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La Théorie des Contrats et les Grèves

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Sommaire

Cette thèse présente une analyse de la détermination des salaires et de l'activité de grève dans le marché du travail. On s'éloigne des modèles d'équilibre général pour se tourner vers des modèles d'équilibre partiel qui prennent en compte la complexité des comportements stratégiques des agents au sein des liens institutionnels qui définissent les possibilités de leur action. Dans cette thèse, nous utilisons la théorie des contrats et la théorie des jeux non-coopératifs pour modéliser l'évolution des salaires, expliquer l'activité de grève et tester l'incidence des grèves sur cette évolution des salaires.

Le premier chapitre est un survol des récentes études de la théorie des contrats incomplets. Quand les relations de travail nécessitent de l'investissement spécifique, les contrats jouent un rôle fondamental en protégeant ces investissements du comportement opportuniste des agents. La théorie suggère deux formes contractuelles qui mettent en oeuvre les niveaux d'investissement spécifique optimaux: (1) Des contrats à court terme où les salaires seront renégociés à chaque période, mais selon des régles de négociation pré-spécifiées; (2) Des contrats (auto-exécutoires) à long terme où les salaires reflètent (partiellement) les conditions contemporaines du marché du travail.

Dans le Chapitre 2, nous testons les prédictions de la théorie des contrats présentée dans le premier chapitre. L'objectif de ce chapitre est de voir si l'évolution des salaires supporte cette théorie plutôt que la théorie d'équilibre du marché "spot". En utilisant des données micro-économiques sur les conventions collectives au Canada, on estime l'incidence des grèves sur l'évolution des salaires. Des méthodes empiriques qui tiennent compte du problème de la simultanéité de la détermination des salaires et des grèves sont développées. Nous estimons un modèle de détermination de salaires à deux régimes, et nous comparons les estimateurs de coupe transversale avec les estimateurs longitudinaux. Finalement, nous proposons un estimateur longitudinal robuste au problème d'endogénéité et à la différence dans l'effet des caractéristiques sur les salaires dans les deux régimes.

Le troisième chapitre se concentre sur les lois qui régissent les négociations salariales et les conflits de travail. Nous faisons appel à des notions de théorie des jeux et de la théorie de négociation non coopérative avec asymétrie d'information pour modéliser les

interventions gouvernementales dans le marché du travail. Dans ces modèles les grèves peuvent servir comme des signaux révélateur de l'information aux yeux de la partie moins informée. On introduit les lois de remplacement qui permettent aux entreprises de remplacer les travailleurs en grève par d'autres. Nous discutons des effets de ces lois sur les salaires, l'incidence des grèves et la durée des grèves.

Le Chapitre 4 consiste en une description des banques de données utilisées dans la partie empirique de la thèse. Des statistiques descriptives des variables sont présentées dans divers tableaux. La thèse termine avec un discussion générale des résultats trouvés et de la contribution de cette thèse à la littérature.

Introduction Générale

L'analyse traditionnelle du marché du travail suppose que les salaires sont déterminés par des forces compétitives de l'offre et de la demande. Cependant, plusieurs études et observations démontrent que cette approche est incapable d'expliquer plusieurs aspects complexes de la relation d'emploi. Nous suggérons qu'il est plus approprié de considérer cette relation sous un aspect contractuel, plutôt que sous la forme d'un simple échange entre le salaire et le temps de travail. Les contrats servent à atténuer les imperfections possibles des mécanismes du marché. En particulier, dans cette thèse nous traitons de deux problèmes: l'incomplétude des contrats dans des relations à long terme et l'asymétrie d'information dans les modèles de négociation.

Le premier chapitre survole les récents développements en théorie des contrats incomplets. Plusieurs raisons expliquent l'incomplétude des contrats. Dans le monde réel, la négociation d'un contrat est souvent une affaire coûteuse. Il arrive forcément un moment où le gain d'efficacité obtenu en tenant compte d'une nouvelle contingence peu probable ne justifie plus le coût de sa prise en compte. La difficulté de faire vérifier par les tribunaux la valeur prise par certaines variables et la rationalité limitée des parties les poussent souvent à négliger certaines variables dont ils ne peuvent évaluer facilement l'effet sur la relation contractuelle. Pour toutes ces raisons, les contrats ne prennent généralement en compte qu'un petit nombre de variables, qui peuvent être les plus pertinentes, mais aussi celles qui sont le plus facilement vérifiables par un tribunal. Si certains événements imprévus surviennent et aucune clause du contrat n'indique comment les parties doivent y réagir, il deviendra donc souhaitable de renégocier ce contrat.

Lorsque les contrats sont complets, la possibilité d'une renégociation ultérieure s'interprète comme une contrainte sur le programme de maximisation des agents *ex ante*, et elle peut aboutir à une perte d'efficacité. Par contre, la renégociation permet de prendre en compte l'imprévu quand les contrats sont incomplets.

Une des principales fonctions des contrats est de faciliter l'échange entre des agents surtout quand cette relation requière de l'*investissement spécifique*, c'est-à-dire un investissement qui à la fois, améliore la productivité de la relation considérée, a une valeur moindre en dehors de cette relation et est coûteux pour celui qui le réalise.

Dans le cas où les investissements spécifiques sont observables par les parties mais ne sont pas vérifiables, le coût d'investissement est, quelque soit la répartition des revenus engendrés par cet investissement, supporté par celui qui le réalise. S'il n'y a pas de contrat signé *ex ante*, les deux parties pourront renégocier après avoir observé la réalisation de la valeur de l'investissement (qui peut être aussi une fonction d'un choc aléatoire réalisé une fois que l'investissement est en place). Supposons que, lors de la renégociation, on partage le surplus net selon la solution de marchandage de Nash. Avec cette division, les parties peuvent être expropriées des fruits de leurs investissements. En conséquence, les parties ne réaliseront qu'un niveau inefficace d'investissement spécifique.

Ce type d'argument est à la base de l'analyse que fait Williamson [1985] des coûts de transaction dans les relations à l'intérieur des entreprises. Grout [1984] a été le premier à formaliser le problème de sous-investissement dans un contexte de négociation salariale entre un syndicat et un employeur. Hart-Moore [1988] trouvent un résultat similaire dans un modèle plus général. En l'absence d'engagement de long terme, le contrat initial peut toujours être renégocié. En conséquence, l'allocation obtenue est inefficace. Aghion-Dewatripont-Rey [1994] montrent toutefois que cette conclusion dépend de la définition du *status quo* contractuel et de l'allocation du pouvoir de marchandage. Tandis que Grout [1984] adopte un marchandage de Nash et que Hart-Moore [1988] fixent le contrat initial, Aghion-Dewatripont-Rey [1994] utilisent à la fois les deux instruments, le pouvoir de marchandage et le contrat initial, pour démontrer qu'il existe des contrats simples qui mettent en oeuvre les niveaux d'investissement spécifique optimaux.

D'autre part, MacLeod-Malcomson [1993] montrent que si l'on peut conditionner le contrat sur une variable corrélée avec les chocs exogènes, alors des contrats simples auto-exécutoires peuvent émerger. Les opportunités externes agissent comme des contraintes à la solution optimale. Chaque fois qu'on heurte la contrainte, le contrat doit accorder le niveau de revenu qui rend l'agent indifférent entre les choix de rester dans la relation ou de briser le contrat.

De récents travaux empiriques ont tenté de tester les prédictions de la théorie des contrats. En particulier, Beaudry-DiNardo [1991,1995] montrent par des tests empiriques sur des données micro-économiques que la détermination des salaires et l'évolution des salaires et des heures du travail supportent la théorie des contrats comme principale explication du marché du travail plutôt que la théorie d'équilibre dans le marché spot.

Dans le Chapitre deux, en faisant appel aux théories des grèves, nous approximons l'incidence de la renégociation par l'incidence d'une grève. Nous essayons de tester empiriquement les effets des grèves sur l'évolution des salaires en utilisant des données sur les conventions collectives canadiennes dans le secteur manufacturier. Les travaux théoriques et empiriques précédents suggèrent que les salaires et les grèves sont conjointement déterminés. Pour corriger le problème d'endogénéité, on estime un modèle à deux régimes avec une règle de décision endogène. Dans ce cadre, on compare les estimateurs de coupe transversale avec les estimateurs longitudinaux. Nous proposons quatre méthodes pour résoudre ce problème.

Nous commencons par des méthodes conventionnelles suggérées par la littérature sur les données en coupe transversale. On corrige ensuite pour l'endogénéité des grèves en utilisant les méthodes de correction pour le biais de sélection (le ratio de Mills) et des variables instrumentales. Puis, profitant des données longitudinales des conventions collectives, on utilise les techniques appropriées aux données panel. Une faiblesse des méthodes standards à effets fixes (différences premières) est l'hypothèse que la composante permanente du terme d'erreur a le même effet dans les deux régimes. On propose un nouvel estimateur longitudinal robuste au problème d'endogénéité et à la différence dans l'effet des caractéristiques observables et non observables sur les salaires dans les deux régimes.

Les résultats empiriques soulignent les problèmes associés aux modèles à effets fixes qui estiment les effets des grèves sur les salaires. En effet, les grèves semblent jouer un rôle significatif, d'une part dans le partage des rentes entre les firmes et les travailleurs, et d'autre part, dans l'ajustement des salaires suite aux chocs nominaux pendant la durée du contrat précédent. Notons par ailleurs que la rigidité salariale dépend des activités de grève. En particulier, l'impact des salaires précédents est significativement réduit quand une grève est observée. Tout comme les études précedentes, ces résultats donnent plus de support pour la théorie des contrats qu'au modèle compétitif.

Dans un contexte assez différent, dans le Chapitre trois, nous considérons la négociation bilatérale entre une firme et ses employés. On se base sur la théorie de la négociation non coopérative pour modéliser les interventions gouvernementales qui ont pour but de limiter les conflits du travail. De récents développements théoriques ont souligné l'importance de l'asymétrie d'information dans les modèles de grèves. Nous considérons un modèle de signal avec information imparfaite du côté du syndicat concernant le type de l'entreprise. Les grèves peuvent servir comme des signaux (coûteux) qui dépendent du type de la partie informée (la firme) et, par conséquent, révèlent de l'information sur les différents types aux yeux de la partie non informée (le syndicat).

Nous discutons des effets des lois qui régissent les conflits de travail. On introduit les lois de remplacement (des lois qui permettent aux entreprises de remplacer les travailleurs en grève par d'autres) en élargissant l'espace de stratégies de l'entreprise par la possibilité d'engager des travailleurs pour remplacer les travailleurs en grève. La multiplicité des équilibres est de règle dans ce type de modèle. Un Équilibre Bayesien Parfait est dérivé pour le jeu de négociation et les implications de la loi sont étudiées. Deux résultats sont soulignés: d'une part, on constate une réduction du bien-être du syndicat, due à une baisse des salaires suite à l'amélioration de la position de l'entreprise durant les négociations. D'autre part, puisque l'asymétrie d'information est la cause principale des grèves, nous démontrons que la mise en exercice des lois de remplacement permet une révélation plus rapide de l'information, ce qui contribue à réduire la fréquence et la durée des grèves.

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Chapter 1

Specific Investment, Incomplete Contracts and Renegotiation

In this chapter we review the recent developments in the theory of incomplete contracts and their role in inducing efficient investment. One function of contracts is to facilitate trade between parties when relationship-specific investments occur. Once these investments have been incurred each party becomes "locked-in" and therefore vulnerable to opportunistic behavior from the other party. Any bargaining or contract renegotiation affecting the division of the gains will have an element of bilateral monopoly. Future uncertainty, observable but unverifiable investments, will lead to a lot of difficulties in predicting future contingencies, and so contracts will be incomplete. In such situations, it is known that ex-post *contract renegotiation may prevent the implementation of first-best outcomes. However, the recent literature exploits the properties of non-cooperative bargaining theory to suggest two alternative solutions for the under-investment problem when both parties make specific investments: (i)* Short-term Contracts with Renegotiation Design *which assume that initial contracts are able to monitor the* ex post *renegotiation process and design the rules that govern this process; in particular, the default options in the case of renegotiation breakdown and authority delegation. (ii)* Long-term Renegotiation-Proof Contracts *which are conditioned on sufficient external variables to ensure renegotiation never occurs. These contracts do not need to be conditioned on the levels of investment themselves, nor do they require breach penalties.*

1.1 Introduction

In most trade partnerships, it is important for parties to make investments. Typically, these will include sunk costs. In a spot market, a supplier may make investments to produce a product before a particular buyer has been identified without the market being inefficient. Contracts will become essential for the efficient execution of the trade if the investments are specific to the transaction[1]. In employment relationships, for example, training may be specific to the production methods of the particular firm. The market value of such training is less than its value within the firm. In general, once these investments have been sunk, parties will become to some extent "locked-in" to each other. Contractual provisions will then play a crucial role in governing these transactions. Williamson [1979,1985] has emphasized that the threat of *ex post* renegotiation can lead to underinvestment in transaction-specific capital. This result was formalized by Grout [1984] and extended by Hart and Moore [1988]. In this paper we review the recent developments in the theory of incomplete contracts and their role in solving the underinvestment problem and inducing efficient investment.

What can be achieved by contracts is limited by what can be enforced, by going to court if necessary. Contract provisions may be unenforceable because they are not regarded as legally binding or because a court does not have the necessary information to enforce them. The literature on specific investments is concerned with issues that arise when investment is too complex or too multidimensional to be verifiable. This literature assumes that investments are not contractable, in the sense that agents cannot make the contract conditional upon the realization of the state of the world, θ. However, θ is ex-post observable to the buyer and seller[2]. Under these assumptions, the parties cannot commit not to renegotiate the initial contract; in particular, Hart and Moore [1988] assume that although the court can observe whether trade has (or has not) occurred, or whether the initial contract is renegotiated, it will not be able to identify which party is responsible for the breach of the initial agreement, and hence in general first-best investment levels cannot be achieved. The intuition underlying this result is as follows: One party's private gain from additional investment is less than the social gain since it does not take into account the benefit accruing to the other party. Put differently,

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[1] There exists a large body of empirical evidence in support of contracts' role in the context of transaction costs; This is provided from many fields of economics: Labor contracts and the effect of renegotiations on wage dynamics (Farès [1997]). Agriculture contracts (Allen-Lueck [1995,1996]). Natural Gas contractual provisions (Molherin [1986], Lyon-Hackett [1993]). And long term coal contracts (Joskow [1988,1990]).

[2] This assumption is maintained because the states of the world θ maybe highly complex and of high dimension, so to describe θ in a sufficient detail that an outsider (the court) can verify it has occurred may be prohibitively costly.

because of the threat of *ex post* renegotiation, parties are not ensured the full marginal return on their investment. The result is a sub-optimal investment level. This result will depend crucially on the rules governing the *ex post* bargaining process.

To understand contract renegotiation, we review the recent developments in bargaining theory. We study the Rubinstein/Stahl standard non-cooperative bargaining approach in which the buyer and the seller exchange offers until a trading price is agreed upon. This model has the convenient property that, with infinite horizon bargaining, a unique subgame perfect equilibrium exists. We discuss the consequences of adding outside options in the form of alternative market opportunities. In such markets, the outside options will act as constraints on the bargaining outcome: If bargaining in the absence of outside options would result in outcome that is better for both parties than the outside options, the existence of outside options has no effect on the equilibrium. If, however, one party would be better off choosing an outside option, that party receives exactly the outside option value.

We discuss two approaches to the hold-up problem for this model. We first discuss short-term contracts and renegotiation design. We then consider long-term renegotiation-proof contracts.

On one hand, we review the theory of short-term contracts with renegotiation design. We look at their role to induce enough incentives for both parties to efficiently invest in the relationship. Chung [1991] shows that efficient investments and outcomes can be induced by a quantity and a payment together with an *ex post* revision via a take-it-or-leave-it offer. Aghion, Dewatripont and Rey [1994] study *Renegotiation Design*, concentrate upon the default options and the allocation of bargaining power to either contracting party. Unlike long-term contracts, renegotiation in these short-term contracts is crucial to achieve efficiency in both trade and investments. The initial contract in these models will be the default option that either party can ask the court to enforce and the court will then oblige both parties to carry out. In U.S legal terminology, the court requires specific performance. The default option will induce one party to efficiently invest The incentive for the other party will be by the proper allocation of all bargaining power, so it becomes the residual claimant and hence will be induced to contingencies (these may involve breach penalties). Renegotiation might occur after t_2, conditional on mutual agreement. The renegotiation procedure will be discussed in details in the next sections. The Von Neumann-Morgenstern utilities are given by $u_s((p,q);i,\theta)$ and $u_b((p,q);j,\theta)$. The two agents are risk neutral and they are only interested in their net payoffs:

$$\begin{aligned} u_s((p,q);i,\theta) &= p - c(q,i,\theta) - \phi(i), \qquad (1.1) \\ u_b((p,q);j,\theta) &= v(q,j,\theta) - p - \psi(j). \qquad (1.2) \end{aligned}$$

Where $c(q,i,\theta)$ is the seller's production cost and $v(q,j,\theta)$ is the buyer's valuation. $\phi(i)$ and $\psi(j)$ are the seller's and buyer's investment costs. Both objective functions are assumed to be twice continuously differentiable and concave with respect to trade and investment. It is assumed that both $v(q,j,\theta)$ and $-c(q,i,\theta)$ are increasing in each of their arguments at a decreasing rate. We also make the following assumptions:

Assumption 1 $v_{qj} \geq 0$ and $c_{qi} \leq 0$.

