\widehat{L_\alpha} = \frac{y\alpha s}{x+c} \tag{4.1}$$

and the efficient quasi rent per worker of a member firm can be expressed as

$$\frac{\widehat{R_\alpha} - x\widehat{L_\alpha} - rK - c\widehat{L_\alpha}}{\widehat{L_\alpha}} = (x+c)\left[\log Q + \frac{1}{s}\log\left(\frac{y\alpha\,(1-s)}{er}\right)\right] \tag{4.2}$$

where

$$Q = \frac{sr}{(1-s)\,(x+c)}.$$

Notice that the second derivative of this expression (with respect to α) is not identically zero, and thus although the distribution of the efficiency parameter is uniform, the distribution of quasi rents per worker of member firms is not.

Because we are now dealing with a continuum of efficiencies, we can no longer talk about the expected quasi rent per worker for firms in the employers association as simply being $\tau\tilde{\psi}^{HI} + (1-\tau)\tilde{\psi}^{LO} - x$. Instead, if we try to calculate the weighted expected quasi rent per worker (as suggested in footnote 15), we must first calculate what share in the total employment of the employers association each firm represents. We begin by noticing that it is easy to show[18] that

$$L_{EA} = \frac{ys\tilde{\beta}\tilde{\xi}}{\overline{x}+c},$$

where L_{EA} is the total employment of the employers association. Weighting each firm in the association by the proportion of the association's employment that it represents, the contribution of each firm to the expected weighted quasi rent per worker for a firm in the association becomes simply the ratio of the firm's revenues net of membership, capital and employment cost (billed at the opportunity wage) to total association employment. Thus the weighted expected quasi rent per worker (E_W) for member firms is[19]

$$E_W\left(\frac{\widehat{R_\alpha}-x\widehat{L_\alpha}-rK-c\widehat{L_\alpha}}{\widehat{L_\alpha}}\right) = \frac{\overline{x}+c}{2s}\left\{\log\left[\frac{ys\left(\tilde{\xi}^2-\frac{\tilde{\beta}^2}{4}\right)}{Q^{1-s}(\overline{x}+c)e^{\frac{3}{2}}}\right] + \frac{\tilde{\xi}^2+\frac{\tilde{\beta}^2}{4}}{\tilde{\xi}\tilde{\beta}}\log\left(\frac{\tilde{\xi}+\frac{\tilde{\beta}}{2}}{\tilde{\xi}-\frac{\tilde{\beta}}{2}}\right)\right\}. \tag{4.3}$$

It can be shown that

$$\frac{\partial\left[E_W\left(\frac{\widehat{R_\alpha}-x\widehat{L_\alpha}-rK-c\widehat{L_\alpha}}{\widehat{L_\alpha}}\right)\right]}{\partial\tilde{\xi}} = \frac{\overline{x}+c}{2s\tilde{\xi}}\left[\frac{3\tilde{\xi}^2+\frac{\tilde{\beta}^2}{4}}{\tilde{\xi}^2-\frac{\tilde{\beta}^2}{4}} + \frac{\tilde{\xi}^2-\frac{\tilde{\beta}^2}{4}}{\tilde{\xi}\tilde{\beta}}\log\left(\frac{\tilde{\xi}+\frac{\tilde{\beta}}{2}}{\tilde{\xi}-\frac{\tilde{\beta}}{2}}\right)\right], \tag{4.4}$$

which is positive, and

$$\frac{\partial\left[E_W\left(\frac{\widehat{R_\alpha}-x\widehat{L_\alpha}-rK-c\widehat{L_\alpha}}{\widehat{L_\alpha}}\right)\right]}{\partial\tilde{\beta}} = \frac{\overline{x}+c}{2s\tilde{\beta}}\left[1-\frac{\tilde{\xi}^2-\frac{\tilde{\beta}^2}{4}}{\tilde{\xi}\tilde{\beta}}\log\left(\frac{\tilde{\xi}+\frac{\tilde{\beta}}{2}}{\tilde{\xi}-\frac{\tilde{\beta}}{2}}\right)\right], \tag{4.5}$$

which is of indeterminate sign.

[18]It is not necessarily the case that all firms face the same opportunity wage or rental rate of capital. We assume, however, that the opportunity wage and rental rate of capital faced by a given firm are independent of its efficiency parameter α, and have a means of $\overline{x}$ and $\overline{r}$ respectively.

[19]The simple expectation can be expressed as

$$E\left(\frac{\widehat{R_\alpha}-x\widehat{L_\alpha}-rK-c\widehat{L_\alpha}}{\widehat{L_\alpha}}\right) = \frac{\overline{x}+c}{s}\left\{\log\left[\frac{ys\left(\tilde{\xi}^2-\frac{\tilde{\beta}^2}{4}\right)^{\frac{1}{2}}}{Q^{1-s}\left(\overline{x}+c\right)e^2}\right] + \frac{\tilde{\xi}}{\tilde{\beta}}\log\left[\frac{\tilde{\xi}+\frac{\tilde{\beta}}{2}}{\tilde{\xi}-\frac{\tilde{\beta}}{2}}\right]\right\}.$$

Throughout the rest of the section, however, we will deal exclusively with the weighted expectation when in the context of the continuous model.

The fact that the derivative with respect to $\tilde{\xi}$ is positive is intuitively appealing. This implies that as the distribution of efficiency parameters shifts up, the expected quasi rent per worker, weighted by employment share, increases. Unfortunately, since the derivative with respect to $\tilde{\beta}$ is of indeterminate sign, we cannot yet say what would happen to the weighted expected quasi rent per worker if we were to add a firm whose efficiency parameter was only marginally below that of the least efficient firm in an existing employers association.

We can reparameterize, allowing b to be the value of α of the most efficient firm in the employers association (i.e. $b = \tilde{\xi} + \frac{\tilde{\beta}}{2}$) and a to be the percentage of the most efficient firm in the association's α possessed by the least efficient firm in the association (i.e. $ab = \tilde{\xi} - \frac{\tilde{\beta}}{2}$). Under this parameterization, we can rewrite (4.3) above as

$$E_W = \frac{\overline{x}+c}{2s}\log(y) + \frac{\overline{x}+c}{2s}\left\{\log\left[\frac{ab^2 s}{Q^{1-s}(\overline{x}+c)e^{\frac{3}{2}}}\right] + \frac{1+a^2}{1-a^2}\log(a)\right\}.$$

We can also directly address the question of what will happen to the weighted expected quasi rent per worker when an additional firm whose α is only marginally less than the least efficient firm directly. $\frac{\partial E_W}{\partial a}$ can be expressed as

$$\frac{\partial E_W}{\partial a} = \frac{(\overline{x}+c)\,a\,(a^2-1-2\log(a))}{s\,(a^2-1)^2},$$

which is of positive sign since a is constrained to lie between 0 and 1..