Assumption 2 $v(0,j,\theta) = 0$ and $c(0,i,\theta) = 0, \forall i,j,\theta$.

Assumption 3 $\max_{\theta} c(q,i,\theta) < \min_{\theta} v(q,j,\theta), \forall i,j,q$.

Assumption 1 is the economically interesting case where incentives to invest are sensitive to expected level of trade. Assumption 2 implies that the investments are relationship-specific. Assumption 3 restricts our attention to the events where gains from trade always exists. This assumption will simplify the analysis. Note that the specification of the value and cost functions, $v(.)$ and $c(.)$, excludes any direct externality of the investment. That is, $v(q,j,\theta)$ is independent of i and $c(q,i,\theta)$ is independent of j; however, investments do affect the probability and the level of trade, q.

1.2.1 First-best contract

Consider the first-best problem as a benchmark. Let U^0 be the seller's *ex ante* reservation utility level which is determined by the *ex ante* market for contracts. If investment levels (i,j) and θ were verifiable, then maximizing the expected payoff of the buyer make the efficient investment.

On the other hand, we consider long term contracts, which avoid renegotiation by making the threat of ex-post bargaining non-credible and thus eliminate any rent-sharing outcomes. MacLeod and Malcomson [1993] show that when contracts can be conditioned on external events, the threat of renegotiation becomes non-credible and thus avoids renegotiation. As in Hart and Moore [1988], we assume that the courts cannot enforce contractually specified levels of trade, even upon request by one party. We model trade as a discrete choice: 0 or 1. The focus on "at-will contracts" as opposed to "specific performance contracts" is justified by its practical application in some contexts. In employment contracts, for example, the courts have been reluctant to enforce specific performance in agency relationships. The reason for this is that to enforce a contract that provides services, the court has to induce the supplier to do so by threatening severe penalties that are in practice limited to what is socially acceptable.

The plan of this paper is as follows. Section 2 describes the model, derives the properties of the first-best contract and formally presents the under-investment problem. Section 3 reviews some basic models of non-cooperative bargaining theory, and introduces the outside options to these models. In Section 4 we discuss incomplete contracts and the results of Hart and Moore. Section 5 and Section 6 provides the two proposed alternatives to achieve optimal investment. We conclude in Section 7.

1.2 Basic Framework

Consider a bilateral trading relationship with specific investment between a risk neutral buyer (B) and a seller (S). At date t_0 they write a contract, then at t_1 each party, simultaneously, chooses a level of investment, $i \in I$ for the seller and $j \in J$ for the buyer. After the investments are made, the realization at date t_2 of a random variable $\theta \in \Theta$ with a cumulative distribution $G(.)$ determines both the value of trade between the two parties and their alternative trading opportunities. Finally, at date t_3, the trade decision occurs. If trade occurs it is summarized by a *quantity* $q \in \Re$ and a corresponding *payment* $p \in \Re$. Agents may choose not to trade at all or to trade with a third party. The initial contract will include payments that depend on each of these subject to the seller's participation constraint will give the complete contingent solution to the first-best problem conditional on (i,j). Formally,

$$\begin{array}{ll} \text{Maximize}_{(q,p)} & \int_{\theta\in\Theta}[v(q,j,\theta)-p]\,dG(\theta)\ -\psi(j) \\ \text{Subject to} & \int_{\theta\in\Theta}[p-c(q,i,\theta)]\,dG(\theta)\ -\phi(i)\geq U^0. \end{array} \tag{1.3}$$

This program will give the first-best solution conditional on investment. For any given $(i,j)\in I\times J$ then $\{(q^*(i,j,\theta),p^*(i,j,\theta)):\theta\in\Theta\}$ describes this solution. Note that i and j do not depend on θ. It is assumed that there are gains from trade for all state of nature $\theta\in\Theta$ so that $q^*(i,j,\theta)>0$. Moreover strict concavity of the total surplus insures, that for given investment levels, the state of nature uniquely determines the *ex post* efficient output level. Now the efficient investments (i^*,j^*) can be defined as follows:

$$\begin{aligned}(i^*,j^*) \equiv\ & \text{Argmax}_{(i,j)}\int_{\theta\in\Theta}[v(q^*(i,j,\theta),j,\theta) \\ & -c(q^*(i,j,\theta),i,\theta)]\,dG(\theta)-\phi(i)-\psi(j).\end{aligned} \tag{1.4}$$

Note that because of the risk neutrality assumption and the quasi-linear utility functions form, the price structure is irrelevant for the choice of efficient output and investment. Its role is to determine how the surplus is divided between the parties. In summary, the first-best levels of investment and output are characterized by the first-order conditions corresponding to the two optimization problems we described above.

$$\begin{aligned} \forall\theta\in\Theta,\ v_q(q^*,j^*,\theta) &= c_q(q^*,i^*,\theta) \\ \int_{\theta\in\Theta}c_i(q^*,i^*,\theta)\,dG(\theta) &= -\phi'(i^*), \\ \int_{\theta\in\Theta}v_j(q^*,j^*,\theta)\,dG(\theta) &= \psi'(j^*). \end{aligned} \tag{1.5}$$

Because both parties must make their investment decision before the uncertainty is realized, the *expected* marginal return on investment is equal to the marginal cost of investment. If i and j were verifiable, then the parties would jointly choose (i^*,j^*) to maximize the expected gains from the relationship.

1.2.2 The under-investment problem

If there is no initial contract, parties will have to negotiate an agreement to determine the quantity and the price for trade at date t_3. For the moment, we assume that the payoffs to such negotiations are given by the generalized Nash bargaining solution, where the buyer will receive a share π $(0 \leq \pi \leq 1)$ of the gains from trade (once the investments have been made and θ is revealed). In the sections below we will look in detail at different bargaining solutions. The attraction of the Nash bargaining solution is its simplicity and its support from non-cooperative bargaining theory. Also, this solution imposes an efficient outcome, so output will equal the First-best level, $q^*(i,j,\theta)$. The actual trading price, $p^*(i,j,\theta)$, will then satisfy

$$v(q^*,j,\theta) - p^*(i,j,\theta) = \pi[v(q^*,j,\theta) - c(q^*,i,\theta)],$$

so we have

$$p^*(i,j,\theta) = (1-\pi)v(q^*,j,\theta) + \pi c(q^*,i,\theta).$$

With this price the payoffs of the seller and the buyer are represented respectively by

$$\begin{aligned} u_s &= p^*(i,j,\theta) - c(q^*,i,\theta) - \phi(i), && (1.6)\\ u_b &= v(q^*,j,\theta) - p^*(i,j,\theta) - \psi(j). && (1.7) \end{aligned}$$

The actual choices of investments the parties will make, when they anticipate this *ex post* rent sharing, have to satisfy the following first-order conditions. In equilibrium, as mentioned earlier, bargaining will result in efficient trade level, so the First-best q^* that satisfies the first-order conditions (1.5) will be the equilibrium output:

$$\left.\begin{aligned} \int_{\theta\in\Theta} c_i(q^*,i^e,\theta)\,dG(\theta) &= -\tfrac{1}{1-\pi}\phi'(i^e),\\ \int_{\theta\in\Theta} v_j(q^*,j^e,\theta)\,dG(\theta) &= \tfrac{1}{\pi}\psi'(j^e). \end{aligned}\right. \qquad (1.8)$$

Because of the factors π and $(1-\pi)$ that enter the above equations, the investment levels will be different from the efficient levels (i^*,j^*) given in Conditions (1.5). In fact, under the assumptions made on the value and cost functions, Conditions (1.8) imply that both agents will under-invest in the relationship; i.e the equilibrium investment level (i^e,j^e) characterized by (1.8) will be such that $i^e \leq i^*$ and $j^e \leq j^*$. This is the problem that

Williamson calls the "hold-up" problem. It was first formalized by Grout [1984] using a generalized Nash bargain to analyze input levels, profits, and wages in the absence of legally binding labor contracts. Grout shows that if the union has any bargaining power ($\pi > 0$), investment will be lower in the absence of binding contracts compared to the investment levels in the conventional binding contract model. Tirole [1986] discusses, in his study of procurement and renegotiation, the impact of renegotiation under a variety of assumptions about investment observability, ex post observability and bargaining. He also presents Williamson's idea that "opportunism" leads to underinvestment in the relationship, and showed support from a variety of examples of procurement contracts used by government agencies and private firms to perform their research, development and production projects. The rest of this paper describes different contracting models proposed in the recent literature to addresse this underinvestment problem.

The theory of contract renegotiation suggests two instruments to achieve investment efficiency: the allocation of bargaining power in the *ex post* bargaining game, and the choice of a default option in the absence of renegotiation. In Section 1.3 we review some simple models of non-cooperative bargaining under complete information. We describe the institutions governing the bargaining process, and study the properties of the equilibria in these games.

1.3 The *Ex Post* Bargaining Process

In this section describe the *ex post* bargaining game which will take place (at t_3) in the absence of any contract. In keeping with most of the non-cooperative bargaining literature with complete information[3], we use the standard Rubinstein/Stahl strategic approach in which the buyer and seller exchange offers until a division of the total surplus, call it s, is agreed on, at which point trade takes place and the game ends. Let S be the set of possible agreements defined as

$$S = \left\{(s_b, s_s) \in \Re^2 : s_b + s_s = s \text{ and } s_i \geq 0 \text{ for } i \in \{b, s\}\right\}.$$

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[3] The complete information framework is appropriate in our model, since the ex post bargaining is taken place after all relevant information is revealed in the previous periods. For a survey of bargaining under asymmetric information, see Kennan and Wilson [1993].

Bargaining rounds are indexed by n, $n \in N = \{0, 1, \ldots\}$, these rounds take place at dates $t_3 + n\Delta$ where Δ is the time delay between offers and $n = 0$ indicates the first round of negotiation. Each period one of the players, either the buyer or seller, makes an offer which is either accepted or rejected by the other player. If the offer is accepted, the bargaining game ends and the agreement is implemented. If the offer is rejected, then after a minimum delay Δ the next round will start in which it is the rejecting player's turn to make a counter-offer. The game continues in this manner until an agreement is reached, with no limit on the number of periods. In practice relationships are not infinitely lived. Osborne and Rubinstein [1990] however show that the infinite horizon game can be viewed as a model in which both agents behave each period as if the relationship is going to last at least one more period.

Both bargainers prefer agreement today to the same agreement tomorrow, and the form of this impatience is given by the discount factors (δ_b, δ_s) for the buyer and the seller, respectively. Also, the players' preferences as defined above are frequently referred to as *time preferences with a constant discount rate*, where, for example, the buyer's utility from a surplus division $s \in S$ reached at round n will be $\delta_b^{n\Delta} s_b$. Before specifying the equilibrium of such a game, we should describe the strategies of each player. These strategies should specify the player's action at each node of the tree at which it is his turn to move. More precisely, the players' pure strategies in the bargaining game are defined as follows[4]. Let S^n be the set of all sequences $(s^0, \ldots, s^{n-1})$ of members of S. S^n represents the history of offers made (and rejected) up to period n. The strategy of the buyer is a sequence $\sigma = \{\sigma^n\}_{n=0}^{\infty}$ of functions, each of which assigns to each history an action from the relevant set. Thus σ^n is the function, $\sigma^n : S^n \to S$ where n is the round where it is the buyer's turn to make an offer, and $\sigma^n : S^{n+1} \to \{A, R\}$ when the buyer is responding, with either an Accept or Reject, to the seller's offer. Similarly, a strategy for the seller is a sequence $\tau = \{\tau^n\}_{n=0}^{\infty}$ of functions with $\tau^n : S^n \to \{A, R\}$ when responding to an offer and $\tau^n : S^{n+1} \to S$ when making one.

The equilibrium concept we use is the *subgame perfect equilibrium* concept. It requires that strategies form a Nash equilibrium at every stage of the game, regardless

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[4] We only look at pure strategies which do not involve any randomization by either one of the players.

of what has happened previously. Subgame perfect equilibrium rules out the use of "incredible threats", because unlike the Nash equilibrium it evaluates the desirability of a strategy not only from the viewpoint of the start of the game, but also at each decision node of the tree, whether or not that node is reached if the players adhere to their strategies.

Rubinstein [1982] shows that this game will have a unique subgame perfect equilibrium, where an agreement is reached with no delays. Furthermore the division of the surplus determining the equilibrium payoffs, s^*, will depend on which the player makes the initial offer. If the buyer makes the offer at $n = 0$ the payoffs are given by

$$s_b^* = \frac{1-\delta_s^\Delta}{1-\delta_b^\Delta \delta_s^\Delta} s \text{ and } s_s^* = s - s_b^*.$$

If the seller makes the initial (acceptable) offer, then the payoffs are

$$s_b^* = \frac{\delta_b^\Delta(1-\delta_s^\Delta)}{1-\delta_b^\Delta \delta_s^\Delta} s \text{ and } s_s^* = s - s_b^*.$$

The equilibrium strategies (σ^*, τ^*) supporting the above payoffs are

$$\sigma^{*n}(s^0, \ldots, s^{n-1}) = s^* \text{ for all } (s^0, \ldots, s^{n-1}) \in S^n,$$

and when the buyer is responding to an offer

$$\sigma^{*n}(s^0, \ldots, s^{n-1}) = \begin{cases} A & \text{if } s_b^* \geq \frac{\delta_b^\Delta(1-\delta_s^\Delta)}{1-\delta_b^\Delta \delta_s^\Delta} s\ , \\ R & \text{otherwise.} \end{cases}$$

The subgame perfect equilibrium strategy τ^* will have a similar symmetric structure. Notice that the bargaining game is asymmetric in one respect: One of the bargainers is the first to make an offer, which will give this player the advantage. One way of diminishing the effect of this asymmetry is to reduce the amount of time between periods. Using l'Hôpital's rule we find that at the limit, when the length of the period shrinks to 0, the amount received by a player is the same regardless of which player makes the first offer.

$$\lim_{\Delta \to 0} s^*(\Delta) = \left(\frac{\log \delta_s}{\log \delta_b + \log \delta_s} s, \frac{\log \delta_b}{\log \delta_b + \log \delta_s} s \right). \tag{1.9}$$

Binmore, Rubinstein and Wolinskey [1986] demonstrate the relationship between the limiting equilibrium shares as the time between offers goes to zero and the payoffs derived from the Nash bargaining solution. The generalized Nash bargaining solution is given by

$$\arg\max_{(s_b,s_s)}[s_b - s_b^0]^{\pi}[s_s - s_s^0]^{1-\pi} \text{ Subject to } s_b + s_s \leq s, \tag{1.10}$$

where (s_b^0, s_s^0) is the threat point and π the bargaining power of the buyer. $s_b^0 = s_s^0 = 0$ and $\pi = \frac{\log\delta_s}{\log\delta_b + \log\delta_s}$ will imply exactly the limiting payoffs in equation (1.9). The parameter π represents the buyer's relative bargaining power and the solution will be $[\pi s, (1-\pi)s]$. This convenient practical relationship between the limiting equilibrium payoffs and the Nash solution will prove to be useful in the following sections.

1.3.1 Bargaining over a stream of surplus

MacLeod and Malcomson [1996] relaxes the assumption that transactions are completed as soon as an agreement is reached. They argue that this neglects an important element of contract bargaining, where time will elapse before the transaction is completed. They capture this characteristic by focusing on contract negotiation over the future division of a *flow* of goods and services. In this framework, agents not only decide on trading price in the contract, but subsequently decide whether to continue trading at that price, to breach, or to renegotiate. With a finite horizon, this bargaining game will have a unique (efficient) subgame perfect equilibrium where the relationship between the limiting equilibrium payoffs and the Nash bargaining solution continues to hold. With an infinite horizon, Muthoo [1990] studies a model in which each player can withdraw from an offer if his opponent accepts it and shows that the subgame perfect equilibrium is no more unique. With bargaining over a stream of surplus and infinite horizon, Haller and Holden [1990] and Fernandez and Glazer [1991] show that the model has a great multiplicity of subgame perfect equilibria, including some in which there is a delay and trade does not commence in the first bargaining round. In the context of union bargaining, Fernandez and Glazer [1991] interpret such inefficient equilibria as involving union strikes before the agreement is reached. The two most important features of the above models are the separation of the trade decision from the agreement on the contract, and the infinite horizon.

1.3.2 Bargaining with outside options

We now consider an extension of the bargaining model in which agents are not restricted to trading with just on partner but also have the opportunities to trade with other agents in the market. We are interested in one form of market opportunity where once taken up will effectively terminate the current relationship. This is known in the literature as an *outside option.* Shaked [1987] shows that the set of equilibria is sensitive to the timing at which the players can opt out. If a player, say the buyer, can quit only after he has rejected an offer, then the game has a unique subgame perfect equilibrium. If he can quit after any rejection before the seller could make him a counter offer, then for some values of the outside option, the game has multiple subgame perfect equilibria. Shaked defines this later market as a "Hi-tech" market where a player can immediately switch to bargaining with another trader without waiting for a counter offer. One such example of markets can be securities trading over the telephone. In contrast with the "Hi-tech" markets, Shaked considers the "bazaars" where the seller always has the time to make a counter offer before the buyer can reach the door. For many markets, the bazaar model seems more appropriate. In labor markets, for example, the employer will typically have a chance to respond to an outside offer made to an employee before the employee actually moves. In this section, bazaars are modeled formally by assuming that either the buyer or the seller, with outside options (v_b, v_s) respectively, can opt out only when responding to an offer from the other party.

The structure of the negotiations is the following: The buyer proposes a division s at $n = 0$. The seller may accept this division, reject it and opt out, or reject it and continue to bargain. In the first two cases the negotiation ends; in the first case the payoff vector is the agreed upon proposal s, and in the second case it is determined by the outside option. If the seller rejects the offer and continues to bargain, play passes to the next round $n = 1$ when it is the seller's turn to make an offer which the buyer may accept, reject and opt out, or reject and continues to bargain. In the event of rejection and continued bargaining, another period passes, and once again it is the buyer's turn to make an offer. The first two periods of the bargaining game with outside options are shown in Figure ?.

The formal description of the results we obtain are in the following proposition

Proposition 1 *Consider the bargaining game described above in which it is efficient for the parties to trade with each other* ($v_b + v_s < s$) *and where both parties prefer the outside options to not trading at all* ($v_b, v_s > 0$). *The limits of the subgame perfect equilibrium payoffs as the time interval between offers goes to zero* ($\Delta \to 0$) *are given by*

- *(i) If* $v_b \leq \pi s \leq s - v_s$ *then the game has a unique subgame perfect equilibrium, which coincides with the subgame perfect equilibrium of the game where no outside options exist. That is, an agreement is reached immediately with the surplus division* $s^* = [\pi s, (1-\pi)s]$.
- *(ii) If* $\pi s < v_b$ *then the game has a unique subgame perfect equilibrium with an agreement reached immediately on the division* $s^* = [v_b, s - v_b]$.
- *(iii) If* $(1-\pi)s < v_s$ *then the game has a unique subgame perfect equilibrium with an agreement reached immediately on the division* $s^* = [s - v_s, v_s]$.

The proof of Proposition 1 relies on standard non-cooperative bargaining theory arguments and is omitted. Osborne and Rubinstein [1990, chapter 3] provides a detailed proof of this proposition. Also, MacLeod and Malcomson [1996, proposition 8] offers a similar proof when agents are bargaining over a flow of surplus. The equilibrium strategies supporting each equilibrium in Proposition 1 are the following: (i) The buyer always proposes s^* and accepts any proposal y in which $y_b \geq s_b^*$ and never opt out. The seller always proposes $s - s^*$ and accepts any proposal y in which $y_s \geq s - s_b^*$ and never opts out. (ii) The buyer always proposes s^* and accepts any proposal y in which $y_b \geq v_b$ and opts out if $y_b < v_b$. The seller always proposes $[\delta v_b, s - \delta v_b]$ and accepts any proposal y in which $y_s \geq \delta_s(s - v_b)$ and never opts out. (iii) The buyer always proposes s^* and accepts any proposal y in which $y_b \geq \delta_b(s - v_s)$ and never opts out. The seller always proposes $[\delta_b(s - v_s), s - \delta_b(s - v_s)]$ and accepts any proposal y in which $y_s \geq v_s$ and opts out if $y_s < v_s$.

Proposition 1 indicates that if the equilibrium payoffs in the absence of outside options are preferred by both parties to their respective outside options then adding these outside options to the game leaves the equilibrium outcome unchanged. It is only when the equilibrium payoffs in the absence of outside options are worse than the outside option for either the buyer or the seller, that the effect of adding the outside option to the game will be that one of the players will receive a payoff exactly equal to his outside option. At first glance it is surprising that the addition of the outside options will have no effect on the equilibrium payoffs in case (i), but the intuition underlying this is simple. The outside options act as constraints on the equilibrium outcome. As long as these constraints are not binding, then the threat of leaving the relationship is not a credible one, and as a result these constraints will have absolutely no effect on the equilibrium payoffs in the absence of these options. On the other hand, when one of the constraints binds, take case (ii), then the buyer is better off opting out than staying in the relationship with a payoff strictly below his outside option value. In this case, the threat of leaving the relationship becomes a credible one, and to prevent separation the seller will offer the buyer exactly his outside option which will induce him to stay in the relationship. Binmore, Rubinstein and Wolinsky [1986] show that the relationship between the limiting equilibrium payoffs in Proposition 1 are the same as those derived from the Nash bargaining solution defined in (1.10) subject to the additional constraints that each player receives at least the value of his outside option. Thus, as in the case without outside options, this convenient property is preserved in the infinite horizon bargaining game.

1.4 Incomplete Contracts

If the parties actions and their investment decisions where contractable, and if the parties are sophisticated enough to preview future contingencies and agree upon various contractual allocations given these contingencies and actions, then renegotiation will not be an issue and parties will be able to achieve jointly the first-best allocation. Unfortunately, this scenario is very unlikely, and there are many reasons why contracts will be incomplete. The traditional explanation of incomplete contracts relies on the existence of transaction costs. At the time of signing a contract, some contingencies may not be foreseeable; moreover, writing foreseeable ones into a contract may be expensive and time consuming. Furthermore, some contingencies may be private information, so a complete contract must then specify an incentive compatible mechanism of information transmission which makes it particularly expensive. All this will make contracts incomplete. Tirole [1986] analyzed a simple two-period procurement model where parties have to invest in the relationship before renegotiation. He showed that Williamson's underinvestment presumption hold under very general assumptions about bargaining and information structure as long as investment is not observable. Hart and Moore [1988] discuss in details incomplete contracts and their main result was that, in general, these contracts cannot induce efficient investment. Consider the initial contract (q^0, p^0) signed at the beginning of the relationship: Under the assumption that trade is voluntary in the sense that the initial contract is not verifiable by the court, the enforcement technology allows this initial contract to allocate all the bargaining power to one party. To understand this, consider the case where $v \geq c > p^0$, the seller will not trade unless the buyer raises the price at least to c. Since the buyer is happy to trade at p^0 and it is the seller who wants a new contract, this will give the buyer the power to dictate terms and the buyer will actually revise the price exactly to c[5]. This will give the buyer sufficient incentive to make the efficient level of investment. As a result, Hart and Moore [1988] show that underinvestment can be avoided if the party making the investment is given the full bargaining power. Nevertheless, the assumption that the initial contract is not enforceable (trade is at will) will be crucial if both parties are to make investment.

The key factor in these results is the "no-trade" outcome as the unique default option. Subsequent literature on underinvestment introduces other potential default options. In the light of the discussion in Section 1.3, default options can be interpreted as the outside options imposed on the *ex post* bargaining game. As a consequence, the outcome of the renegotiation will be determined as in Proposition 1, with the surplus being defined appropriately. The initial contract, if it can be enforceable, will become the default option, and proper design of this contract will solve the investment problem. In particular, the recent literature argues that under-investment can be avoided in a wide range of situations. Contracting parties may introduce other forms of contracts

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[5] If $p^0 > v \geq c$ then the exactly symmetric argument can apply, and it is the seller who will have all the bargaining power

that can be used as substitutes for incomplete contracts. One possible way of doing this is to introduce long-term contracts. In the absence of commitment, however, these contracts should be renegotiation proof. Another natural way is to include the possibility of renegotiation and revision in the initial agreements as new information becomes available. The parties will then have to define the institutions that will govern the renegotiation process. One important factor that will affect the bargaining outcome of the renegotiation is the relative bargaining power of the parties. The allocation of the bargaining power may become a contentious issue when designing the renegotiation rules. Different schemes can be agreed upon and will result in different allocations. As we saw in section 1.3 the timing of the offers is a crucial point. The first party to make an offer will have a clear advantage. This will disappear when the negotiations become friction-less, in the sense that the time delay between offers shrinks to zero. The strategic approach describing the bargaining game shows that the bargaining power is influenced by the parties attitude toward time, and their degree of patience. Aghion, Dewatripont and Rey [1994] show how the allocation of the bargaining power to one party can be achieved by penalizing the other party if trade is delayed. A once-and-for-all monetary penalty or a sequence of small penalties to be paid as long as trade is delayed will achieve this goal. Another interpretation of this penalty scheme is that at the beginning of the relationship, one party could grant the other a financial "hostage" which is given back only if trade takes place. These provisions will be sufficient to give bargaining power to one party or the other. These breach penalties are not always needed to achieve some particular bargaining power allocation. If instead of alternating offers bargaining game, the revision scheme can take the form of take-it-or-leave-it offers made by one of the parties, then the bargaining position of the party making the offer is substantially enhanced. Finally, the parties can, for example, state explicitly each parties' *ex post* bargaining positions in the contract as a contractual term or they can implicitly embed these into their organizational mode. The next two sections will survey these two forms of contracts.

1.5 Short-term Contracts

In this section we analyze how simple contracts with renegotiation design can provide incentives to overcome the under-investment problem described in section (1.2.2). Two contractual instruments are used to reach the investment targets: (i) The allocation of all bargaining power to one party, and (ii) the adequate choice of a default option in case renegotiation fails or it is unnecessary. These instruments can be specified in the initial contract that the parties agree on at the start of their relationship. It is assumed that the court is able to enforce the initial agreement on quantities and prices, say (q^0, p^0), in the signed contract unless the parties voluntarily agree to replace this by another allocation. It is also assumed that the parties can commit to the bargaining scheme they will use *ex post*. The allocation of all bargaining power to one party can be enforced by the court as an explicit contractual term or can be an implicit arrangement supported (or dictated) by "customs" or "social norms". Alternatively, this allocation can be achieved by a designed renegotiation bargaining game that penalizes the other party if trade is delayed. By imposing this monetary penalty, the bargaining power in the *ex post* bargaining game will be altered in favor of one party and, for a high enough penalty, the party that has to pay the penalty will have zero bargaining power. All these contractual provisions enable both players to precommit themselves to giving all bargaining power to one party starting from any arbitrary initial contract (q^0, p^0). The problem of inducing efficient investments is now considered. The following proposition shows how a simple contract can indeed implement the first-best in the above context:

Proposition 2 *Under the following authority delegation rule and initial contract :*

(i) Let the buyer have all the bargaining power in the ex post *renegotiation game,*

(ii) The initial contract (q^0, p^0) *is such that*

- $\int_{\theta\in\Theta} c_i(q^0, i^*, \theta)\, dG(\theta) = \phi'(i^*)$,
- p^0 *gives the seller his first-best expected level of utility.*

The first-best is achieved; In particular, $(i^e, j^e) = (i^*, j^*)$.

Proof. We proceed to construct the optimal initial contract (q^0, p^0). Consider the *ex post* renegotiation game, let $(q^i, p^i) \in \Re^2$ be any given initial contract, the buyer solves the following maximization problem:

$$\begin{aligned} &\max_{(q,p)} \; v(q,j,\theta) - p - \psi(j) \\ &\text{Subject to } \; p - c(q,i,\theta) - \phi(i) \quad \geq p^i - c(q^i,i,\theta) - \phi(i). \end{aligned} \tag{1.11}$$

With all the bargaining power given to the buyer, the seller's individual rationality constraint becomes binding, and the buyer will choose the efficient level of trade $q^*(i,j,\theta)$

$$q^* \equiv \text{argmax}_q \, v(q,j,\theta) - c(q,i,\theta) - \psi(j) - [p^i - c(q^i,i,\theta)].$$

Anticipating this outcome, the seller's choice of the investment level i will solve

$$i^e \equiv \text{argmax}_i \int_{\theta\in\Theta} [p^i - c(q^i,i,\theta)] \, dG(\theta) - \phi(i).$$

The concavity assumptions of the cost functions will insure an interior solution to the seller's problem. Also using the implicit function theorem, the maximum i^e satisfying the first order condition

$$-\int_{\theta\in\Theta} c_i(q^i, i(q^i), \theta) \, dG(\theta) - \phi'(i(q^i)) = 0$$

is continuous in q^i. If we differentiate with respect to q^i we have

$$\frac{di^e}{dq^i} = \frac{\int c_{iq} \, dG(\theta)}{-\int c_{ii} \, dG(\theta) - \phi''}$$

The second order condition implies that the denominator is negative. Together with Assumption 1 ($c_{iq} \leq 0$), this will yield $\frac{di^e}{dq^i} \geq 0$. If $q^i = 0$ then the seller's *ex post* utility is $p^i - \phi(i)$ (this is due to Assumption 2 $c(0,i,\theta) = 0$) therefore the seller will choose $i^e = 0$. Also, let $\bar{q}^i = \max_{\theta\in\Theta} q^*(i^*, j^*, \theta)$, then we have $i^e(\bar{q}^i) > i^*$. Therefore, by the intermediate value theorem and the continuity of i^e, there exists a q^0 such that $i^e(q^0) = i^*$. The price in the initial contract can be set to satisfy the seller's *ex ante* participation constraint (i.e)

$$\int_{\theta\in\Theta} [p^0 - c(q^0, i^*, \theta)] \, dG(\theta) - \phi(i^*) = U^0.$$

Finally the above mechanism makes the buyer the residual claimant inducing him to choose the optimal investment level $j^e = j^*$ once the seller chooses $i^e = i^*$. In particular,

$$\begin{aligned} j^e &\equiv \operatorname{argmax}_j \int_{\theta\in\Theta} \{v(q^*(i^*,j,\theta),j,\theta) - c(q^*(i^*,j,\theta),i^*,\theta) \\ &\qquad -\psi(j) - [p^0 - c(q^0,i^*,\theta)]\}\, dG(\theta), \\ &= j^*. \end{aligned} \tag{1.12}$$

QED.

Proposition 2 details how a simple contract, consisting of a choice of allocation and power delegation, will induce both players to make efficient investments, and thus can implement the first-best outcome. The intuition underlying proposition 2 is as follows: Given the chosen levels of investment, *ex post* renegotiation yields efficient trading. The buyer has the full bargaining power he gets all the return from his own investment, minus a constant sum which is independent of his own investment, therefore the buyer will make the efficient investment decision. The initial contract directly determines the payoff of the seller, hence an appropriate choice of the default option will give the party with no bargaining power the correct investment incentives. The existence of such initial contract is guaranteed by Assumption 1 on the sign of the cross derivative c_{iq}. This result is in sharp contrast with the predictions of Hart and Moore where inefficient investment cannot be avoided using incomplete contracts. This difference stems from the alteration of the enforcement technology that governs the relationship and in particular the initial contract: They assume trade is voluntary, it takes place only if both players agree on it. Proposition 2 shows that different results can be obtained if we allow for the courts to legally enforce the initial contract. In technical terms, allowing for another default option than the otherwise unique (in the context of Hart and Moore) "no-trade" default option is enough to produce enough incentives for both players to undergo efficient investment.

1.6 Long-Term Contracts

A contract is renegotiated if and only if, under the terms of the contract, one party prefers either not to trade or an outside option over trade. If trade under the original contract is better for both parties than breaking the contract, trade will occur without any renegotiation. Renegotiation can then at best only shift the parties along the bargaining frontier, so one party's gain can come only at the expense of the other party's loss. Thus any new contract one party would offer will always be rejected by the other party. Given that the outside options are not binding, the threat of leaving the relationship if an offer is rejected is not credible, and no-renegotiation is a subgame perfect equilibrium. Since specific investments are valuable for trade only with the chosen partner, the return on the specific investment is not reflected in the value of the outside options. As a result, an investor fails to receive the marginal return on investment, not only when renegotiation results in surplus sharing, but also when it results in the investor's outside option constraint being binding. Whenever renegotiation occurs, whether because under the existing contract one party would prefer no to trade at all or because one party would prefer its outside option, the outcome will be determined as described in proposition 1 and an investor will not receive the full marginal return on investment. An optimal contract in this case should be a renegotiation-proof contract. Therefore, efficient investments requires a contract conditioned on external variables to ensure renegotiation never occurs.

MacLeod and Malcomson [1993] show how simple contracts can achieve efficient investment by avoiding renegotiation. They motivate their model by relying on evidence from the coal contracts and the collective bargaining agreements from the labor market. Both these contracts are characterized by their long duration, and the two types of contracts emphasize the importance of escalation clauses incidences in the determination of prices and wages over the life of the contract. Joskow [1988,1990] describes in details contracts from the coal industry, negotiated among public utilities and coal suppliers, and with large number of escalator clauses that make contract prices conditional on external circumstances such as the price of inputs and productivity changes affecting comparable mines. These contracts are of significantly longer durations with some contracts spanning over 20 years, and rare incidences of contract renegotiations. In the unionized labor market, Cost-Of-Living-Allowance (COLA) are commonly observed in the collective bargaining agreements. There is a large body of empirical work studying wage determination and contract duration in the union sector, and it is well documented that contracts with COLA clauses are on the average of longer duration than contracts with no COLA clauses. Also, studying collective bargaining agreements from the Canadian manufacturing sector, Farès [1997] show that contract renegotiations (proxied by strike incidences) are significantly reduced if previous contracts include an escalator clause.

To formalize these ideas and give more theoretical content to the above empirical evidence, in the context of the model described in section 1.2, suppose it is possible to make the price specified in the initial contract contingent on θ. Let the contract price $p(\theta)$ be such that:

$$c(q,i,\theta) < p(\theta) < v(q,j,\theta)\,,\ \forall i,j \geq 0 \text{ and } \forall \theta \in \Theta\,, \tag{1.13}$$

and for this price the outside options for either party are not binding, (i.e) $u_s(p(\theta),i,\theta) \geq v_s(\theta)$ and $u_b(p(\theta),j,\theta) \geq v_b(\theta)$, $\forall i,j,\theta$. Under these conditions[6], the rent sharing and *ex post* renegotiation, as described in Proposition 1, will never occur regardless of the levels of investment made by the two agents. Without the threat of *ex post* renegotiation, the parties will expect to have their full marginal return on their investment, and as a result, the investment chosen *ex ante* will be optimal. In particular, the equilibrium investment levels will satisfy

$$i^* \equiv \arg\max_{i\in I} \int_{\theta\in\Theta} [p(\theta) - c(q,i,\theta)]\, dG(\theta) - \phi(i), \tag{1.14}$$

$$j^* \equiv \arg\max_{j\in J} \int_{\theta\in\Theta} [v(q,j,\theta) - p(\theta)]\, dG(\theta) - \psi(j). \tag{1.15}$$

Because $p(\theta)$ is independent of i and j this will give the efficient investment levels as defined in the first-best contract first order conditions (1.5). Note that the contract price need not to be conditioned on the levels of investments, only on the random variable θ.