In the context of the continuum of efficiencies, it is useful to take a second look at the decision problem facing the firm. Rewriting (3.1) with the substitutions appropriate to the continuous model yields

$$\min C = [(\text{out}, \text{obey}), (\text{out}, \text{disobey}), (\text{in}, \text{obey}), (\text{in}, \text{disobey})], \tag{4.6}$$

where

$$\begin{aligned}
(\text{out}, \text{obey}) &= \Pi_1[\overline{x} + \gamma E_W] + (1-\Pi_1)x \\
(\text{out}, \text{disobey}) &= \Pi_1[\Pi_2(\overline{x} + \gamma E_W + P) + (1-\Pi_2)x] + (1-\Pi_1)x \\
(\text{in}, \text{obey}) &= c + \overline{x} + \gamma\left(E_W - \tfrac{\partial E_W}{\partial a}\right) \\
(\text{in}, \text{disobey}) &= c + \Pi_2\left[\overline{x} + \gamma\left(E_W - \tfrac{\partial E_W}{\partial a}\right) + P\right] + (1-\Pi_2)x,
\end{aligned}$$

This new set of expressions uses the fact that we allow only one employers association per sector and that the efficiency parameters of the member firms form a continuum, and makes use of the assumption that we start looking at firms from the most efficient down[20], so that each firm is faced with joining an employers association composed exclusively of firms more efficient than it. Hence, if the marginal firm were to join, the weighted expected quasi rent per worker for member firms would change by $-\frac{\partial E_W}{\partial a}$.

We can now write the conditions analogous to equations (3.6), (3.7), (3.8) and (3.9) for the continuous case. They are as follows.

[20]This is consistent with the idea that duty to bargain laws oblige at least the most efficient firms to negotiate

$$\underline{(\text{in}, \text{obey})} \tag{4.7}$$

$$\begin{array}{rcrcl}
\Pi_2 P & + & (1-\Pi_2)\gamma\frac{\partial E_W}{\partial a} & + & (1-\Pi_2)[(x-\overline{x})-\gamma E_W] \geq \\
-c & + & \gamma\frac{\partial E_W}{\partial a} & + & (1-\Pi_1)[(x-\overline{x})-\gamma E_W] \geq \\
(\Pi_1\Pi_2 P - c) & + & \gamma\frac{\partial E_W}{\partial a} & + & (1-\Pi_1\Pi_2)[(x-\overline{x})-\gamma E_W] \geq
\end{array}$$

$$\underline{(\text{in}, \text{disobey})} \tag{4.8}$$

$$\begin{array}{rcrcl}
\Pi_2 P & + & (1-\Pi_2)\gamma\frac{\partial E_W}{\partial a} & + & (1-\Pi_2)[(x-\overline{x})-\gamma E_W] < \\
-(c+\Pi_2 P) & + & \Pi_2\gamma\frac{\partial E_W}{\partial a} & + & (\Pi_2-\Pi_1)[(x-\overline{x})-\gamma E_W] \geq \\
[(\Pi_1-1)\,\Pi_2 P - c] & + & \Pi_2\gamma\frac{\partial E_W}{\partial a} & + & (1-\Pi_1)\,\Pi_2[(x-\overline{x})-\gamma E_W] \geq
\end{array}$$

$$\underline{(\text{out}, \text{disobey})} \tag{4.9}$$

$$\begin{array}{rcrcl}
(\Pi_1\Pi_2 P - c) & + & \gamma\frac{\partial E_W}{\partial a} & + & (1-\Pi_1\Pi_2)[(x-\overline{x})-\gamma E_W] < \\
[(\Pi_1-1)\,\Pi_2 P - c] & + & \Pi_2\gamma\frac{\partial E_W}{\partial a} & + & (1-\Pi_1)\,\Pi_2[(x-\overline{x})-\gamma E_W] < \\
\Pi_1\Pi_2 P & + & 0\,\gamma\frac{\partial E_W}{\partial a} & + & \Pi_1\,(1-\Pi_2)[(x-\overline{x})-\gamma E_W] <
\end{array}$$

$$\underline{(\text{out}, \text{obey})} \tag{4.10}$$

$$\begin{array}{rcrcl}
-c & + & \gamma\frac{\partial E_W}{\partial a} & + & (1-\Pi_1)[(x-\overline{x})-\gamma E_W] < \\
-(c+\Pi_2 P) & + & \Pi_2\gamma\frac{\partial E_W}{\partial a} & + & (\Pi_2-\Pi_1)[(x-\overline{x})-\gamma E_W] < \\
\Pi_1\Pi_2 P & + & 0\,\gamma\frac{\partial E_W}{\partial a} & + & \Pi_1\,(1-\Pi_2)[(x-\overline{x})-\gamma E_W] \geq
\end{array}$$

We now have a set of equations for which the parameters can be estimated.

In principle, r, K, x and the state of the firm can be determined from the data, a, b, c, P, s, γ, Π_1 and Π_2 are parameters, and y is a random variable upon which we can impose a distribution. In addition, notice that the random variable y appears in the sets of equations (4.7), (4.8), (4.9) and (4.10) only in the E_W term as $\log(y)$. Thus if we were to impose a lognormal distribution on y and some other distribution on one of the parameters[21], we would find ourselves with a highly nonlinear (but estimable) bivariate two-dimensional choice limited dependent variable model.

[21] In section 6 we allow P to be distributed exponential with parameter $\overline{P}$.

Table 5.1: Descriptive Statistics (Std. Dev. in Parenthesis)

	IO	OO	ID	OD	Total
% of Sample	47.1	49.7	1.5	1.7	100
Number of Enterprises	1802	1901	58	66	3827
Tot. Employment (by estab.)	438.5 (1547.8)	177.7 (3497.7)	572.8 (1294.0)	102.4 (160.9)	305.2
Tot. Employment (by ent.)	4149.0 (10737.3)	3780.2 (10080.1)	154.9 (148.1)	199.1 (245.3)	3837.1
Real Rental Cost of Capital Index	176.6 (27.4)	169.7 (22.6)	170.9 (26.6)	166.6 (17.8)	172.9 (25.2)
Opp. Comp. Cost per worker, 1000s of 1980 Francs	125.1 (1.9)	125.1 (1.9)	125.2 (1.8)	124.7 (2.1)	125.1 (1.9)
Units of Capital Used	14157 (183073)	9334 (111885)	206 (247)	277 (418)	11310 (148375)

IO=(In,Obey); OO=(Out,Obey); ID=(In,Disobey); OD=(Out,Disobey);
Sources: State-La Base, Données Annuelles Salariales (DAS), Enquête sur la Structure des Salaires (ESS) and author's calculations; Total Employment (by establishment)-ESS; Total Employment (by enterprise)-Bénéfices Industriels et Commerciaux (BIC); Rental Cost of Capital-Banque de Données Macroéconomiques (BDM); Opportunity Compensation Cost-DAS and author's calculations; Value of Capital Used-BIC

5. The Data

The data used in the estimation of the maximum likelihood model described above were derived from sources provided by France's Institut National de Statistique et des Etudes Economiques (INSEE) and Ministère du Travail. In total, 3,827 French enterprises from 1986 were included in the sample. Descriptive statistics appear in table 5.1, broken down by state (e.g. (in,obey), (out,obey), (in disobey), (out,disobey)), and a cross-tabulation table appears as table 5.2.