The role of the escalator clause is to change prices so that the constraints imposed by the outside options will never bind, and renegotiation will not take place. MacLeod and Malcomson interpret the outside options as the market conditions (prices), and the optimal contracts discussed in this section will yield a contract price that in general covary (although with some degree of rigidity) with the market conditions, so these

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[6] Note that the total surplus will then satisfy $u_s + u_b \geq v_s + v_b$ which guarantees that trade is efficient. Remember that trade in this model is only a 0, 1 decision.

conditions will not become binding. These implications are supported by empirical evidence also documented in Farès [1997] study of wage determination in the Canadian manufacturing sector. The motive of escalators is different from what we expect in insurance contracts. If the motive was insurance, then the role of the escalator would be to protect the parties from market fluctuations, which implies that the contract prices and the market prices will diverge. In fact what we observe is that the escalator clauses do a very good job in following the market price of coal and the alternative wage of the union workers.

In practice, the state of the world might be very complex, and writing a contract conditional on θ might be very costly, even unattainable. Escalator clauses can allow the price to be conditioned *partially* on the state of nature, but unless very complicated, they are unlikely to capture everything about θ relevant to the relationship. This can be modeled by allowing the contract to be conditioned on verifiable events that are subsets of the possible states. Consider Γ a verifiable partition of Θ so that contracts can be written with prices $p(\gamma)$ for the verifiable event $\gamma \in \Gamma$. Under such contracts, the prices are the same for all the states of nature within the event γ, reflecting that complete contracting is not possible. MacLeod and Malcomson show that under the assumption that the partition Γ is sufficiently rich so that it can be divided into "good" events and "bad" events: Where for good events if it is efficient to trade for some $\theta \in \gamma$ then it is efficient to trade for all $\theta \in \gamma$ even if no investment is made. And bad events are the events for which trade is never efficient. This assumption will ensure a trading price that is independent of the levels of investment, and the levels chosen will be efficient. Moreover, the contract does not need breach penalties, and no actual renegotiation will take place as long as it is efficient to trade.

Contrary to the short term contracts where initial contracts are always renegotiated, and the renegotiation design (the allocation of the bargaining power) together with the proper design of the initial contract (which will be always binding) will induce both the buyer and the seller to make the optimal level of investment, long-term contracts are renegotiation proof. For the short term contracts, renegotiation has to take place, and it is crucial to achieve efficient trading levels and efficient investment decisions. Long-term contracts are shaped in order to avoid renegotiation, and hence, avoid any surplus sharing. The initial contract in this case might include escalator clauses, or in general, the prices might be conditioned on verifiable external events so these prices will covary with the market conditions, and as a result the outside options constraints will not be binding and renegotiation will not be observed.

1.7 Discussion

This paper reviews some of the recent developments in the theory of incomplete contracts addressing the Williamson's under-investment problem. We study the assumptions underlying the results of Hart and Moore, and we show how the literature, by changing some of these assumptions, was able to develop a theory to induce efficient investment. Relying on propositions from the non-cooperative bargaining theory, in particular the role of outside options, two contracts were shown capable to reverse the Hart and Moore results. Renegotiation design, under the assumption of specific performance is one potential contract. These contracts can suffer from some serious difficulties: the legal enforceability of the instruments proposed in the renegotiation design (specific performance), and the complexity of the contracts that may include some randomization. Long-term contracts on the other hand, are another example of simple contracts that can be used to achieve optimal efficiency. The shortfalls of this literature is the lack of explicit modeling of the trade quantities, and the necessity of a proper external indicator.

The common theme is the role of the contracts in generating and allocating the rents from continuing matches that arise as soon as we move away from the frictionless world of textbook markets. With specific investment these contracts allocate the *ex post* rents in such a way as to avoid inefficiencies in investments, separation and bargaining costs. The precise manner in which contracts differ from the competitive market models depends on a variety of factors, including the nature of the relationship specific investments and the ability to enforce explicit contract terms.

More empirical research is needed to exploit the role of relationship specific investments in the price determination process in many alternative markets. In particular, in the labor market, this role might help clarify some unanswerd questions with respect to wage stickiness and conflicts.

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Chapter 2

Strikes and Wage Dynamics

This chapter is a preliminary investigation into contract renegotiation. It presents an empirical analysis of the effect of strikes on the evolution of wages, based on data from union wage settlements in the Canadian manufacturing sector. Previous studies focus on the effect of strikes on the level of wages while less is known about determinants of strike incidences. This chapter explores the determinants of strike incidence based upon a switching regime model. We correct for the strike endogeneity in cross a section by using sample selection methods and instrumental variables. We then consider the fixed effect method usually used with longitudinal data. We extend this method by allowing the time invariant (fixed) specific effect to have a differential impact in the two regimes. This paper also presents a new panel data estimator that is robust to both non-random selection and to differential characteristic (observed and unobserved) rewards in the strike and the non-strike regimes. The empirical findings of the paper cast some doubts on the use of fixed-effects models in estimating strike effect on wages. Strikes appear to have a significant rent-sharing role, as well as "catching-up" for uncompensated inflation during the previous contract term. There is evidence that wage rigidity depends on the strike's activity, in particular, previous wages have a significantly reduced impact on wage negotiations when a strike takes place.

2.1 Introduction

This paper is a preliminary investigation into contract renegotiation. We test whether the effect of labor market conditions on wage formation adhere more to the spot market description of the labor market rather than to the contract approach. In simple competitive models, wages are negotiated continuously, which implies that current labor market conditions play a significant role in wage determination. On the other hand, contract models predict that wage history experienced by workers affects their current wage.

We use strike activities to proxy wage renegotiations. Our purpose is to explore the effects of strikes upon wage outcomes using a sample of collective bargaining agreements from the Canadian manufacturing sector. We examine how wage settlements signed after a strike may differ from other negotiated wage agreements. In particular, we compare the effects on the negotiated wage agreements of the previous wages, alternative wages and rents variables.

We exploit different instrumental-variable strategies to estimate wage determination in the Canadian manufacturing sector. We find that strikes on average have no significant effect on the wage level, nevertheless, this is not true for wage dynamics. We find a significant effect of previous wages on current wage determination. This effect is reduced when a strike is observed relative to the effect of contemporaneous labor market conditions. We interpret this result as support to the role of contracts in wage determination as opposed to simple competitive models. Beaudry and DiNardo [1990] reached a similar conclusion by examining cyclical movements in real wages. Using individual data from the Current Popullation Survey and the Panel Study of Income Dynamics, they found that individual wages moved with market conditions in a manner consistent with a contract model, in which there are enforcement constraints, rather than spot market model. In a recent related paper, Beaudry and DiNardo [1995] using data form the PSID suggest further evidence against the competitive model by studying the joint behavior of hours and wages. In contrast, earlier work by Abowd and Card [1989] used four different U.S. data sets and found that the relative variation of earnings and hours changes among workers with the same employer over time is inconsitent with the pattern of earnings smoothing implied by the implicit contract models.

Until recently little attention was given to the effects of costly delays and failures to agree; these inefficiencies were seen by some authors as due to irrational or misguided behaviors, or simply mistakes, and therefore inaccessible to theoretical analysis (See Hicks [1932]). Ashenfelter and Johnson [1969], in a first attempt trying to explain strikes, argued that the basic function of a strike is to square up the union membership's wage expectations with the firm's ability to pay. Recent developments in noncooperative bargaining theory emphasize the importance of private information, and suggest strikes as an information-revealing device used in the presence of asymmetric information. From an ex-ante perspective, therefore, the costly process of bargaining can be an efficient way of establishing a common informational basis for an agreement[1]. Strikes are then explained by private information about some aspect critical to reaching agreement, such as the firm's willingness to pay. Disputes arise as a credible means of communicating this private information. Hence a firm with private information about its willingness to pay can signal this information through its willingness to endure a strike. A firm with a high willingness to pay prefers to settle at a high wage without a strike; whereas a firm with a low willingness to pay prefers to endure a strike and settle at a low wage. A direct implication of the asymmetric information model is the negative correlation between strikes' durations and strikes' wages.

Card [1990] and McConnell [1989] try to test the private information strike models, using panel data from Canada and the United States, respectively. They find contradicting results; Card finds a positive and significant effect of a strike indicator on wages, as for McConnell the estimates of a strike dummy are insignificant in all her specifications, nevertheless an estimated concession schedule gives some support to the asymmetric information model. Earlier work by Lacroix [1986], estimating a cross section model, a separate wage equation for each year in his sample of Canadian data, concludes that on average strikes have no effect on wages.

In contrast with this literature, this paper is an attempt to test for the effects of strikes on the wage evolution, as opposed to the effects on the wage level. In addition to estimating the effect of strikes on the level of wages, by adding a strike indicator to a conventional log-linear wage regression, we recognize that wages may follow different regimes depending on whether agreement is reached after a strike had occurred. Consequently, different wage equations are estimated, and the results are interpreted in the context of alternative contract theory.

Given that some endogenous process determines the strike behavior, questions nat-

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[1] See Kennan and Wilson [1993] for a survey of bargaining with private information.

urally arise about what strike effects measure in the endogenous strike decision context and how they should be interpreted. In order to correct for this endogeneity, a switching regime model with endogenous switching rule is estimated. Within this framework, both cross-sectional and longitudinal estimators may be compared. Since the interpretation and the properties of the estimators depend crucially on the underlying endogenous process, a detailed, explicit characterization is provided for the stochastic structure.

Four approaches to solve the problem are considered: We first start with cross-sectional methods suggested in the literature of cross section data. We correct for the strike endogeneity by using sample selection methods and instrumental variables. Then we consider the fixed effect method usually used with longitudinal data. We discuss in details the fixed effect model and the first differencing methods ability to correct for the endogenous biases.

We extend these methods by relaxing some restrictions imposed by the fixed effect model, and we allow time invariant specific effect to vary between the two regimes in order to account for the differently rewarded observed and unobserved determinants of the contract wages. This would invalidates the standard assumption made in panel data models that unobserved characteristics are captured by a time-invariant fixed effect equally valued in the two regimes. This paper presents a new panel data estimator that is robust to both non-random selection and to differential characteristic rewards in the strike and the non-strike regimes. The time-invariant unobservable is interacted with the strike dummy in the wage equation. The estimator is obtained by first *quasi-differencing* the wage equation, and then fitting this quasi-differenced equation using non-linear instrumental variables techniques.

The plan of this paper is as follows. Section 2 defines the wage determination equations, and discuss the theoretical background as well as the econometric problems. This section also explains how the effects of observed as well as unobserved wage determinants can vary with the strike activities. Section 3 describes the cross-sectional and longitudinal estimation methodology. Section 4 describes the data used in this study. In Section 5 the empirical results of estimates from the Canadian wage data are shown. We conclude in Section 6.

2.2 The Model

In this section we present a model in which the wage process depends on whether a strike has occurred during contract negotiations. We argue in the framework of alternative contract theories that the previous wage, alternative wages, other observed characteristics, and a time-invariant unobserved characteristic have different effects on contract wages, depending on the strike activity. Formally, consider the following two-regime wage equations: If there is no strike before a contract agreement is reached, wages are given by:

$$w_{it}^{ns} = \delta^{ns} + \rho^{ns} w_{i,t-1} + \beta^{ns} X_{it} + \epsilon_{it}^{ns}. \tag{2.1}$$

Alternatively, when a strike takes place during contract negotiation, wages are given by

$$w_{it}^{s} = \delta^{s} + \rho^{s} w_{i,t-1} + \beta^{s} X_{it} + \epsilon_{it}^{s}. \tag{2.2}$$

Where w_{it}^{σ} , $\sigma \in \{s, ns\}$ is a measure of the contract t wage[2] reached by the bargaining unit i; $w_{i,t-1}$ is the lagged wage from the previous contract signed in the same bargaining unit; X_{it} is a vector of other observable (both to the market and to the econometrician) covariates: it includes observable alternative wages that might act as proxies for threat points during wage negotiations, firm specific variables, aggregate data on the industry level and the national level describing labor and product markets as well as business cycle conditions.

2.2.1 Theoretical Background

When studying wage formation, a common theme is that observed wage-employment combinations do not correspond to the intersection of demand and supply in a frictionless world of textbook markets. This section reviews contract models of wage formation. One hypothesis is that insurance is the primary motivation for a contract, this is known as the *Implicit Contracts*[3]. Implicit contract theory suggests that contracts are negotiated between risk averse agents. Since workers are assumed to be more risk averse

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[2] Different real wage measures are used in the empirical analysis: Beginning of contract wage, weighted average over the life of the contract and expected weighted average over the life of the contract.

[3] See Rosen [1985] for a survey of implicit contract theory.

than their employers, contracts will then insure workers against fluctuations and uncertainties in the economy. This results in downward real wage rigidity (Harris and Holmsrtrom [1982]) , where nominal shocks play no role in the wage determination, and through contract renegotiation. This latter is prompted by real shocks (productivity) and real wages are adjusted (upward) to reflect these changes in productivity.

Williamson [1985] highlights the important role the contracts play to protect investments from the *hold-up* or opportunism. Most worker-firm relationships require costly specific investments to be made, and specific skills to develop. Ex-post sharing of the returns from specific investment reduces the incentives for efficient investment. MacLeod and Malcomson [1993] show that when specific investment arises from turnover costs, the optimal contract wages may display some form of nominal rigidity, where contracts are renegotiated only when market (or other) alternatives to the bargaining parties become more attractive than the terms of the contract in place. In other words, contract renegotiations occur when outside options are binding, and then we can expect upward or downward adjustment to the nominal wage.

Both insurance motivation and the hold-up motivation for contracting imply that with no contract renegotiation, wages are mainly determined by the previous wage. If a strike is a proxy for wage renegotiation, then we should expect that $\rho^s < \rho^{ns}$ indicating that strikes undermine the role of the previous wage in the contract renegotiations. Also both contract theories suggest that when strikes occur, their role is to align contract wages with alternative wages. Therefore, labor market conditions should be very important determinants of the wage after a strike. On the other hand, the implications on the effect of inflation differ between the two models. While insurance contracts smooth real wages by (fully) adjusting them to inflation, hold-up contracts suggest only partial indexation.

2.2.2 Econometric Issues

The properties of different estimators considered in this paper depend on the assumptions made about the nature of the disturbances ϵ_{it}^{ns} and ϵ_{it}^{s}. Decompose the disturbances in equations (2.1) and (2.2) into time-invariant components and remainders:

$$\begin{aligned}\epsilon_{it}^{ns} &= \theta_i^{ns} + \eta_{it}^{ns}, && (2.3)\\ \epsilon_{it}^{s} &= \theta_i^{s} + \eta_{it}^{s}. && (2.4)\end{aligned}$$

The time-invariant components, θ_i^{ns} and θ_i^s, may be thought of as threat points or issues that arise during negotiations, and differ among bargaining units depending on the strike activity. They can also be a measure of firm specific rents[4], or the union value (workers' quality) to the firm. The remainders η_{it}^{ns} and η_{it}^{s} represent time-varying omitted variables that may be represented as random drawings for each bargaining unit, and that may differ over contracts. Equations (2.1) and (2.2) can be combined using a dummy variable,S_{it} , for the strike activity:

$$w_{it} = S_{it}w_{it}^{s} + (1 - S_{it})w_{it}^{ns}. \qquad (2.5)$$

Expand (2.5) and rearrange to get the estimating equation

$$\begin{aligned} w_{it} &= \delta^{ns} + (\delta^s - \delta^{ns})S_{it} + (\rho^s - \rho^{ns})S_{it}w_{i,t-1} + \rho^{ns}w_{i,t-1}\\ &\quad +(\beta^s - \beta^{ns})S_{it}X_{it} + \beta^{ns}X_{it} + \nu_{it}\\ &= F_{it}(w_{i,t-1}, X_{it}, S_{it}; \Gamma) + \nu_{it}. && (2.6)\end{aligned}$$

With

$$\begin{aligned} F_{it}(w_{i,t-1}, X_{it}, S_{it}; \Gamma) &= \delta^{ns} + (\delta^s - \delta^{ns})S_{it} + (\rho^s - \rho^{ns})S_{it}w_{i,t-1}\\ &\quad +\rho^{ns}w_{i,t-1} + (\beta^s - \beta^{ns})S_{it}X_{it} + \beta^{ns}X_{it},\\ \text{and } \nu_{it} &= \epsilon_{it}^{ns} + (\epsilon_{it}^{s} - \epsilon_{it}^{ns})S_{it}.\end{aligned}$$

Note that Γ is the vector of parameters to be estimated. The standard estimates of the strike effect are OLS estimates of the parameter $\delta(= \delta^s - \delta^{ns})$ in equation (2.6), where δ is usually called the direct effect of strikes on wages. For the OLS estimates of Γ to be consistent, a set of conditions needs to be satisfied. In particular, the disturbance ν_{it} must be uncorrelated with the strike activities, previous wages and X_{it}. The problem with the OLS estimates is that the strike dummy, and as a consequence all the interaction terms, is likely to be correlated with the disturbance. One can think of strikes as

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[4] Rents can arise for different reasons; Uncertainty and risk aversion, or specific investment.

a strategic decision made by either bargaining party in an attempt to enhance its bargaining position during negotiations. In this context, both strikes and wages are jointly determined and strikes are not exogenous. A parallel argument can be made for the correlation between θ_i and S_{it}: If, for example, θ_i contains information about the value of the union to the firm, then according to asymmetric information models of strikes, one should expect a negative covariance between θ_i and the strike dummy. Alternative interpretation of θ_i can be a measure of unobserved union characteristics (risk aversion, threat points, relative bargaining power), this will then lead to a positive covariance between θ_i and the strike dummy. The inability to control for the bargaining unit specific effect in a cross section (individual years or as a pooled cross section/time series) will lead to a bias in the cross-section estimates of the parameters in equation (2.6). To account for this omitted-variables bias two cross-sectional approaches can be considered. We correct for the endogeneity using either an instrumental variables technique or a sample selection correction method. The main drawback of this approach is the need to make distributional or exclusion assumptions.

The availability of longitudinal data for equation (2.6) suggests an alternative to the cross-section approach for the strike endogeneity problem. If unobserved bargaining unit specific effect θ_i are constant over time one can control for them by estimating a fixed-effect model. However, standard fixed-effect methods (first differencing) imposes another assumption, mainly $\epsilon_{it}^{s} = \epsilon_{it}^{ns}$, ignoring differences arising from strike activities. We relax this assumption by allowing the permanent effects of the disturbances to be different, $\theta_i^{ns} \neq \theta_i^{s}$. Longitudinal differencing will not eliminate the specific effect θ_i from equation (2.6), and the standard fixed effect estimates will not be consistent. Instead we suggest the use of a non-linear instrumental variables estimation techniques.

2.3 Estimation Methods

In order to correct for the problems arising from the endogeneity of strikes, $\mathrm{Cov}(S_{it}, \nu_{it}) \neq 0$, and consequently, the correlation of the interaction terms $S_{it}w_{i,t-1}$, $S_{it}X_{it}$ with ν_{it} , several alternative approaches to estimate equation (2.6) were suggested in the literature. This section describes Two techniques common in the cross section estimations literature: Instrumental Variables (IV) and control function methods, the inverse Mills ratio (IM)[5]. One drawback of the cross section estimates, either IM or IV, is the need to make arbitrary, and sometimes implausible, distributional and/or exclusion assumptions. The use of panel data allows one to relax these assumptions. If strikes are only correlated with the time-invariant component of the error term, consistent estimates can be obtained using a fixed effect approach. Standard specification tests (Hausman [1978]) can then be used to investigate whether estimates which do not control for fixed effects are inconsistent. The appropriateness of the standard fixed effect model is then tested. The test is obtained by noting that the difference equation implies that changes in the explanatory variables should have the same effect (in absolute value) on the wage rate whether they are increases or decreases. Following Chamberlain [1982], we do a specification test by comparing the effect on the wage of moving from a Strike to a No-Strike to the effect of moving from a No-Strike to a Strike. If the two coefficients are of equal but opposite signs, we can not reject the fixed effect model. Finally we allow the coefficient on the time-invariant error term to vary among regimes, in the same manner as all other explanatory variables are treated. With this generalization, first-differencing will not succeed in eliminating the unobservables from the wage equation. We consider two estimates. As a first attempt, we run separate first differenced models on observations with two consecutive strikes and observations with two consecutive No-Strikes. We then combine all observations, by quasi-differencing the wage equation, and then fitting the quasi-differenced equation using non-linear methods[6]. A Wald-type test can then be used to test the restrictions imposed by the standard fixed effect model. Throughout

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[5] Heckman and Robb [1985] used similar methods when estimating the impact of training on earnings when enrolement of persons is the outcome of a selection process. See also Robinson [1989] for a similar treatment yet in a another context.

[6] This estimator was used in Lemieux [1993,1997] and is very close to what Jakubson [1991] and Card [1996] proposed to estimate the effects of unions on wage inequality.

this section we assume that the permanent component of the wage disturbance, the time-invariant specific effects, is the only source of strike endogeneity.

2.3.1 Sample Selection Bias and Instrumental Variable Methods

The first class of estimators to be considered is the control function type, of which the inverse Mills ratio methods has been most widely used. The selection model is based on two regression equations and a criterion function that determines which of these two equations is applicable. This is known as "switching regression model with endogenous switching". The two wage regimes are a contract wage settled after a strike and a contract wage settled with no strike as described in equations (2.1) and (2.2). The second part of the model is the decision rule determining the strike activity and therefore the regime that takes place. Consider the Latent variable, S^*_{it}: In this case a strike occurs only when $S^*_{it} \geq 0$. S^*_{it} is the net-of-costs wage difference from choosing to strike[7]:

$$S^*_{it} = w^s_{it} - w^{ns}_{it} - C^s_{it}.$$

The costs C^s_{it} in the event of a strike can be due to loses in wage payments during the strike duration, or a reduction in benefit payments after a drop in production caused by the strike. Rewriting in a more compact way,

$$\begin{aligned} S^*_{it} &= \pi Z_{it} + \mu_{it}, && (2.7)\\ \text{and } \mu_{it} &= \epsilon^s_{it} - \epsilon^{ns}_{it}. && (2.8) \end{aligned}$$

Where Z_{it} is a vector of observable contract characteristics and other aggregate covariates that might influence the agents decisions when strike considerations are in place. π is a parameter vector, and μ_{it} is the composite error term. Since S^*_{it} is a latent variable, it is not observable. What we observe is the strike indicator S_{it} such that:

$$S_{it} = \begin{cases} 1 & \text{if } S^*_{it} \geq 0, \\ 0 & \text{Otherwise.} \end{cases}$$

This formulation of the decision rule clarifies the source of endogeneity. In particular, the existence of $\epsilon^s_{it} - \epsilon^{ns}_{it}$ in the error term implies the non-zero correlation between S_{it}

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[7] This selection is from the union side.

and ν_{it} . The decision rule represented by S_{it} hides a complex set of interactions in the economy, among workers, their union representatives and the firms. Conflicts during contract negotiations may arise as a consequence of many different reasons. Many theoretical explanation have been advanced to explain strikes. Asymmetric information models consider strikes as a signaling device that bargaining parties use to transmit informations credibly through the bargaining process. If the union makes its wage offer in an attempt to extract some of the rents due to the specific relationship with the firm, and if the firm judge the offer as too high, in this case, enduring a strike will be the firm's way to respond to the unaffordable union wage offer. On the other hand, strikes can be the union's way to pressure the firm and force wages to catch up with previous uncompensated nominal (or real) shocks. For these reasons, assuming that the selection decision can be represented in a single linear index function can be problematic. We should be cautious when interpreting the empirical results. Also the Z_{it} vector is assumed to include all the regressors in the wage equations. There will be no exclusion restrictions in the form of elements of the Z_{it} vector not found in the wage equation.

Because the sample selection is observed, we have the observations S_{it}, and we can use a probit model to estimate the parameters π. Since π is estimable only up to scale, we shall assume that $\text{Var}(\mu_{it}) = 1$. Also assuming that the error terms in equations (2.1) and (2.2), ϵ_{it}^{ns} and ϵ_{it}^{s}, and μ_{it} are jointly normally distributed with mean vector zero and the following covariance structure

$$\begin{bmatrix} \sigma_{ns}^2 & \sigma_{sns} & \sigma_{ns\mu} \\ & \sigma_s^2 & \sigma_{s\mu} \\ & & 1 \end{bmatrix}$$

Note that the normality assumption, and the particular structure of the covariance matrix are not required to produce efficient estimators. In the literature (Heckman [1976,1979]) weaker *sufficient* conditions are imposed, and as a consequence nonlinear least squares can be used. Using maximum likelihood methods, normality produces more efficient estimator.[8]

The problem with estimating equations (2.1) and (2.2) using OLS estimation tech-

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[8] Also see Lee [1982] for some non-normal models.

niques is that the conditional means of the disturbances are not zero:

$$E[\epsilon_{it}^{ns}|\mu_{it} < -\pi Z_{it}] \neq 0 \text{ and } E[\epsilon_{it}^{s}|\mu_{it} \geq \pi Z_{it}] \neq 0.$$

A two-stage estimation can be developed, exploiting the distributional assumptions made, to calculate these expected values of the residuals. In order to obtain $E[\epsilon_{it}^{ns}|\mu_{it} < -\pi Z_{it}]$, note that the conditional distribution of ϵ_{it}^{ns} given μ_{it} is normal, with mean $\sigma_{ns\mu}\mu_{it}$ and variance $\sigma_{ns}^2 - \sigma_{ns\mu}^2$, remember that the variance of μ_{it} is normalized to one. Hence,

$$\begin{aligned} E[\epsilon_{it}^{ns}|\mu_{it} < -\pi Z_{it}] &= \sigma_{ns\mu} E[\mu_{it}|\mu_{it} < -\pi Z_{it}] \\ &= -\sigma_{ns\mu}\frac{\phi(-\pi Z_{it})}{\Phi(-\pi Z_{it})} \\ &= -\sigma_{ns\mu}\frac{\phi(\pi Z_{it})}{1-\Phi(\pi Z_{it})}. \end{aligned}$$

Similarly

$$\begin{aligned} E[\epsilon_{it}^{s}|\mu_{it} \geq -\pi Z_{it}] &= \sigma_{s\mu} E[\mu_{it}|\mu_{it} \geq -\pi Z_{it}] \\ &= \sigma_{s\mu}\frac{\phi(-\pi Z_{it})}{1-\Phi(-\pi Z_{it})} \\ &= \sigma_{s\mu}\frac{\phi(\pi Z_{it})}{\Phi(\pi Z_{it})}. \end{aligned}$$

The functions ϕ and Φ are the standard normal probability density function and cumulative density function, respectively. We can then rewrite equations (2.1) and (2.2), adding the correction terms, as

$$\begin{aligned} w_{it}^{ns} &= \delta^{ns} + \rho^{ns} w_{i,t-1} + \beta^{ns} X_{it} - \sigma_{ns\mu}\tfrac{\phi(\pi Z_{it})}{1-\Phi(\pi Z_{it})} + \tilde{\epsilon}_{it}^{ns}, \\ w_{it}^{s} &= \delta^{s} + \rho^{s} w_{i,t-1} + \beta^{s} X_{it} + \sigma_{s\mu}\tfrac{\phi(\pi Z_{it})}{\Phi(\pi Z_{it})} + \tilde{\epsilon}_{it}^{s}. \end{aligned} \tag{2.9}$$

Where $\tilde{\epsilon}_{it}^{ns}$ and $\tilde{\epsilon}_{it}^{s}$ are the new residuals with zero conditional means:

$$\begin{aligned} \tilde{\epsilon}_{it}^{ns} &= \epsilon_{it}^{ns} + \sigma_{ns\mu}\frac{\phi(\pi Z_{it})}{1-\Phi(\pi Z_{it})}, \\ \tilde{\epsilon}_{it}^{s} &= \epsilon_{it}^{s} - \sigma_{s\mu}\frac{\phi(\pi Z_{it})}{\Phi(\pi Z_{it})}. \end{aligned}$$

Equivalently, we can combine these two equation similar to equation (2.6)

$$\begin{aligned} w_{it} &= F_{it}(w_{i,t-1}, X_{it}, S_{it}; \Gamma) + \sigma_{ns\mu}\lambda_{it} \\ &\quad + [\sigma_{s\mu} - \sigma_{ns\mu}]\,\lambda_{it} S_{it} + \tilde{\nu}_{it} \end{aligned} \tag{2.10}$$

dummy are $\Delta w_{i,t-2}$ or $w_{i,t-2}$ together with interactions with the strike dummy and alternative wages from previous contracts and lagged year effects.

Regression (2.13) can be generalized to allow for a non-linear specification. Under the assumption $\epsilon_{it}^{s} = \epsilon_{it}^{ns}$ the disturbance ν_{it} will be reduced to:

$$\nu_{it} = \epsilon_{it}^{ns} = \theta_i + \eta_{it}.$$

Where we have dropped the {ns} superscript for simplicity. Following Chamberlain [1982], consider the wage equation from a cross-section augmented by the specific effect θ_i. If θ_i is correlated with the strike dummy at period t, then in general, it will be correlated with the strike activity at any period. Specifically, let S_i^h represent an indicator variable for the hth possible "strike history", of a bargaining unit i, in the longitudinal sample. We assume that $E[S_i^h \eta_{it}] = 0$ for all h and all t. We restrict the set of possible histories to the minimum needed in a panel data set, only two consecutive periods. In this case four alternative histories of strike activities within a specific bargaining unit can be defined :

$$\begin{array}{l} S_i^{01} = 1 \text{ if } S_{i,t-1} = 0 \text{ and } S_{it} = 1 \text{ ; 0 Otherwise.} \\ S_i^{10} = 1 \text{ if } S_{i,t-1} = 1 \text{ and } S_{it} = 0 \text{ ; 0 Otherwise.} \\ S_i^{00} = 1 \text{ if } S_{i,t-1} = 0 \text{ and } S_{it} = 0 \text{ ; 0 Otherwise.} \\ S_i^{11} = 1 \text{ if } S_{i,t-1} = 1 \text{ and } S_{it} = 1 \text{ ; 0 Otherwise.} \end{array}$$

S_i^{11} will indicate two consecutive contracts reached by the bargaining unit i involving strikes at the signing of each contract. We further assume that the permanent component of the disturbance can be decomposed into a linear function of the observed indicators for all but one of the possible strike histories.

$$\theta_i = \phi_1 + \phi_{01} S_i^{01} + \phi_{10} S_i^{10} + \phi_{11} S_i^{11} + \xi_i.$$

Where ξ_i is an error component with $E[\xi_i S_i^h] = 0$ for all $h \in \{01, 10, 11\}$. Replacing θ_i in the wage regression (2.6), we get

$$\begin{aligned} w_{it} &= \delta^{ns} + \phi_1 + [(\delta^s - \delta^{ns}) + \phi_{01}] S_i^{01} + \phi_{10} S_i^{10} \\ &\quad + [(\delta^s - \delta^{ns}) + \phi_{11}] S_i^{11} + \rho^{ns} w_{i,t-1} + (\rho^s - \rho^{ns}) S_{it} w_{i,t-1} \\ &\quad + (\beta^s - \beta^{ns}) S_{it} X_{it} + \beta^{ns} X_{it} + \xi_i + \eta_{it}. \end{aligned}$$

If we do the same replacement in the regression for $w_{i,t-1}$ we get

$$w_{i,t-1} = \delta^{ns} + \phi_1 + \phi_{01} S_i^{01} + [(\delta^s - \delta^{ns}) + \phi_{10}] S_i^{10}$$

With $\tilde{\nu}_{it} = \tilde{\epsilon}_{it}^{ns} + (\tilde{\epsilon}_{it}^{s} - \tilde{\epsilon}_{it}^{ns})S_{it}$. and where λ_{it} is the inverse Mills ratio defined as

$$\lambda_{it} = \begin{cases} -\frac{\phi(\pi Z_{it})}{1-\Phi(\pi Z_{it})} & \text{if } S_{it} = 0 \\ \frac{\phi(\pi Z_{it})}{\Phi(\pi Z_{it})} & \text{if } S_{it} = 1 \end{cases}$$

The method we describe below will produce consistent estimates provided that the conditional disturbances $E[\epsilon_{it}^{ns}|\mu_{it} < -\pi Z_{it}]$ and $E[\epsilon_{it}^{s}|\mu_{it} \geq -\pi Z_{it}]$ are consistently estimated.[9]

The two-stage estimation consists of first estimating a probit model for the probability of strikes ($S_{it} = 1$). The estimated probit coefficients $\hat{\pi}$ are then used to compute estimates $\hat{\lambda}_{it}$ of λ_{it} by substituting $\hat{\pi}$ for π. We next estimate equation (2.10) by OLS substituting $\hat{\lambda}_{it}$ for λ_{it} . This procedure yields consistent estimates of Γ as well as for $\sigma_{ns\mu}$ and $\sigma_{s\mu}$. To obtain estimates of σ_{ns}^2 and σ_s^2, we need to look at the variances of $\tilde{\epsilon}_{it}^{ns}$ and $\tilde{\epsilon}_{it}^{s}$ in equation (2.9). Because of heteroscedasticity arising from the manipulation used to correct for the sample selection, we should, in principle, estimate the wage equation by weighted least squares rather than ordinary least squares.(See Maddala [1983] p.225).