The first obvious point worth noting is the very small percentage of firms in our sample that disobey. This is due largely to the way in which the obey-disobey dimension of the state variable is determined. The details are discussed in appendix A.1, but the basic idea is that we compared actual net salaries (as reported by the firm in its tax forms) with a weighted average of the net salary minima drawn from collective agreements that applied to a particular occupation in a particular sector of the economy. In cases where the actual salary

Table 5.2: In-Out and Obey-Disobey Cross-tabulation

	In	Out	Total
Obey	1802 47.1%	1901 49.7%	3703 96.8%
Disobey	58 1.5%	66 1.7%	124 3.2%
Total	1860 48.6%	1967 51.4%	3827 100%

paid was lower than the weighted average, we classed the firm as disobedient. Unfortunately, we could not determine exactly how much each employee at each of our 3827 firms should have been paid according to the specific agreement(s) that applied to him or her. Furthermore, it is difficult to detect firms that are marginally disobedient (as described in the introduction) by any means, let alone through the self-reported tax data we use in determining the state of a firm. Finally, we are obliged to use minimum negotiated salaries stripped of all bonuses and premiums in computing benchmark contractual salaries. Hence we are surely overstating the proportion of firms in the "obey" categories, although there is little we can do to correct for this problem.

The next point of interest is the fact that the variable used for the rental cost of capital is actually a unitless relative index, i.e. each sector is given a value for the cost of a unit of capital in that sector at that date, as relative to an all-sector mean in the base year 1980. We can use this index, along with information on the value of capital used, to create a variable that describes the real value of capital in terms of a unit of capital generic to all industries, but we would still need to know how much that "unit" of capital costs in order to calculate the amount of capital used. Unfortunately, we could not determine how much this "unit" cost from our data sources, so we were forced to apply an arbitrary scaling constant to the price of capital index in order to generate a unitless amount of capital used variable (K in our model).

The data suggest several interesting contrasts between negotiating and non-negotiating, and between obedient and disobedient firms. First, by both our employment by enterprise and value of capital variables, it seems that the bigger firms, on average, are more obedient. This conclusion is not surprising, for two main reasons.

First, the larger a firm is (particularly as measured by number of employees), the more likely it is to be subjected to a "random" inspection, and the more people there are to lodge complaints with the Minister of Labor if the firm is blatantly disobedient. That would imply that large firms face a higher probability of getting caught in disobedience (Π_2) than small firms. Ceteris paribus, this should reduce the proportion of large firms that disobey, which is what our data shows. In the estimation of our model, however, we assume that the probability of getting caught is independent of firm size, so this point (in conjunction with the fact that the vast majority of firms in the sample are obedient) might instead lead us to conclude that our eventual estimate of Π_2 could be biased upwards.

The second possible explanation for the preponderance of large firms in the "obey" categories lies in the difficulty of detecting marginally disobedient firms. A large firm, for the reasons described above among others, has a greater incentive to “restructure” its work force to get around having to pay the higher negotiated wages than a smaller firm. Thus it is more likely that larger firms, although perhaps just as disobedient as smaller firms, are going about not paying what they should by means that are difficult to detect empirically. In other words, if we could better measure which firms were marginally disobedient, we might find that there was no real distinction between obedient and disobedient firms on the basis of size.

As far as the distinction between negotiating and non-negotiating firms is concerned, there appear to be cleavages along both establishment-level employment lines and in terms of the real rental cost of capital. As far as the difference in establishment-level employment is concerned, one explanation lies in the method in which the negotiating/non-negotiating dimension is determined. Among the labor legislation passed in France in 1982 (commonly called the Auroux laws, after the Minister of Labor at the time), was a requirement that all enterprises employing over 50 employees hold annual negotiations over various issues, many of which overlap the national level agreements[22]. As discussed in appendix A.1, our measure of the in/out dimension is based on the response to a survey question about the obligation to bargain. Thus it is not surprising that the firms not obligated to bargain (those with under 50 employees in the establishment questioned) should pull down the average employment by establishment for non-negotiating employers.

Finally, table 5.1 points towards a pattern in rental costs of capital, namely that the average firm that negotiated collective agreements was faced with a higher rental cost of capital than the average non-negotiating firm. There are many potential explanations for why this might be the case, such as these firms could be the ones that have invested the most heavily in newer technologies. This could be taken to support the idea that the employers association forms from the most efficient firms down, since under that hypothesis the average firm that negotiates is more efficient than the average non-negotiator, and regardless of whether the firm decides to disobey or not, it could be using newer, more productive capital in its production process than the average non-negotiating firm.

6. Estimation of the Continuous Model

As is clear from the systems of equations (4.7), (4.8), (4.9) and (4.10), the likelihood function that is to be maximized is not going to be pretty. In this system, we have a total of eight parameters (a, b, c, P, s, γ, Π_1 and Π_2), while we only have four “explanatory” variables (K, x, r, and the state). Thus we are relying heavily upon the nonlinearity of the functional forms that go into the likelihood function for identification of our model.

In addition, we will need a second source of variability in order to obtain all four alternatives of our bi-dimensional choice model with positive probability. This second source of variability comes from imposing a distribution in P, which is equivalent to saying that firms do not know the penalty that might be imposed if they get caught cheating, but rather only have prior beliefs on the distribution of the penalty. We treat the mean of this distribution

[22]See Howell (1992) [?] for a discussion of the Auroux Laws and their impact on collective bargaining in France; see Abowd and Kramarz (1992) [?] for an econometric analysis of this sort of firm-level bargaining in France.

as a parameter that must be estimated.