The conventional solution in case of a suspected endogenous explanatory variable is to use instrumental variables (IV). The IV estimator do not need any distributional assumptions to be made on the error components in the wage regression and the selection rule. The source of bias when estimating Equation (2.6) by OLS is the correlation between the strike dummy and the disturbance, $\text{Cov}(S_{it}, \nu_{it}) \neq 0$. The strike endogeneity problem can lead to a positive or negative bias in the OLS estimates of the strike effect on wages, depending on the nature of θ_i. When chosing instruments, say Z, two basic conditions must be satisfied so the instrumental variables method can correct for the contemporaneous correlation between S_{it} and the error term ν_{it}. They are the

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[9] Note that the disturbances in equation (2.10) has a zero mean and is uncorrelated with S_{it} :

$$E[\tilde{\nu}_{it}] = E[\tilde{\epsilon}_{it}^{ns}] + E[(\tilde{\epsilon}_{it}^{s} - \tilde{\epsilon}_{it}^{ns})S_{it}] = 0,$$

since S_{it} is uncorrelated with $(\tilde{\epsilon}_{it}^{s} - \tilde{\epsilon}_{it}^{ns})$. Also

$$E[S_{it}\tilde{\nu}_{it}] = E[S_{it}\tilde{\epsilon}_{it}^{ns}] + E[(\tilde{\epsilon}_{it}^{s} - \tilde{\epsilon}_{it}^{ns})S_{it}^2].$$

But $S_{it}^2 = S_{it}$, since S_{it} take on the value zero or one; hence

$$E[S_{it}\tilde{\nu}_{it}] = E[S_{it}\tilde{\epsilon}_{it}^{ns}] + E[(\tilde{\epsilon}_{it}^{s} - \tilde{\epsilon}_{it}^{ns})S_{it}] = 0.$$

mean-independent of the error term of equation (2.6) *i.e*

$$E[\nu_{it}|Z] = E[\epsilon_{it}^{ns} + (\epsilon_{it}^{s} - \epsilon_{it}^{ns})S_{it}|Z] = 0, \tag{2.11}$$

and the second condition is that Z is correlated with the strike dummy S_{it}. In the fixed effect model where $\epsilon_{it}^{s} = \epsilon_{it}^{ns}$, the problem of estimating the strike effects comes down to the problem arising from S_{it} being correlated with, or stochastically dependent on, ϵ_{it}. We only need to find some variables uncorrelated with ϵ_{it} and correlated with S_{it}. In this case instrumental variables methods can identify the effect of strikes on wages. This can be also true if $\epsilon_{it}^{s} - \epsilon_{it}^{ns}$ is not forecastable (probably because of informational problem) at the date the strike decision is made.

Nevertheless, in the general case where $\epsilon_{it}^{s} \neq \epsilon_{it}^{ns}$, the validity of the assumptions necessary for the IV estimator to be consistent depends on the underlying process generating strikes. What is required is a variable Z that affects the probability of strikes but does not enter in the wage equation, $E[(\epsilon_i^s - \epsilon_i^{ns})S_i|Z_i] = 0$. This might seem as an implausible assumption, and it leads to strong restrictions on the relationship between $(\epsilon_i^s - \epsilon_i^{ns})$ and ν_i, in the random effect model.[10] In particular, it is hard to think of a variable that affects the strike decision and does not enter in the wage equation. As a consequence no exclusion restrictions are made, and the identification is based solely on non-linearities induced by distributional assumptions.

Finally, the assumption made above also implies restrictions on the conditional disturbances, $E[\epsilon_i^s|S_i = 1]$ and $E[\epsilon_i^{ns}|S_i = 0]$, in each equation. The disturbance ν_{it} has the expected value

$$\begin{aligned} E[\nu_{it}] &= E[(\theta_i^s + \eta_{it}^s)S_{it} + (\theta_i^{ns} + \eta_{it}^{ns})(1 - S_{it})] \\ &= E[(\theta_i^s + \eta_{it}^s)|S_{it} = 1]Pr(S_{it} = 1) \\ &\quad E[(\theta_i^{ns} + \eta_{it}^{ns})|S_{it} = 0]Pr(S_{it} = 0) \end{aligned}$$

Since $Pr(S_{it} = 1)$ and $Pr(S_{it} = 0)$ are non negative terms, the assumption of zero mean for this disturbance imposes opposite signs on the conditional means of ϵ_i^s and ϵ_i^{ns}. This rules out positive (or negative) selection, to be contrasted with the results from the

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[10] We are calling this a random effect since the effect of strikes on wages include the difference term $(\epsilon_i^s - \epsilon_i^{ns})$ which is a random factor.

$$+[(\delta^s - \delta^{ns}) + \phi_{11}]S_i^{11} + \rho^{ns} w_{i,t-2} + (\rho^s - \rho^{ns})S_{i,t-1}w_{i,t-2}$$
$$+(\beta^s - \beta^{ns})S_{i,t-1}X_{i,t-1} + \beta^{ns}X_{i,t-1} + \xi_i + \eta_{i,t-1}.$$

With the history '00' treated as the omitted category. From the above two equations, it is clear what restrictions the conventional specific-effect model imposes on the coefficients of the strike histories. In particular, consider the first difference wage equation

$$\begin{aligned}\Delta w_{it} &= \alpha_1 S_i^{01} + \alpha_2 S_i^{10} + \alpha_3 S_i^{11} + \rho^{ns}\Delta w_{i,t-1} \\ &\quad +(\rho^s - \rho^{ns})\Delta(S_{it}w_{i,t-1}) + (\beta^s - \beta^{ns})\Delta(S_{it}X_{it}) \\ &\quad +\beta^{ns}\Delta X_{it} + \Delta\eta_{it}.\end{aligned}$$

An equivalent specification is

$$\begin{aligned}\Delta w_{it} &= \alpha_1 S_{it} + \alpha_2 S_{i,t-1} + (\alpha_3 - \alpha_2 - \alpha_1)S_{i,t-1}S_{it} + \rho^{ns}\Delta w_{i,t-1} \\ &\quad +(\rho^s - \rho^{ns})\Delta(S_{it}w_{i,t-1}) + (\beta^s - \beta^{ns})\Delta(S_{it}X_{it}) \\ &\quad +\beta^{ns}\Delta X_{it} + \Delta\eta_{it}. \qquad (2.14)\end{aligned}$$

The conventional specific-effect model implicitly constrains the coefficients on S_{it} and $S_{i,t-1}$ to be equal in magnitude but opposite in sign, and the coefficient of the interaction term $S_{it}S_{i,t-1}$ to zero. We can test these restrictions:

$$\alpha_1 = -\alpha_2 \qquad \text{and} \qquad \alpha_3 = 0.$$

Because of the restrictive assumptions made in the fixed effects model, we are able to estimate the effect of strikes on wages and the role played by previous and/or alternative wages in the wage determination equation. In this section we want to recognize the fact that unobservables may not be the same conditional on the strike behavior. Assume that the disturbances in the two wage equation (2.1) and (2.2) differ only by their respective permanent components. More specifically, suppose that $\theta_i^s = \psi\theta_i^{ns} = \psi\theta_i$. The wage disturbances will then have the following forms:

$$\epsilon_{it}^{ns} = \theta_i + \eta_{it} \qquad (2.15)$$

$$\epsilon_{it}^{s} = \psi\theta_i + \eta_{it} \qquad (2.16)$$

sample selection correction techniques. Hausman's specification test can then be used to test for the exogeneity of the strike dummy.

2.3.2 Longitudinal Estimates

Without any further restrictions on the error term ν_{it}, the wage regression (2.6) is a random effect model of strikes effects on wages: A contract wage reached after a strike differ from a contract wage reached with no strike by the following terms; $(\delta^s - \delta^{ns})$, $(\rho^s - \rho^{ns})$, $(\beta^s - \beta^{ns})$ and $(\epsilon_{it}^s - \epsilon_{it}^{ns})$. With the last term representing the random effect of strikes. We maintain the assumption that the permanent component of the error term is the only source of strike endogeneity. η_{it} is assumed to have a zero mean conditional on θ_i and on all leads and lags of X_{it} and S_{it} :

$$E(\eta_{it} | w_{i,t-1}, X_i, S_i, \theta_i) = 0. \tag{2.12}$$

The simplifying assumption that is usually made in order to move to a fixed effect framework, is by imposing that the permanent effects are the same across regimes *i.e* $\theta_i^s = \theta_i^{ns}$. This yields,

$$\begin{aligned}
\Delta\nu_{it} &= \Delta\eta_{it}^{ns} + (\theta_i^s - \theta_i^{ns})\Delta S_{it} + \Delta[(\eta_{it}^s - \eta_{it}^{ns})S_{it}] \\
\Delta\nu_{it} &= \Delta\eta_{it}^{ns} + \Delta[(\eta_{it}^s - \eta_{it}^{ns})S_{it}].
\end{aligned}$$

Since $E[(\eta_{it}^s - \eta_{it}^{ns})S_{it}] = 0$ then $E[\Delta\nu_{it}] = 0$. Differencing over consecutive contracts within the same bargaining unit will lead to the following first differenced wage equation:

$$\begin{aligned}
\Delta w_{it} &= (\delta^s - \delta^{ns})\Delta S_{it} + (\rho^s - \rho^{ns})\Delta(S_{it}w_{i,t-1}) + \rho^{ns}\Delta w_{i,t-1} \\
&\quad + (\beta^s - \beta^{ns})\Delta(S_{it}X_{it}) + \beta^{ns}\Delta X_{it} + \Delta\eta_{it}^{ns}.
\end{aligned} \tag{2.13}$$

The assumptions made will purge the first-differenced specification from the correlation between the strike dummy and the error term. Nevertheless, simple OLS estimates of regression (2.13) will not give consistent estimator since first-differencing will create a (negative) correlation between $\Delta w_{i,t-1}$ and $\Delta\eta_{it}^{ns}$ (See Holtz-Eakin, Newey, and Rosen [1988] for a complete discussion). This is very similar to the usual problem of differencing dynamic equations. Instrumental variable techniques therefore have to be used. Suitable instruments for the previous wage and the previous wage interacted with the strike

Since permanent component of the error term is differently rewarded in the two wage equations, first differencing will not succeed in eliminating the fixed effect *e.g* If $S_{i,t-1} = 0$ and $S_{it} = 1$ then the the first difference of the error term will be $\Delta\nu_{it} = (1-\psi)\theta_i + \Delta\eta_{it}$. One possible solution is to estimate the two wage equations (2.1) and (2.2) separately by splitting the wage sample into two subsamples corresponding to two different strikes histories; S_i^{00} and S_i^{11}. Applying standard fixed effect methods (first differencing) on each of these equations will give us consistent estimates of the effects of previous wages, alternative wages, and other covariates on the contract wage.

A more general approach to solve the problems facing the fixed effect models is to combine all the observations and to apply a non-linear IV procedure to obtain a consistent and more efficient estimator. In this framework, restrictions imposed in the usual fixed effect literature are tested.

Combining equations (2.6) and (2.15) yields

$$\begin{aligned} w_{it} &= \delta^{ns} + (\delta^s - \delta^{ns})S_{it} + [\rho^{ns} + (\rho^s - \rho^{ns})S_{it}]w_{i,t-1} \\ &\quad + [\beta^{ns} + (\beta^s - \beta^{ns})S_{it}]X_{it} + [1 + (\psi - 1)S_{it}]\theta_i + \eta_{it} \\ &= F_{it}(w_{i,t-1}, X_{it}, S_{it}; \Gamma) + [1 + (\psi - 1)S_{it}]\theta_i + \eta_{it}. \end{aligned} \tag{2.17}$$

The term $F_{it}(w_{i,t-1}, X_{it}, S_{it}; \Gamma)$ is the predicted contract wage, given previous wages, and other observable contract and aggregate characteristics together with the strike indicator. Because of the interaction term, the brackets in front of θ_i which depends on S_{it}, first-differencing the data will fail to eliminate the fixed-effect θ_i. Instead, a more appropriate approach is to solve explicitly for θ_i, exploiting the information available in the panel data. We first take the lag (with respect to t) of equation (2.17) and we solve for θ_i;

$$\theta_i = \frac{w_{i,t-1} - F_{i,t-1}(w_{i,t-2}, X_{i,t-1}, S_{i,t-1}; \Gamma) - \eta_{i,t-1}}{1 + (\psi - 1)S_{i,t-1}}. \tag{2.18}$$

And then we plug θ_i back into (2.17). This will yield a wage equation in quasi-differenced form;

$$\begin{aligned} w_{it} &= F_{it}(w_{i,t-1}, X_{it}, S_{it}; \Gamma) + \frac{1 + S_{it}(\psi - 1)}{1 + S_{i,t-1}(\psi - 1)}[w_{i,t-1} \\ &\quad - F_{i,t-1}(w_{i,t-2}, X_{i,t-1}, S_{i,t-1}; \Gamma)] + \mu_{it}, \end{aligned} \tag{2.19}$$

where the error term is

$$\mu_{it} = \eta_{it} - \frac{1 + S_{it}(\psi - 1)}{1 + S_{i,t-1}(\psi - 1)}\eta_{i,t-1}.$$

The term $w_{it} - F_{it}(w_{i,t-1}, X_{it}, S_{it}; \Gamma)$ is the excess wage that indicates by how much the observed wage departs from the wage predicted on the basis of previous wages and other observables. Equation 2.19 thus indicates that the excess wage in period t is related to the excess wage in period $t-1$ by the factor $\frac{1+S_{it}(\psi-1)}{1+S_{i,t-1}(\psi-1)}$. This factor depends directly on the strike history of a bargaining unit, in the following manner

$$\frac{1 + S_{it}(\psi - 1)}{1 + S_{i,t-1}(\psi - 1)} = \begin{cases} 1 & \text{for } S_i^{00} \text{ and } S_i^{11} \\ \psi & \text{for } S_i^{01} \\ 1/\psi & \text{for } S_i^{10}. \end{cases}$$

This reflects the fact that, ignoring the error term η_{it}, the excess wage is equal to $\psi\theta_i$ if a strike occurs, and θ_i if no strike took place when the contract was signed. Note that if $\psi = 1$ this equation takes the usual first-differenced form, thus testing the hypothesis $\psi = 1$ will be a direct test for the appropriateness of the standard fixed-effect models. Equation (2.19) is non-linear and could be estimated by non-linear methods. This estimator will still be inconsistent since $w_{i,t-1}$ is correlated with $\eta_{i,t-1}$ and therefore with μ_{it}. But instrumental variables techniques could be used, by chosing instruments correlated with $w_{i,t-1}$ but not with μ_{it}. Natural instruments usually suggested in long panel data are further lags of wages ($w_{i,t-2}$, $w_{i,t-3}$). It follows from the exogeneity condition 2.12 that any function of the history of S_{it} and X_{it} can be a valid instrument for $w_{i,t-1}$. In particular, the discussion in the previous section suggests the history indicators $\{S_i^{00}, S_i^{01}, S_i^{10}, S_i^{11}\}$ interacted with X_{it} and $X_{i,t-1}$ are valid potential instrumental variables. Call the set of valid instruments Z_i, it must satisfy the following condition;

$$E(\mu_{it} Z_i) = 0. \tag{2.20}$$

The parameters of the model can then be estimated by setting the sample analog of condition (2.20) to zero. A consistent estimator is the non-linear IV procedure that solve the following program:

$$Min_\alpha(\mu(\alpha)'Z)(Z'Z)^{-1}(Z'\mu(\alpha)).$$

Where $\mu(\alpha) = (\mu_{1t}, \mu_{2t}, \cdots, \mu_{Nt})'$; N is the number of bargaining units in the sample, and α is the vector of structural parameters to be estimated. We need to impose a normalization condition

$$\frac{1}{TN}\sum_i \sum_t \hat{\theta}_{i,(t)} = 0,$$

where $\hat{\theta}_{i,(t)}$ is the fitted value from the equation

$$\hat{\theta}_{i,(t)} = \frac{w_{it} - F_{it}(w_{i,t-1}, X_{it}, S_{it}; \Gamma)}{1 + (\psi - 1)S_{it}}.$$

This normalization is necessary since the parameters δ^s, δ^{ns}, and $(\delta^s - \delta^{ns})$ cannot be identified separately. This is similar to a standard first-difference specification, (when $\psi = 1$), where only $(\delta^s - \delta^{ns})$ can be directly identified.

2.4 Empirical Results

2.4.1 Cross Section Results

This section applies the estimation methods outlined in section 2.3.1 to the 1965-1993 data from the Canadian manufacturing sector. OLS estimates of the wage equation (2.6) are presented in column 1 of Table 2.1. This estimator does not correct for any source of strike or wage endogeneity but can serve as a benchmark for comparison with the other estimators. The Inverse Mills estimates are reported in column 2 (using the wage specification in equation (2.10)). The IV estimates are reported in the third column. Other than the variables shown in Table 2.1, all models also include 27 unrestricted year dummies, 21 unrestricted industry dummies and the interactions of these dummies with the strike dummy. With no exclusion restrictions made for the IV estimation, the instruments used for the strike dummy are the predicted strike probability obtained from a probit model, and X_{it}, the vector of exogenous variables in the wage equation.

The direct effect of strikes (coefficient of the strike dummy in the second row) is positive but marginally significant. When we correct for strike endogeneity using the IM or the IV method, the coefficient becomes nonsignificant. The effect of the previous wage is stable across specifications and is not significantly different from unity. Nevertheless, when interacted with the strike dummy, the effect of the previous wage is reduced significantly. This implies that the effect of previous wages when a strike occurs is significantly lower than their effects when no strike takes place (*i.e* $\rho^s < \rho^{ns}$). Alternative wages do not seem to play a role in the wage determination except when IM methods are used. In this case, alternative wages have a positive effect on contract wages and this effect is reduced (reversed) when a strike takes place. This result is hard to reconcile with theoretical models of wage determination which emphasize the importance of market alternatives, proxied here by the wages from 2-digit industries. The estimated effect of previous inflation reported in Row 7 of Table 2.1, consistently show the importance of previous nominal shocks. In particular, these effect increase significantly when inflation is interacted with the strike dummy. This suggests that strikes might be playing a catching-up role for previous uncompensated price inflation. The national unemployment rate has a negative effect on contract wages, reflecting the contract wage responses to the business cycles.

The coefficient of the mills ratio in equation (2.10) is positive and significant. This means that the error components ϵ^s and ϵ^{ns} and μ are significantly correlated and that strikes are endogenous. This constitutes a test for strike endogeneity rejecting that strikes can be treated as exogenous in the wage equation. Also we should notice that the covariances $\sigma_{s\mu}$ and $\sigma_{ns\mu}$ are significant and of opposite signs, this implies positive selections, which the IV methods assumes away.

Table 2.1: Cross-Sectional Estimates of the Wage Determination Equation

Cross-Sectional Estimates of the Wage Determination Equation.

(Standard Errors In Parentheses)

Dependent variable: Average Log real wage			
	OLS	IM	IV
1.Constant	-0.025	0.442	0.0127
	(0.036)	(0.086)	(0.028)
2.Strike	0.219	0.129	0.051
Dummy	(0.150)	(0.151)	(0.019)
3(a).Wage at the end	0.949	0.956	0.95
of previous contract	(0.005)	(0.005)	(0.005)
3(b). Strike Dummy	-0.073	-0.080	-0.073
interacted with 3(a).	(0.015)	(0.015)	(0.017)
4(a).Alternative	-0.009	0.032	-0.011
Wage[11].	(0.016)	(0.018)	(0.017)
4(b). Strike Dummy	-0.065	-0.117	-0.003
interacted with 4(a).	(0.051)	(0.053)	(0.036)
5(a).Firm size	0.002	-0.011	-0.0008
	(0.001)	(0.002)	(0.002)
5(b).Strike Dummy	0.003	0.019	0.002
interacted with 5(a).	(0.003)	(0.005)	(0.003)
6(a). Dummy for a	0.010	-0.006	0.007
COLA Clause	(0.002)	(0.003)	(0.003)
6(b).Strike Dummy	0.002	0.024	0.0008
interacted with 6(a).	(0.005)	(0.008)	(0.006)

Notes: Sample consists of 2,955 observations on contracts negotiated between 1966 and 1993. Except for the dummies, all variables are measured as the deviation from their sample mean. All equations include 27 unrestricted year dummies and 21 unrestricted industry dummies, also interactions with the strike dummy are included. Standard deviation of the dependent variable is 0.275.

Cross Section Estimation of Wage Determination (Continued)
(Standard Errors In Parentheses)

Dependent variable: Average Log real wage			
	OLS	IM	IV
7(a). Previous Inflation rate	0.094	0.060	0.088
	(0.021)	(0.021)	(0.023)
7(b).Strike Dummy interacted with 7(a).	0.178	0.212	0.181
	(0.055)	(0.055)	(0.060)
8(a).Expected future inflation rate[12]	0.022	-0.216	-0.021
	(0.030)	(0.050)	(0.036)
8(b).Strike Dummy interacted with 8(a).	-0.247	0.045	-0.254
	(0.074)	(0.106)	(0.081)
9(a). Industrial GDP	0.001	0.014	0.0036
	(0.003)	(0.003)	(0.003)
9(b). Strike Dummy interacted with 9(a).	0.023	0.007	0.028
	(0.007)	(0.009)	(0.008)
10(a). Canadian Unemployment rate	-0.010	-0.012	-0.011
	(0.002)	(0.002)	(0.002)
10(b). Strike Dummy interacted with 10(a).	-0.001	0.000	0.003
	(0.007)	(0.007)	(0.006)
11(a). Mills ratio	.	0.074	.
	.	(0.012)	.
11(b). Strike Dummy interacted with 11(a).	.	-0.107	.
	.	(0.041)	.

Notes: Sample consists of 2,955 observations on contracts negotiated between 1966 and 1993. Except for the dummies, all variables are measured as the deviation from their sample mean. All equations include 27 unrestricted year dummies and 21 unrestricted industry dummies, also interactions with the strike dummy are included. Standard deviation of the dependent variable is 0.275.

2.4.2 Longitudinal Results

We first start by looking at the fixed effect model. Restricting the permanent component of the error disturbance in the wage equation to be the same in the two regimes, we take the first difference within the bargaining unit as described in equation (2.13). Standard first difference estimates of the model in equation (2.13) are reported in column 1 of Table 2.2. The results in general are not very different from the results when using cross section estimates. The direct effect of strike incidence is not significant. Previous wage as well as alternative wages have a significant effect on contract wages. The effect of the previous wage drops marginally when a strike is observed, whereas the effect of alternative wages is enhanced. These results underline the importance of market alternatives relative to previous wages when a strike happens. The effect of the previous inflation rate on wages is not significant when the contract wage is reached without a strike, but this effect becomes positive and significant in the event of a strike. The national unemployment rate has a negative and significant effect on wages in the two regimes.

As we noted earlier, the presence of the lagged wage in the regression will create a correlation between $\Delta w_{i,t-1}$ and the error term. This will bias the OLS estimator of the regression parameters. To correct for this, we instrument for the previous wage difference using further lagged wages $w_{i,t-2}$ and lagged alternative wages interacted with the indices for strike histories.

Table 2.2: Panel Estimation of Wage Determination

Panel Estimation of Wage Determination

(Standard Errors In Parentheses)

Dependent variable: first-differenced average contract Log real wage		
	FE	FE-IV
2.Strike	0.0272	0.060
Dummy	(0.0656)	(0.068)
3(a).Wage at the end	0.3371	0.510
of previous contract	(0.0147)	(0.084)
3(b). Strike Dummy	-0.0186	-0.015
interacted with 3(a).	(0.0103)	(0.011)
4(a).Alternative	0.0052	0.098
Wage	(0.0219)	(0.022)
4(b). Strike Dummy	0.0153	-0.014
interacted with 4(a).	(0.0112)	(0.012)
5(a).Firm size	0.0081	0.013
	(0.0033)	(0.003)
5(b).Strike Dummy	0.0013	-0.000
interacted with 5(a).	(0.0022)	(0.002)
6(a). Dummy for a	0.0012	0.000
COLA Clause	(0.0023)	(0.002)
6(b).Strike Dummy	0.0022	0.002
interacted with 6(a).	(0.0036)	(0.003)

Notes: Sample consists of 2,464 observations from wage contracts. All variables are in first difference. Year dummies and interactions with the strike dummy are included. Instruments for the previous wage include $w_{i,t-2}$ with its interaction with lag strike dummy, also lagged year effects and lagged year effects interacted with lagged strike dummy.

Panel Estimation of Wage Determination(Continued)
(Standard Errors In Parentheses)

Dependent variable: first-differenced average contract Log real wage		
	FE	FE-IV
7(a). Previous Inflation	-0.0065	-0.027
rate	(0.0169)	(0.017)
7(b).Strike Dummy	0.0921	0.044
interacted with 7(a).	(0.0384)	(0.040)
8(a).Expected future	0.1117	0.125
inflation rate	(0.0252)	(0.026)
8(b).Strike Dummy	-0.1593	-0.136
interacted with 8(a).	(0.0509)	(0.053)
9(a). Industrial GDP	0.0019	-0.001
	(0.0044)	(0.004)
9(b). Strike Dummy	0.0014	-0.002
interacted with 9(a).	(0.0054)	(0.005)
10(a). Canadian	-0.0063	-0.002
Unemployment rate	(0.0017)	(0.001)
10(b). Strike Dummy	-0.0035	-0.005
interacted with 10(a).	(0.0050)	(0.005)

Notes: Sample consists of 2,464 observations from wage contracts. All variables are in first difference. Year dummies and interactions with the strike dummy are included. Instruments for the previous wage include $w_{i,t-2}$ with its interaction with lag strike dummy, also lagged year effects and lagged year effects interacted with lagged strike dummy.

Table 2.3: Testing for the Fixed-Effect Specification

Testing for the Fixed-Effect Specification

(Standard Errors In Parentheses)

Dependent variable: first-differenced average contract Log real wage		
	FE	FE-IV
S_{it}	0.030	0.058
	(0.065)	(0.067)
$S_{i,t-1}$	-0.035	-0.079
	(0.065)	(0.066)
$S_{it}S_{i,t-1}$	0.010	0.015
	(0.005)	(0.005)
F value	2.0836	3.847

Notes: Both regressions include all the other variables used in the previous tables. The critical value of the F-Distribution, $F(2, 2390) = 3$ at 5%.

What emerges from the empirical estimates presented in Table 2.2 is that with both estimation methods the direct strike effect is non significant and the effect of alternative wages and labor market pressures on contract wages do not vary between the two regimes. This is inconsistent with the predictions of contract theory. Previous wages always have a significant role in wage determination, there is no strong evidence of any catching up for previous uncompensated price inflation. In Table 2.3, we test the the conventional FE specification by testing whether the interaction term $S_{it}S_{i,t-1}$ is significant, and by testing whether the coefficient of current and lagged strike dummy are equal, and with opposite signs. We follow the same strategy as in the previous table, by using two estimators. OLS estimates of the wage equation (2.14) are presented in column 1 of Table 2.3 and IV estimates are presented in column 2. The instruments used to correct for the previous wage correlation with the error term are $w_{i,t-2}$, $S_{i,t-1}w_{i,t-2}$, lagged year effects and lagged year effects interacted with the strike dummy. Although the fixed effect model cannot be rejected in the OLS specification in the first column, the joint F-test, in the IV specification, rejects the null hypothesis and cast doubts about the appropriateness of the FE model.

Based on the test reported in Table 2.3, we suggest modifications to the FE models. We allow the fixed component of the disturbance term to have a different impact in the two regimes. As a first attempt, we split the sample into two subsamples with two exclusive strike histories S_i^{00} and S_i^{11}. Estimating two wage regressions separately, using first differencing methods will lead to consistent estimates since the permanent component does not vary within a bargaining unit. The direct effect of strikes $(\delta^s - \delta^{ns})$ cannot be identified using this method. Also we have to be cautious when interpreting the empirical estimates, since by using subsamples we create a new non-random selection problem, and because of the significant drop in the degrees of freedom, most of the estimates are not precisely estimated (especially in the sample where $S_i^{11} = 1$).

Table 2.4 presents the empirical estimates, using OLS and FE methods on the two different subsamples. As in the previous tables, the FE estimates of the effect of the previous wage is significantly reduced in the strike sample. On the other hand, the effect of the labor market conditions -measured by alternative wages and unemployment rate- is more important in the strike sample. Because of the small sample sizes, the effect of previous inflation is imprecisely estimated, but the point estimates is considerably higher in the strike sample.

Table 2.4: Panel Estimation of Wage

Panel Estimation of Wage

Using two subsamples

(Standard Errors In Parentheses)

Dependent variable: Average contract Log real wage	OLS		FE	
	Strike	No Strike	Strike	No Strike
Constant	0.012	0.000	.	.
	(0.134)	(0.012)	.	.
Wage at the end	0.792	0.952	0.186	0.400
of previous contract	(0.058)	(0.005)	(0.077)	(0.017)
Alternative	0.042	0.006	0.165	0.059
Wage	(0.310)	(0.017)	(0.174)	(0.026)
Firm size	-0.005	0.001	0.006	0.001
	(0.010)	(0.001)	(0.021)	(0.004)
Dummy for a	-0.013	0.008	0.000	-0.001
COLA Clause	(0.024)	(0.002)	(0.012)	(0.002)
Previous Inflation	0.256	0.122	0.110	0.012
rate	(0.140)	(0.023)	(0.119)	(0.019)
Expected future	-0.439	0.048	0.147	0.117
inflation rate	(0.241)	(0.032)	(0.135)	(0.028)
Industrial GDP	0.090	0.001	0.027	0.007
	(0.026)	(0.003)	(0.024)	(0.005)
Canadian	-0.014	-0.007	-0.026	0.0023
Unemployment rate	(0.019)	(0.002)	(0.010)	(0.0017)
Sample size	117	1986	98	1649

Notes: All regressions include year effects and industry effects.

The non-linear estimation methods described in the previous section is more efficient since it utilizes the full sample. It allows for a direct test of the assumption made in the FE models ($\theta_i^{ns} = \theta_i^s$) by testing the hypothesis $\psi = 1$. Table 2.5 presents the non-linear IV estimates. The instrumental variables used to correct for the previous wage correlation with the error term are: All the exogenous variables in the wage equation, $w_{i,t-2}$ with its interaction with the lagged strike dummy. And the two strike history indices S^{10} and S^{01} interacted with the alternative wages, gdp, firm size and previous inflation.

The results reinforce the previous predictions. Previous wages have a significant larger effect when no strikes occur, with the effect being nonsignificant when we observe a strike. The effect of alternative wages is larger when a strike occurs, and previous inflation have a higher effect on contract wages when we observe a strike during the contract negotiations. The direct effect of the strike, measured by the coefficient difference $\delta^s - \delta^{ns}$ is nonsignificant, in contrast with the insurance contract presented in Harris and Holmsrom [1982] where contract renegotiation leads to an upward adjustment of the real wages, which implies a significant positive effect of strikes on wages. We cannot reject the holdup model though, since these models predicts upward or downward wage adjustments when renegotiations occur.

Table 2.5: Non-Linear Panel Estimation of Wage determination

Non-Linear Panel Estimation of Wage determination

(Standard Errors In Parentheses)

Dependent variable: Average contract Log real wage	Strike	No Strike
Wage at the end	-0.0049	0.25
of previous contract	(0.162)	(0.09)
Alternative	0.20	0.16
Wage	(0.079)	(0.05)
Firm size	0.006	0.004
	(0.013)	(0.007)
Dummy for a	-0.11	0.028
COLA Clause	(0.08)	(0.02)
Previous Inflation	0.35	0.023
rate	(0.34)	(0.063)
Expected future	-0.92	0.33
inflation rate	(0.61)	(0.15)
Industrial GDP	-0.094	-0.007
	(0.03)	(0.01)
Canadian	-0.10	0.023
Unemployment rate	(0.04)	(0.009)
$\delta^s - \delta^{ns}$	0.043	
	(0.04)	
ψ	1.3	
	(0.22)	
Sample size	2464	

Notes: Regression include quadratic year trend. Instruments used for the endogenous previous wage include $w_{i,t-2}$, with the interaction with the lagged strike dummy, also all exogenous variables (current and lagged) , and their interactions with a history index of strike activities within a bargaining unit.

2.5 Conclusion

In this paper we investigate contract renegotiation and wage dynamics. In contrast with previous studies in the literature, which mainly look at the effect of strikes on wage levels, we present an empirical analysis of the effect of strikes on the evolution of wages. The estimation methods correct for the strike endogeneity as well as the differential impact of the unobserved contract characteristics. Cross-sectional and longitudinal estimates are discussed.

We find that strikes on the average have no significant effect on the wage level; Nevertheless, strikes have a significant effect on wage dynamics. The main finding in this paper is the evidence on a significant decrease of the effect of previous wages on contract wages after a strike. In our most general specification, the previous wage effect is actually nonsignificant. This result lends support for contract models as opposed to competitive models of wage determination. Also, labour market conditions – measured by the unemployment rate and the alternative wages – have an increasing effect on wages when we observe a strike. Finally, strikes appear to play a significant "catch-up" role for uncompensated inflation rate during the previous contract term.

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Chapter 3

Replacement Laws, Strikes and Wages

Bargaining models studying conflicts that arise during negotiations emphasize the importance of the parties payoffs (threat points) during the disputes, and recognize their effect on the bargaining outcomes. Recently a great deal of progress in the theoretical analysis of disputes has been made by focusing on one-sided asymmetric information over the size of the bargaining surplus. We consider a class of imperfect information models, the signaling models, where the union is not fully informed about the firm's type it is facing, and we incorporate the firm replacement strategy and analyze its effect on the wage outcome and the strike activity. A Bayesian Perfect Equilibrium *is derived for the bargaining game, and the implications of the replacement laws are studied. Under the assumptions of our model, we show that the possibility of replacement workers increases in the strike threat payoff of the firm and has a negative effect on wage settlements. Further, since hiring replacement workers is an alternative signalling device to reveal private information in the asymmetric information bargaining game, the possibility of replacement workers reduces strike incidence and strike duration.*

3.1 Introduction

Bargaining models studying conflicts that arise during negotiations emphasize the importance of the parties payoffs during the disputes, and recognize their effect on the bargaining outcomes. In labor negotiations, disputes usually take the form of strikes, and the dispute payoffs (the threat points) are usually taken to be the union's utility from an alternative wage and zero for the firm. But in some situations, these payoffs during strikes might differ from the usual assumptions. In particular, if we allow the firm to hire replacement workers when its own work force goes on strike, then the firm's payoffs during the conflict might rise above zero. In a perfect information bargaining game, the threat of hiring replacement is in some cases credible. This will increase the threat point of the firm, and enhance its bargaining position leading to a better settlement for the firm. On the other hand, in an asymmetric information bargaining game, where the union is not fully informed about the firm's profitability (or ability to pay), replacement workers will have an additional role to play besides the enhancement of the firm's threat point. We argue that hiring replacement workers will be an extra mechanism to reveal more information, and will be a credible signal that the firm can use. Since strikes, in these models, are the result of asymmetric information, introducing an alternative signaling device will have the effect of reducing strike activities and durations.

Non-cooperative bargaining theory provides a useful framework to discuss labor negotiations. The standard approach to bargaining in economic models is the Rubinstein/Stahl strategic approach in which the buyer (the union) and the seller (the firm) exchange offers until a trading price (wage) is agreed, at which point trade (employment) takes place and the game ends. This model has the property that, under perfect information, it has a unique subgame perfect equilibrium. In equilibrium, an agreement is reached in the first round of negotiations, and no delay occurs. Moreover, the equilibrium outcome will be directly determined by the threat points and the relative bargaining power of the agents. The equilibrium payoffs coincide with the Nash bargaining solution, a convenient solution concept for applications, as shown in Binmore, Rubinstein and Wolinsky (1986).