Even though all of the parameters are identified by nonlinearity, each is subject to some sort of constraint. The probabilities (Π_1 and Π_2) are constrained to lie between 0 and 1, as are the three other "share" parameters (a, s and γ). The remaining parameters (b, c and $\overline{P}$) must be non-negative. We will put off discussing the manner in which these restrictions are imposed until appendix B. In the next section (section 6.1), we discuss the derivation of the likelihood function. We then describe and discuss the results of the estimation and some simulation exercises in section 6.2[23].

6.1. Calculation of the (Log) Likelihood function

Let us consider each option available to the firm, (in,obey), (in,disobey), (out,obey) and (out,disobey), as one of four states labelled IO, ID, OO and OD respectively. Let d_j^i be an indicator function that takes on the value 1 when firm i is in state j, and 0 otherwise. We shall denote the vector of firm specific variables r, K, x and the state (either IO, ID, OO or OD) as Ω_i, and the vector of the remaining parameters a, b, c, $\overline{P}$, s, γ, Π_1 and Π_2 as Θ. The parameters in Θ are the parameters to be estimated[24]. Given this notation, we can write each firm's contribution to the overall likelihood as

$$\mathrm{L}\left(\Omega_i,\Theta\right)=\prod_{j=IO,ID,OO,OD} P\left(cost_j^i \le \min_{k\neq j}\left\{cost_k^i\right\} \mid \Omega_i,\Theta\right)^{d_j^i}.$$

The overall likelihood can be written as

$$\mathrm{L}\left(\Theta\right)=\prod_{i=1}^{n}\left[\prod_{j=IO,ID,OO,OD} P\left(cost_j^i \le \min_{k\neq j}\left\{cost_k^i\right\} \mid \Omega_i,\Theta\right)^{d_j^i}\right]$$

and the log likelihood can be expressed as

$$L\left(\Theta\right)=\sum_{i=1}^{n}\sum_{j=IO,ID,OO,OD} d_j^i \,\log\left[P\left(cost_j^i \le \min_{k\neq j}\left\{cost_k^i\right\} \mid \Omega_i,\Theta\right)\right]. \tag{6.1}$$

The probability of a state's occurrence is simply equal to the probability that *all* of the corresponding inequalities for the sets of equations (4.7), (4.8), (4.9) and (4.10) hold. Notice that there are really only 6 different inequalities that are used to define the states. Each of these can be rewritten so as to isolate the (log of the) random variable y on one side of the inequality, while writing some complicated nonlinear function of the parameters and data on the other side. These equations are all of the form

$$\begin{aligned}\log(y) \le\ & \tfrac{2s(x-\overline{x})}{\gamma(\overline{x}+c)}+\tfrac{1+a^2}{1-a^2}\log(a)+\log\left[\tfrac{Q^{1-s}(\overline{x}+c)e^{\frac{3}{2}}}{ab^2s}\right]\\ &+\tfrac{2sf}{(\overline{x}+c)\gamma h}+\tfrac{2a\left(a^2-1-2\log(a)\right)g}{(a^2-1)^2h}\end{aligned} \tag{6.2}$$

[23] The algorithms used in the estimation procedure are described in appendix B.

[24] An implicit assumption here is that these parameters are identical for all firms in the economy. This is an obvious simplification, since at least the union's bargaining power parameter (γ), and probably the parameters a, b, c, s, and Π_1 as well, are likely to vary from sector to sector, and Π_1 and Π_2 may well vary with firm size. However, since there are over 100 different industries covered by the data and firms of all different sizes, this would entail estimating a vector of parameters well over 500 elements long and, depending on the optimization routine selected, maybe even inverting a 500 by 500 matrix. Computationally, this is extremely time consuming, if not impossible.

where

Equation	f	g	h
IOID	$\Pi_2 P$	$1-\Pi_2$	$1-\Pi_2$
IOOD	$\Pi_1\Pi_2 P - c$	1	$1-\Pi_1\Pi_2$
IOOO	$-c$	1	$1-\Pi_1$
IDOO	$-(c+\Pi_2 P)$	Π_2	$\Pi_2-\Pi_1$
OOOD	$\Pi_1\Pi_2 P$	0	$\Pi_1(1-\Pi_2)$
IDOD	$(\Pi_1-1)\Pi_2 P - c$	Π_2	$(1-\Pi_1)\Pi_2$

These six inequalities are actually pairwise comparisons of each of the four states against the other three. A firm finds itself in state IO when the comparison inequalities IOID ((in,obey) versus (in,disobey)), IOOO ((in,obey) versus (out,obey)) and IOOD ((in,obey) versus (out,disobey)) all hold. It will choose state OD when neither IOOD, IDOD nor OOOD hold. In cases where $\Pi_1 < \Pi_2$, it will choose state OO when OOOD holds but IDOO and IOOO do not, and state ID when IDOD and IDOO hold but IOID does not. When $\Pi_1 > \Pi_2$, the firm will choose OO when OOOD and IDOO hold but IOOO does not, and ID when IDOD holds but IDOO and IOID do not. And, finally, when $\Pi_1 = \Pi_2$, the cost of OO relative to ID is invariant to changes in y. This means OO is chosen when OOOD holds, IOOO does not hold and the second inequality representing IDOO in either the system of equations (4.8) or (4.10) is positive, while ID is chosen when this inequality is negative, IDOD holds and IOID is violated[25].

Given this formulation, we can see that the right-hand side expressions of the inequalities defined in equation (6.2) actually define boundaries for regions of the domains of the random variables P and $\log(y)$. The probability of a firm finding itself in a certain state, given the parameter vector Θ and the vector of exogenous covariates Ω_i is thus the probability that the random variables fall between the boundaries that determine that state. Figure **??** provides an example of how the various constraints described by equation (6.2) might partition the two-dimensional space of the random variables $\log(Y)$ and P.

For evaluation of the likelihood function, we shall suppose that y is distributed lognormal with parameters μ and σ (i.e. $\log(y) \sim \mathcal{N}(\mu, \sigma^2)$) and that P is distributed exponential with parameter $\frac{1}{\overline{P}}$, i.e. $P(P=p) = \frac{1}{\overline{P}} e^{-\frac{p}{\overline{P}}}$. We shall also define the following five additional indicator functions.

[25] These complications arise as a result of having to divide by h in order to arrive at equation (6.2). Fortunately, in the empirical implementation of the model, the probability that $\Pi_1 = \Pi_2$ is zero.

Figure 6.1: Partition of the Space of Random Variables

$$d_{OOID} = \begin{cases} 1 \text{ if } \Pi_1 \geq \Pi_2 \\ 0 \text{ if otherwise} \end{cases}$$

$$dOO1^i = \begin{cases} 1 \text{ if } \max\left(\mathrm{IOOO}\left(\Theta, \Omega_i\right), \mathrm{IDOO}\left(\Theta, \Omega_i\right), \right) < \mathrm{OOOD}\left(\Theta, \Omega_i\right) \\ 0 \text{ if otherwise} \end{cases}$$

$$dOO2^i = \begin{cases} 1 \text{ if } \min\left(\mathrm{OOOD}\left(\Theta, \Omega_i\right), \mathrm{IDOO}\left(\Theta, \Omega_i\right)\right) > \mathrm{IOOO}\left(\Theta, \Omega_i\right) \\ 0 \text{ if otherwise} \end{cases}$$

$$dID1^i = \begin{cases} 1 \text{ if } \min\left(\mathrm{IDOD}\left(\Theta, \Omega_i\right), \mathrm{IDOO}\left(\Theta, \Omega_i\right)\right) > \mathrm{IOID}\left(\Theta, \Omega_i\right) \\ 0 \text{ if otherwise} \end{cases}$$

$$dID2^i = \begin{cases} 1 \text{ if } \max\left(\mathrm{IOID}\left(\Theta, \Omega_i\right), \mathrm{IDOO}\left(\Theta, \Omega_i\right)\right) < \mathrm{IDOD}\left(\Theta, \Omega_i\right) \\ 0 \text{ if otherwise} \end{cases}$$

Now, the log likelihood function originally given by (6.1) can be expressed as

$$\begin{aligned} L\left[\Theta\right] = \quad & \textstyle\sum_{i=1}^{n} \{ \quad d_{IO}^{i} \log [\quad \Phi\left(\frac{\min(\mathrm{IOID},\mathrm{IOOD},\mathrm{IOOO})-\mu}{\sigma}\right)] \\ & + \quad d_{OD}^{i} \log [\quad 1-\Phi\left(\frac{\max(\mathrm{IOOD},\mathrm{OOOD},\mathrm{IDOD})-\mu}{\sigma}\right)] \\ & + d_{OOID} \{ \quad d_{OO}^{i} \log [\quad dOO1^{i}\left[\Phi\left(\frac{\min(\mathrm{OOOD},\mathrm{OOID})-\mu}{\sigma}\right)\right. \\ & \qquad \left. -\Phi\left(\frac{\mathrm{IOOO}-\mu}{\sigma}\right)\right]] \\ & + \quad d_{ID}^{i} \log [\quad dID1^{i}\left[\Phi\left(\frac{\mathrm{IDOD}-\mu}{\sigma}\right)\right. \\ & \qquad \left. -\Phi\left(\frac{\max(\mathrm{IOID},\mathrm{OOID})-\mu}{\sigma}\right)\right]]\} \\ & + \quad (1-d_{OOID}) \{ \quad d_{OO}^{i} \log [\quad dOO2^{i}\left[\Phi\left(\frac{\mathrm{OOOD}-\mu}{\sigma}\right)\right. \\ & \qquad \left. -\Phi\left(\frac{\max(\mathrm{IOOO},\mathrm{OOID})-\mu}{\sigma}\right)\right]] \\ & + \quad d_{ID}^{i} \log [\quad dID2^{i}\left[\Phi\left(\frac{\min(\mathrm{IDOD},\mathrm{OOID})-\mu}{\sigma}\right)\right. \\ & \qquad \left. -\Phi\left(\frac{\mathrm{IOID}-\mu}{\sigma}\right)\right]]\} \end{aligned} \tag{6.3}$$

6.2. Estimation Results

The results of the estimation appear in table 6.1. We also ran several simulations, perturbing each parameter from its estimated value. These simulations are presented in table 6.2.

The first point worth noting is the estimate of firm beliefs about the probability of contract extension to be. Π_1 is estimated to be 0.936 while the proportion the agreements in our sample that actually were extended is 0.693. This falls far outside of the 95 percent confidence interval, suggesting that firms seriously overestimate the probability that a contract will be extended to them. In fact, as our simulations suggest, if firms were to revise their

Table 6.1: Estimation Results With 95% Confidence Intervals

Parameter Symbol	Parameter Description	Estimate	
		-95%	+95%
	Likelihood Value	-3206.971	
a	Share of Most Efficient Firm's Productivity in Least Efficient Firm	0.012	
		0.012	0.012
b	Productivity Parameter of the Association's Most Efficient Firm	69.644	
		67.706	71.638
c	Membership Cost in the Employers Assoc. (FF/worker)	6.492	
		5.873	7.176
$\overline{P}$	Mean of Beliefs About the Penalty if Caught in Disobedience (FF/worker)	40,835.21	
		37,424.46	44,556.79
s	Share of Productivity Coming from Labor	0.995	
		0.995	0.995
γ	Union Bargaining Power	0.968	
		0.968	0.969
Π_1	Probability of Contract Extension	0.936	
		0.934	0.937
Π_2	Probability of Getting Caught in Disobedience	0.992	
		0.992	0.992

Table 6.2: Perturbations of the Parameters About their Estimated Values

Parameter Symbol	Base State	Perturbation Down			Perturbation Up		
		Change	P(In)	P(Obey)	Change	P(In)	P(Obey)
No Change	IO	0 %	0.4867	0.9676	0 %	0.4867	0.9676
	ID	0 %	0.4890	0.9676	0 %	0.4890	0.9676
	OO	0 %	0.4856	0.9676	0 %	0.4856	0.9676
	OD	0 %	0.4776	0.9675	0 %	0.4776	0.9675
a	IO	- 10 %	0.2167	0.9670	+ 10 %	0.7555	0.9683
	ID	- 10 %	0.2183	0.9670	+ 10 %	0.7572	0.9683
	OO	- 10 %	0.2158	0.9670	+ 10 %	0.7546	0.9683
	OD	- 10 %	0.2100	0.9669	+ 10 %	0.7482	0.9682
b	IO	- 10 %	0.7544	0.9706	+ 10 %	0.2463	0.9650
	ID	- 10 %	0.7561	0.9706	+ 10 %	0.2481	0.9650
	OO	- 10 %	0.7535	0.9706	+ 10 %	0.2454	0.9649
	OD	- 10 %	0.7471	0.9705	+ 10 %	0.2391	0.9649
c	IO	- 10 %	0.4869	0.9676	+ 10 %	0.4865	0.9676
	ID	- 10 %	0.4892	0.9676	+ 10 %	0.4887	0.9676
	OO	- 10 %	0.4858	0.9676	+ 10 %	0.4854	0.9676
	OD	- 10 %	0.4778	0.9675	+ 10 %	0.4773	0.9675
$\overline{P}$	IO	- 10 %	0.4867	0.9641	+ 10 %	0.4868	0.9705
	ID	- 10 %	0.4889	0.9641	+ 10 %	0.4890	0.9705
	OO	- 10 %	0.4855	0.9641	+ 10 %	0.4856	0.9705
	OD	- 10 %	0.4775	0.9640	+ 10 %	0.4776	0.9704
s	IO	- 0.5 %	0.2520	0.9649	+ 0.5 %	0.7187	0.9703
	ID	- 0.5 %	0.2536	0.9649	+ 0.5 %	0.7208	0.9703
	OO	- 0.5 %	0.2509	0.9648	+ 0.5 %	0.7180	0.9703
	OD	- 0.5 %	0.2445	0.9648	+ 0.5 %	0.7112	0.9702
γ	IO	- 1 %	0.4867	0.9679	+ 1 %	0.4867	0.9673
	ID	- 1 %	0.4890	0.9680	+ 1 %	0.4889	0.9673
	OO	- 1 %	0.4856	0.9679	+ 1 %	0.4856	0.9673
	OD	- 1 %	0.4775	0.9678	+ 1 %	0.4777	0.9672
Π_1	IO	- 1 %	0.0991	0.9668	+ 1 %	0.9501	0.9686
	ID	- 1 %	0.1001	0.9668	+ 1 %	0.9507	0.9686
	OO	- 1 %	0.0986	0.9668	+ 1 %	0.9498	0.9686
	OD	- 1 %	0.0952	0.9667	+ 1 %	0.9477	0.9685
Π_2	IO	- 10 %	0.4184	0.6035	+ 0.5 %	0.4871	0.9881
	ID	- 10 %	0.4205	0.6037	+ 0.5 %	0.4894	0.9881
	OO	- 10 %	0.4173	0.6034	+ 0.5 %	0.4860	0.9881
	OD	- 10 %	0.4098	0.6026	+ 0.5 %	0.4780	0.9881

beliefs about the probability of extension downward by even 1 percent (to 0.927), the probability that the mean obedient, negotiating firm would drop out of the employers association increases by a full 80 percent, and a downward revision of Π_1 by 5 percent will result in the probability of the mean firm in any category to be essentially nil[26]. On the other hand, if the beliefs of the mean disobedient, non-negotiating firm were to be revised upwards by 1 percent (to 0.945), the probability that this firm would join in the negotiations increases by 98 percent. Unfortunately, such an increase in beliefs about the probability of extension will only cause the probability of obedience for the same firm to increase by 0.10 percent.

Interestingly, it seems that maintaining such a high perception of getting caught is essential to obedience. Although the estimated probability that firms believe they will be caught in disobedience is quite high at 0.992, a 10 percent drop in this perceived probability (to 0.893) will cause the probability of obedience for the mean obedient, negotiating firm in our sample to decrease by 38 percent. Relaxing the penalty does not seem to have as dramatic an effect on obedience; a 10 percent decrease in $\overline{P}$ leads the mean negotiating obedient firm to decrease the probability it will obey an extension order or collective agreement by only 0.36 percent. Similarly, it seems that the best way for the government to improve obedience might be to try to nudge up the perceived probability of getting caught. A 0.5 percent increase in Π_2 leads the probability that the mean non-negotiating disobedient firm will change its mind and obey the extension order or agreement by 2.1 percent, while a 10 percent increase in $\overline{P}$ leads the same firm to increase the probability it will obey by only 0.30 percent.

A final set of interesting results center around the effect of the cost of joining the employers association on membership. Although the estimate of c is not very large (only 6.492 FF/worker), one might expect that increasing the membership cost would have an effect on membership in the association. This is not supported by our simulation results. An increase in c of 10 percent causes the mean obedient member to decrease the probability that it will join by only 0.04 percent. Similarly, decreasing the cost of membership does not seem to attract non-member firms very strongly. A drop in c of 10 percent leads the mean obedient non-member firm to increase the probability that it will join the association by only 0.04 percent. One interpretation of this result, coupled with the results on Π_1, is that membership in an employers association is much more a function of the fear that an extension order will be issued than whether joining is too costly or not. The extremely high estimate of the union's bargaining power parameter γ (0.968) seems to lend further credence to this argument, as the increase in costs for a non-member firm brought about by the issuance of an extension order increase monotonically in γ (see equation (4.6)).

7. Conclusion

We have seen that when the Minister of Labor in a country has the right to extend collective bargaining agreements to cover non-negotiating firms, the behavior of all firms in the country is affected. Sections 3 and 4 developed a theoretical model to explain how the presence of such a policy would affect firm behavior. The models described how the probability of extension affects the decision to participate in the negotiations via an employers association.

[26] P(In) is 0.000013 for the mean IO firm, 0.000014 for the mean ID firm, 0.000013 for the mean OO firm, and 0.000012 for the mean OD firm.

They also allowed firms the opportunity to disobey the extension order or the provisions of the collective agreements in whose negotiation they participated, and showed how this decision is affected by the probability of getting caught in disobedience and the size of the penalty assessed by the courts in the event the firm is caught disobeying an extension order or collective agreement.

Our empirical implementation of the bivariate two-dimensional discrete choice model revealed some interesting aspects about the behavior of French firms in 1986 in response to the presence of just such a policy. We found that firms seriously overestimate the probability that the Minister of Labor will exercise his right to extend collective agreements, but if they adjusted their belief to more accurately reflect the probability of extension nobody would bargain any longer, with all firms (except those obligated to bargain for other reasons) opting to risk the extension order. We also found that it is the risk of being caught, more than the size of the penalty, that seems to determine a firms decision whether or not to obey an extension order or collective agreement. However, we also showed that the government has very little room to manipulate this probability, as it is already very high (0.992), and any downward revision, even a small one, will dramatically increase the probability that firms will stop obeying extension orders and collective agreements.

Although it has not drawn much attention in the economics literature, it is clear that the policy of contract extension has a major impact on firm behavior in countries where such a right is made available to the Minister of Labor. In fact, contract extension is just one of the many policies found in Western European labor markets that are likely to impact firm behavior, and perhaps performance. Other such policies include regulations on works councils (such as those concerning worker participation in staffing and capital investment decisions) plant closure and workforce "conversion" requirements, and standard harmonization and capital flow liberation (which allow any European firm to produce from anywhere in the European Community, sell to anywhere else in the European Community, import and export capital as it likes to finance such projects), just to name a few. This extensive involvement of governments, be they national or transnational, in Western European markets make these countries ideal settings for policy analysis research.

Table A.1: Ministère de Travail Qualification Codes with related PCS Codes

Description	Qual. Level	PCS
1st level unskilled blue-collar worker	1	67, 68, 69
2nd level unskilled blue-collar worker	2	67, 68, 69
1st level skilled blue-collar worker	3	62, 63, 64, 65
2nd level skilled blue-collar worker	4	62, 63, 64, 65
1st level unskilled white-collar worker	5	55, 56
2nd level unskilled white-collar worker	6	55, 56
1st level skilled white-collar worker	7	54
2nd level skilled white-collar worker	8	54
1st level novice blue-collar supervisor	9	48
2nd level novice blue-collar supervisor	10	48
1st level confirmed blue-collar supervisor	11	48
2nd level confirmed blue-collar supervisor	12	48

Source: Ministère du Travail internal tables and PCS tables.

A. Compilation of the Data

A.1. Determination of the State of the Enterprise

The state of the firm was determined through the use of 3 different sources. The first is La Base, which is a collective bargaining data file maintained by the Ministère du Travail. This file reports minimum nominal salary grids as specified in French collective agreements; unfortunately this data base only covers collective agreements that applied to 10,000 or more people in 1985. La Base has its salary grids broken down into 22 standardized "qualification" levels (see table A.1). For each qualification level for each collective agreement covered (denoted by a separate identifier, or MT code), La Base provides a contractual minimum salary and often a minimum guaranteed salary, which includes extra premiums and bonuses that apply to all workers in the category. However, since the guaranteed minima tables in La Base are full of missing data points, we used the contractual minima in the computation of the collectively bargained salary.

Table A.1: (continued)

Description	Qual. Level	PCS
1st level white-collar supervisor	13	46
2nd level white-collar supervisor	14	46
1st level technician	15	47
2nd level technician	16	47
1st level superior technician	17	47
2nd level superior technician	18	47
1st level novice manager	19	37, 38
2nd level novice manager	20	37, 38
1st level confirmed manager	21	37, 38
2nd level confirmed manager	22	37, 38

By using the MT codes and a conversion table created at the Ministère du Travail, we were able to determine which contracts applied to which NAP100 (roughly equivalent to 2-digit SIC) sectors. Since there exist a large number of collective bargaining agreements that could potentially cover the service and agricultural sectors, no effort was made to exclude them from the study. Weighted average nominal annual gross contractual salary per sector by qualification level variables were constructed based on data concerning the number of employees covered by each collective agreement (available in La Base), and these nominal annual gross contractual salaries were converted to nominal annual net contractual salaries by qualification level by referring to existing tax laws.

The second source used in the construction of the state variable was the Données Annuelles Salariales (DAS), or annual salary data. These are roughly the equivalent in the United States to Social Security Earnings Reports, and are reported by all enterprises employing 10 or more employees. The data provided by INSEE were for all employees born in October in even numbered years. These data include a company identification code (called the SIREN), the company's NAP600 code (roughly the equivalent of a 4-digit SIC code), an individual identification number, an occupational code (called the PCS), a full- or part-time status indicator, the number of days worked during the calendar year, the geographic location of the employing establishment, the nominal annual net salary received and the full-year-equivalent real annual net salary.

Since the PCS codes in the DAS do not, unfortunately, correspond perfectly to the qualification levels employed in La Base, the PCS codes had to be converted (see table A.1). Next, we converted the NAP600 codes to NAP100 codes, and we used the qualification levels and NAP100 sector to calculate each employee's nominal annual net contractual salary for each of their jobs appearing in the DAS. We then selected only those entries corresponding to full-time jobs, and for each individual in each year we calculated the full-year-equivalent nominal net salary received for the job that they held for the greatest number of days in that year. Finally, we aggregated up both the actual and contractual salaries in order to create two new variables for each SIREN: average nominal annual net contractual salary per worker and average nominal annual net salary received per worker.

The third data source used in constructing the state variable is called the Enquête sur la Structure des Salaires (ESS), or the salary structure survey. This survey was performed twice, in 1978 and 1986, although for technical reasons we used only the 1986 survey. Its information corresponds to the state of the work force at a sampled employer at the end of October 1986. Its 23,501 enterprises are chosen to be a representative sample of French employers, although a minimum size of 10 employees was required to be at risk of being included in the survey. The survey includes the SIREN, the sector (NAP100) and the size of the work force. It also asked the enterprises if they were obligated to negotiate (question NEG) and whether or not they were covered by a collective bargaining agreement (question CC). Using this information, the states were determined as follows:

NEG	Collectively Bargained Salary $\geq$ Actual Salary	State
Yes	No	(in,obey)
No	No	(out,obey)
Yes	Yes	(in,disobey)
No	Yes	(out,disobey)

Clearly, this method of classification presents many potential problems. For example, NEG only tells us if a firm was *obligated* to bargain, not if it chose to bargain (even when not obligated), and the model applies most cleanly to those firms who have the choice to bargain or not. We have no choice in this matter; the variable available to us that is closest to the question of whether a firm was a member of the employers association or not is NEG, and although we cannot explicitly correct for the bias towards grouping firms as "out" that is introduced by using such a measure, we should at least recognize that such a bias might exist.

Another, perhaps more disturbing, problem is the fact that it is always difficult to detect disobedience in empirical data, especially when the data are reported by those who might be disobeying themselves. In our case, the obey-disobey dimension of the state variable was determined without reference to the actual coverage status of the enterprise (CC=Yes or No). Clearly we could make use of the CC variable, requiring it to be Yes and the actual salary to be below the negotiated salary before we assigned the enterprise to the "disobey" group.

This strategy presents two problems. First of all, even if a firm says that it is covered by a collective agreement, we are unable to tell which collective agreement should apply to the firm, if indeed only one agreement is applicable. We would therefore be forced to apply the sectoral mean anyway, as we have done above. In other words, there is no additional information contained in the CC variable. Secondly, if we were to only consider the intersection of the set of those firms paying below our measure of the contractual salaries and the set of those reporting themselves as covered by collective agreements as disobeying firms, we might miss a number of firms that would disobey were a collective agreement extended to them. These firms are very important in the context of the model, and as long as the probability of contract extension is less than 1, these would-be disobeying firms would be mis-classified under the alternative approach.

The approach we have taken implicitly assumes that all firms that currently pay below the contractual salary would continue to do so were a contract extended to them. The literature on union threat models tries to explain why those that are not covered by collective agreements might pay above the opportunity wage anyway[27] and it might not be unreasonable to suppose that, in France, responses to the threat of unionization would be observationally equivalent to responses to the threat of extension and getting caught disobeying. If this were the case, then a firm that would not disobey were a contract extended would behave as a threat model would predict and pay more than the alternative wage, while those that would disobey were the contract extended will not respond to the threat of unionization either, and thus pay relatively less.

Furthermore, since the standard against which actual salaries are compared is in fact a baseline minimum, it is clear that, even with this strategy, we are not going to appropriately class all firms that pay below what they should according to the collective agreement. This is because our measure of the collectively bargained salary is a very conservative underestimate of what should be paid. There are no annual bonuses or premiums in our measure, nor are there seniority premiums. The latter omission is due to the fact that La Base does not contain seniority premium data, not even in the guaranteed minimum tables. However,

[27]See, for example, Hirsch and Addison (1986) [?].

since seniority premiums often make up a substantial share of total pay[28], this is likely to seriously bias our classifications in favor of the "obey" states.

A.2. Opportunity Wages

The opportunity wage applicable to a firm was calculated by performing a very basic human capital regression using data from the DAS (see above). The dependent variable was the level full-year-equivalent nominal total compensation cost. We calculated this by calculating the full-year-equivalent nominal net annual salary and adding back in both employee and employer tax contributions according to the rates and thresholds that were in effect during the year in question. The explanatory variables included sex, age, PCS code and département of the employing establishment. No measures of educational attainment were available.

The resulting predicted values were then aggregated by NAP100 and averaged by year. The 1986 values of these sectoral opportunity wages were then merged back in with the state variables by NAP100. Thus each firm in the same sector is implicitly assumed to be drawing on the same labor market.

A.3. The Distribution of Output Prices y

The distribution of output prices was derived by reconstruction of a series of price expectations derived from the Enquête Mensuelle sur l'Activité dans l'Industrie, or the monthly survey of industrial activity. Firms are asked in this survey whether they believe the sale price of their product will be higher or lower in the following month. The results are coded as the percentage of respondents who answered "higher" less the percentage who answered "lower".

We took these responses and constructed a series of anticipated output prices, without correction for previous errors. January 1980 was set to have a value of 100, and the percentage change in our series from month to month was equal to 0.001 times the value reported by the survey. Thus, for example, if the percentage of enterprises that responded that they anticipated a price increase was the same as the percentage that anticipated a decrease, the series would not change. If 60 percent anticipated an increase while 40 percent anticipated a decrease, the survey would have reported a value of 20, and the value of our series in month $t+1$ would have been equal to that in month t times 1.02. On the other hand, if 30 percent expected an increase and 70 percent a decrease, the survey would have reported a value of -40, and our the value of the series in month $t+1$ would have been equal to the value in month t times 0.96.

We then calculated the first two moments of our series and constructed a lognormal distribution for y with the same first two moments. In other words, if

$$\text{Mean of the series} = m$$
$$\text{Variance of the series} = v$$
$$\log(y) \sim \mathcal{N}(\mu, \sigma^2)$$

[28] See Topel (1991) [?].

then

$$\mu = \log\left(\frac{m^2}{\sqrt{v+m^2}}\right)$$

$$\sigma = \sqrt{\log\left(\frac{v+m^2}{m^2}\right)}.$$

μ was determined to be 7.46237, and σ was 0.29199.

A.4. Rental Rate of Capital

We derived the figure for the rental rate of capital directly from the Banque de Données Macroéconomiques (BDM), or the macroeconomic data base, from which the National Income and Product Accounts are generated. These data were available by broadly defined sector (NAP40, slightly less detailed than 2 digit SIC codes). This variable comes unitless, as an index whose all-industry mean in 1980 is set to be 100. We used the data for 1986. In order to convert this index value to an actual rental rate of capital, it would have been necessary to multiply the index value by the price of the generic unit of capital upon which its calculation is based. Unfortunately, such data was not available. We chose 1.3 FF per unit of capital as our scaling constant because the rental rates of capital thus generated (see table 5.1) were more or less comparable to the opportunity compensation costs, which were calculated more precisely.

A.5. Quantity of Capital Employed

The data for our measure of the amount of capital employed by a firm came from the Bénéfices Industriels et Commerciaux (BIC), or industrial accounting data. This data is basically the accounting data all firms supply to the government for tax purposes. To construct our measure, we simply took the sum of debt and shareholders equity and divided by the rental rate of capital, as defined in section A.4 above.

B. Parameter Restrictions and Maximization Algorithms

In order to enforce the various non-negativity and boundary constraints required by the model, we can choose from an infinite number of potential functional forms that can be applied to "underlying" parameters in order to generate the required constrained estimators. This problem only really presents itself because most maximization algorithms, including the one used here (see below) require the parameter(s) being estimated to be free to vary between $-\infty$ and $+\infty$. Thus the standard procedure is to provide the algorithm with an unrestricted vector of underlying parameters, only transforming its elements into the constrained estimates when such values are needed, such as during evaluation of the log likelihood function and score vector, and at the end of the algorithm when the final results are output. Table B.1 shows the transformation functions used to impose the necessary constraints on the parameters of interest.

We employed a modification of the Davidon-Fletcher-Powell multivariate minimization algorithm known as the BFGS (Broyden-Fletcher-Goldfarb-Shanno) algorithm, as described in Press, et. al. [?] and implemented through the GAUSS routine MAXLIK, in the actual

Table B.1: Constraining Functions

variable	type of constraint	functional form
a	$0 \leq a \leq 1$	$a = \frac{\arctan(a^\star)+\frac{\pi}{2}}{\pi}$
b	$b \geq 0$	$b = \exp(b^\star)$
c	$c \geq 0$	$c = \exp(c^\star)$
$\overline{P}$	$\overline{P} \geq 0$	$\overline{P} = \exp(\overline{P}^\star)$
s	$0 \leq s \leq 1$	$s = \frac{\arctan(s^\star)+\frac{\pi}{2}}{\pi}$
γ	$0 \leq \gamma \leq 1$	$\gamma = \frac{\arctan(\gamma^\star)+\frac{\pi}{2}}{\pi}$
Π_1	$0 \leq \Pi_1 \leq 1$	$\Pi_1 = \frac{\arctan(\Pi_1^\star)+\frac{\pi}{2}}{\pi}$
Π_2	$0 \leq \Pi_2 \leq 1$	$\Pi_2 = \frac{\arctan(\Pi_2^\star)+\frac{\pi}{2}}{\pi}$

$\star$ denotes a continuous parameter which varies from $-\infty$ to $+\infty$

estimation of the continuous model. This algorithm has the advantage that, if one can provide both the objective function and its derivatives, the matrix of second derivatives at the optimum is generated as a by-product. We programmed in the likelihood function directly, although we allowed the GAUSS routine to take numerical derivatives as it needed them.