As much as the full information model can be seen as a powerful theoretical tool to explain wage determination in labor negotiation, still it does not help in understanding how can inefficient equilibria, in the form of strikes, take place. Muthoo (1990) studies a model in which each player can withdraw from an offer if the opponent accepts it and shows that the subgame perfect equilibrium is no more unique. The crucial assumptions in this model are the separation of the trade decision from the agreement on a contract, and the infinite horizon. Fernadez and Glazer (1991) show that the model has a great multiplicity of subgame perfect equilibria including some in which there is a delay before the start of trade. In the context of union bargaining, they interpret such inefficient equilibria as involving union strikes before the agreement is reached. However, MacLeod and Malcomson (1995) show that by imposing a strong renegotiation proofness, where at every node of the game agents agree to play a subgame perfect equilibrium that is Pareto efficient in the set of subgame perfect equilibrium payoffs at that node, then trade will occur with no delays. These results cast some doubt on the use of such models as a basis for a theory of strikes.

On the other hand, many authors have tried to extend the analysis to the case of incomplete information. The now standard model, consist of an asymmetric information bargaining game, with a seller who does not know how much the buyer is willing to pay. Admati and Perry (1987) and Grossman and Perry (1986), for example, establish that delay can signal a player's valuation. The substance of the underlying hypothesis is that bargaining is substantially a process of communication necessitated by initial differences in information known to the parties separately. Thus delay might be required to convey private information. In these models, multiple equilibria exist, fully separating as well as possibly pooling equilibria, with delay taken place in equilibrium. These models, when applied to labor market negotiations, are now considered as essential for any strategic explanation of strike behavior. For instance, willingness to endure a strike might be the only convincing evidence that a firm is unable to pay a high wage. Thus, it is usually assumed in the signaling models that strikes, as a signaling device, are the only credible signal that the firm can use.

An empirically testable prediction of the asymmetric information models of strikes is the existence of a negatively sloped "concession curve" between wages and strike duration. Card (1990) and McConnell (1989), using Canadian and U.S data respectively, attempt to test these models with a sample of labor contracts which includes information on both the negotiated wage and work stoppages. Their empirical analysis provides limited support for the class of one-sided asymmetric information strike models. For the Canadian manufacturing sector, the trade-off between negotiated wages and shorter strikes is generally positive, however, very long strikes are associated with lower wage settlements. As for the U.S data, the estimated concession schedule was very flat, where after the average strike length of 41 days the negotiated wage is only about 1 percent lower than it would have been in the absence of a strike. In parallel to this literature, there exists an empirical literature studying the effects of replacement laws on bargaining outcomes. This literature is mainly of Canadian content, since labor legislations in Canada differ among provinces, and replacement workers are allowed in some parts of the country, and outlawed in other parts. This constitutes a natural experiment, that labor economists tried to exploit using Canadian data. A series of empirical papers used logit and hazard models, to test the effect of prohibition of replacement workers on strike activities. Gunderson and Melino (1990) used a hazard model, and found that the prohibition of replacement workers increases the conditional strike duration. In an attempt to test the effect on strike incidence, Gunderson, Kervin and Reid (1989) found that the prohibition of replacement workers is associated with a statistically significant increase in strikes. They used a logit model, to estimate these effects in Canada between 1971 and 1985. More recent work by John Budd (1996), using Canadian panel data, estimated a fixed effect model and found no evidence to support the contention that the presence of legislation affecting the use of strike replacements significantly alters relative bargaining power and the wage determination process, or significantly impact strike activity. Although Budd's results constitute a challenge to the conventional wisdom and the previous established empirical evidence on the effect of the prohibition of replacement workers, still the general consensus that emerges from those studies is: The negative effect of replacement workers law on the probability of a strike, and the significant reduction of the strike duration. These findings, together with the weak evidence supporting the asymmetric information strike models, suggest that a richer model may be needed to capture all the features of the wage and strikes outcomes data.

This paper expand the existing signaling models to incorporate other strategies that the firm might find useful to implement in some scenarios. We develop a game theoretical model, that can shed some light on the previous empirical results concerning replacement laws, and strike theory. By allowing the firm to hire replacement workers when its own work force is on strike, we introduce a new credible signaling device at the disposition of the firm. The firm will then use this instrument strategically to achieve two goals: The enhancement of its own bargaining power and the more efficient revelation of information. We show that in equilibrium, Among the firms that experience a strike, profitable firms will always choose to hire replacement workers, whereas, less profitable firms will endure a strike without the use of any replacement workers. The equilibrium outcome shows that the law will have a distributive effect by shifting the settlements to favor the firm due to its increased bargaining power relative to its work-force. Also, we show that the introduction of the replacement workers will also have efficiency consequences in terms of the reduction of strikes' incidence and strikes' durations.

We will proceed as follows: In section 2 we will present the complete information bargaining game when replacement workers are allowed. Section 3 will then cover an asymmetric signaling model and the equilibrium will be derived. Section 4 contains some comparative statics. We conclude with a discussion in section 5. All proofs are in the appendix unless they are immediate from the text.

3.2 Model with Complete Information

A union and a firm are bargaining over a surplus of size b. They alternate wage offers, w, with the other party free to accept or reject. We allow both traders to alternate in making wage offers after a required minimum delay Δ_0 of time between consecutive offers. The common discount factor δ from one period of delay is then given by $\delta = e^{-r\Delta_0}$, where r is the instantaneous interest rate. In each period, one of the players, either the firm or the union, makes an offer which is either accepted or rejected by the other player. If the offer is accepted, the bargaining game ends and the agreement is implemented. If the offer is rejected then, after a minimum delay Δ_0, it is the rejecting player's turn to propose an agreement. The game continues in this manner, and there is no limit on the number of periods, until an agreement is reached. The infinite horizon assumption can be reinterpreted in a context where agents behave in each period as if the relationship is going to last at least on more period. Both the union and the firm prefer agreement today to the same agreement the next period, and the form of this impatience is given by the discount factor δ. The players will thus have time preferences with a constant discount rate, where, for example, the union's utility from a surplus division (b_u, b_f) reached at time t will be $\delta^t b_u$. In a model of bilateral monopoly, where neither party can find alternative trading partner, Rubinstein (1982) shows that this game has a unique subgame perfect equilibrium where an agreement is reached with no delays, and the equilibrium payoffs are $(\frac{1}{1+\delta}b, \frac{\delta}{1+\delta}b)$, with $\frac{1}{1+\delta}b$ being the outcome payoff of the player who makes the first offer.

This result is slightly modified if we allow the firm the right to hire replacement workers while its union is on strike. This will shift, in the equivalent static Nash bargaining problem[1], the threat points of the bargaining parties in favor of the firm, and may possibly result in a different agreement outcome. In details, after any offer, or counter offer, made by the union, the firm has the choice to either hire or not hire replacement workers before making its counter offer in the next period. The timing of this decision turns out to be very important, in particular, if the firm can hire replacement workers before the union can come back with an offer then the game will have multiple equilibria[2]. We restrict the attention to the former timing framework because it suits best most of the employment bargaining processes. In the case of a strike with no replacement workers, we normalize the payoffs of both the firm and the workers to zero. When the firm hire replacements, the firm receives αb where $0 \leq \alpha \leq 1$ captures the reduction in the surplus due to less skilled replacement workers, minus an amount M which is the fixed sunk cost to the firm necessary to hire and train the new replacement workers. The presence of specific human capital will justify the assumption of the non-substitutability of the union with the alternative work force ($\alpha < 1$).

In this section, the characterization of the equilibrium will follow the same methodology introduced in Shaked and Sutton (1984). The extensive form of this game has a stationary structure, we can distinguish two classes of subgames: G the subgame where the firm has not hired replacement workers yet, and G^s the subgame that starts as soon as the firm hires scabs. In the subgame G^s, the firm receives αb plus its share of

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[1] See Binmore, Rubinstein and Wolinskey (1986) for a demonstration of the relationship between the limiting equilibrium payoffs in the strategic bargaining game and the Nash bargaining solution.

[2] Shaked (1987) shows how the set of equilibria is sensitive to the timing at which the players can choose their alternative trading partners.

a Rubinstein full information bargaining game over a pie of size $(1-\alpha)b$. There is a unique subgame perfect equilibrium to this game, in which the player with the initial offer makes an acceptable offer, and the agreement is reached immediately with the outcome payoffs $(\frac{1}{1+\delta}(1-\alpha)b,\ \frac{\delta}{1+\delta}(1-\alpha)b)$. So if the firm rejects a union's offer and hire replacement workers at time t, it will receives $\delta^t(\alpha b + (1-\alpha)\frac{b}{1+\delta} - M)$.

The equilibrium in the subgame G is more involved than in G^s, and is established in the following lemma.

Lemma 1 *The subgame G has a unique subgame perfect equilibrium, in which parties settle at the first period and the outcome is $(b-P, P)$ with $P = \max\left\{\frac{\delta}{1+\delta}b,\ \frac{\delta}{1+\delta}(1+\delta\alpha)b - \delta M\right\}$.*

Proof: We solve the game by backward induction. First we note that because of the stationarity of the game, the subgame G starting in period 2, is identical to the whole game. Let P be the highest payoff the firm can obtain in this subgame. In period 1, the firm offers w_1 that would make the union indifferent between accepting w_1 and waiting one extra period and receiving $(b-P)$. This implies $w_1 = \delta(b-P)$. Proceeding backward to period 0, the union offers w_0 such that

$$b - w_0 = \max\left\{\delta(b-\delta(b-P)), \frac{\delta}{1+\delta}(1-\alpha)b + \delta\alpha b - \delta M\right\}.$$

But stationarity ensures us that $P \equiv b - w_0$ which ends the proof of the lemma[3]. We are now ready to characterize the solution to the original game.

Proposition 3 *The full information bargaining game has a unique subgame perfect equilibrium in which the union makes an acceptable initial offer, and the agreement is reached in the first period, with no delays. The firm's payoffs are :*

$$\begin{array}{lll} (i) & \frac{\delta}{1+\delta}b & \text{if } b \leq (\frac{1+\delta}{\delta})\frac{M}{\alpha}, \\ (ii) & \frac{\delta}{1+\delta}(1+\delta\alpha)b - \delta M & \text{if } b > (\frac{1+\delta}{\delta})\frac{M}{\alpha}. \end{array}$$

If $b \leq (\frac{1+\delta}{\delta})\frac{M}{\alpha}$, the standard equilibrium strategies would support such an equilibrium outcome. In particular, the union's strategy is to always make a wage offer at least as high as the equilibrium wage offer, and never to accept a wage offer that is

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[3] A symmetric argument can be made starting with the lowest payoff in the second period and solving backward.

strictly less than the equilibrium wage. The firm will have the symmetrically opposed strategy, by offering always a wage that is equal to the equilibrium wage, and never accepting any wage that is strictly higher than the equilibrium wage, and never hiring replacement workers. If $b > (\frac{1+\delta}{\delta})\frac{M}{\alpha}$, the firm will reject any wage that is strictly higher than the equilibrium wage, in which it hires scabs and offer $(1-\alpha)\frac{b}{1+\delta}$. If the firm hires replacement workers, the union will accept a counter-offer if and only if it is at least equal to that wage, and will offer that wage in subsequent periods.

The unique subgame perfect equilibrium in the full information model, indicates that the addition of the replacement law will only affect the results via the *status-quo* payoffs. If the firms' profits are high enough, the firm will have a higher threat point by hiring replacement workers, in this case, the threat of replacements becomes credible, and the bargaining outcome will tilt towards the firm. At first glance it is surprising that the addition of the replacement workers strategy will have no effect on the equilibrium payoffs in case (i) of proposition 3. But the intuition underlying this is simple: The payoff of hiring replacement workers acts as a constraint on the equilibrium outcome. As long as this constraint is not binding, the firm's threat to hire replacement workers is not credible, and as a result the constraint will have no effect on the equilibrium outcome. On the other hand, when this constraint becomes binding, case (ii), the firm's threat to hire replacement workers become credible, that is the firm is better off hiring replacement workers than enduring a delay with no production and a payoff strictly below the payoff when hiring replacement workers. In this case, the union will offer the firm a wage that corresponds to exactly the level of payoff from hiring replacement workers.

As discussed earlier in the introduction, the handicap of the symmetric information model is its inability to generate strikes as an equilibrium behavior. With an infinite bargaining horizon, the results can change if we separate the trade decision from the agreement decision, this will yield multiple equilibria with some involving delays. However, it was shown that if one imposes a not unreasonable condition of renegotiation proofness on equilibrium, no delay occurs and the equilibrium payoffs are exactly the same as for the finite horizon model. This throws doubt on whether these models can be used to provide a satisfactory theory of strikes. Information asymmetry is then suggested as an alternative explanation for strikes, the next section will analyze a bargaining game with asymmetric information, enriched by a strategic option of hiring replacement workers during a strike.

3.3 Bargaining with Asymmetric Information

In order to provide a basis for a theory of strikes, recent work developed dynamic models of bargaining in which some form of imperfect information is assumed. The underlying hypothesis is that bargaining is a process of communication triggered by informational differences. In this case, enduring a strike acts as a signaling device to reveal private information. The main insight is that although strikes are not Pareto optimal *ex-post* they can be Pareto optimal *ex-ante*. We consider a variant of the model discussed in section 3.2, where the firm knows the surplus b but the union only knows the distribution of b, $F(b)$, over the interval $[\underline{b}, \bar{b}]$, $\underline{b} \geq 0$. The firm and the union can delay arbitrarily long before responding to an offer. The discount factor from one period of delay, $\delta = e^{-r\Delta_0}$, means that delays are costly and therefore are credible signals of the strength of one's bargaining position.

An equilibrium outcome for the incomplete information game must specify for all type-b firm: The agreement wage, the delay before the agreement is reached and when the firm hires replacement workers if it does. We let w_0 denote the union's initial wage offer. $w(b)$ denotes the equilibrium wage for the type-b firm, $\Delta(b)$ denotes the equilibrium time elapsed before a settlement, and $t(b)$ is the time at which the type-b firm hires replacement workers, if any. In equilibrium, we say that a type-b firm hires replacement workers if and only if $t(b) \leq \Delta(b)$. The equilibrium payoff accruing to the firm is given by:

$$U(b) = \begin{cases} b - w_0 & \text{if the firm accepts } w_0 \ , \\ (\alpha e^{-rt(b)} + (1-\alpha)e^{-r\Delta(b)})b & \\ \quad -e^{-r\Delta(b)}w(b) - e^{-rt(b)}M & \text{if } t(b) \leq \Delta(b) \ , \\ e^{-r\Delta(b)}[b - w(b)] & \text{if } t(b) > \Delta(b) \ . \end{cases}$$

More generally the firm's payoff function can be written as

$$\begin{aligned} U(b) &= S(b;\alpha)b - [e^{-r\Delta(b)}w(b) + e^{-rt(b)}M] \qquad (3.1) \\ \text{Where } S(b;\alpha) &= (1-\alpha)e^{-r\Delta(b)} + \alpha max\{e^{-r\Delta(b)}, e^{-rt(b)}\} \end{aligned}$$

With $t(b) = \infty$, when no replacement workers are hired. It is useful to start by stating some general properties that hold in any Bayesian Perfect equilibrium for this game.

Proposition 4 *In all Perfect Bayesian Equilibrium of the asymmetric information bargaining game*

- *There exists a $\tilde{b}$ such that the type-b firm rejects w_0 if and only if $b < \tilde{b}$.*
- *If $b' < b < \tilde{b}$ then the equilibrium outcome must satisfy:*

$$\begin{aligned} S(b;\alpha) &\geq S(b';\alpha) \qquad (3.2) \\ e^{-r\Delta(b)}w(b) + e^{-rt(b)}M &\geq e^{-r\Delta(b')}w(b') + e^{-rt(b')}M \qquad (3.3) \end{aligned}$$

The results in Proposition 4 are standard and rely on the single crossing property of the traders' preferences. This means that the slope of the indifference curve in the effective delay – effective payment space is monotone in b. When no replacement workers are allowed, proposition 4 simply states that wages are non-decreasing in b , while the delays are non-increasing in b . When replacement laws are introduced, we must use the more general concept of effective delays and payments. Proposition 4 limits the set of equilibria but still allows for the existence of multiple equilibria. Like in most signaling games, out-of-equilibrium beliefs can be arbitrarily selected to support a large set of pooling and separating equilibria. Restrictions on the out-of-equilibrium beliefs may be imposed to limit the set of admissible outcomes[4]. We have chosen not to do so;

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[4] See Admati-Perry (1987), Grossman-Perry (1986).

However, in what follows we shall concentrate on one special equilibrium. Although it is one of many possible equilibria, its basic structure is similar to the equilibrium selected in Admati-Perry (1987), Cramton (1992) and more generally it is similar to the refined equilibrium in signaling games. We will restrict our attention to the equilibrium in which the continuations of the game for all initial offers w_0 correspond to the fully-revealing and efficient signaling strategy for type-b firms rejecting w_0 .

The fact that the continuation of the game is fully revealing implies that upon receiving the firm's counter-offer (after a certain delay) the union becomes fully informed of the firm's type. The acceptable counter-offer will thus correspond to the complete information solution of the bargaining game. Henceforth, we restrict our attention to the equilibrium where

$$w(b) = \begin{cases} \frac{\delta}{1+\delta} b & \text{if} \quad \Delta_0 \leq \Delta(b) < t(b), \\ \frac{\delta}{1+\delta}(1-\alpha) b & \text{if} \quad \Delta_0 \leq t(b) < \Delta(b). \end{cases} \tag{3.4}$$

The equilibrium level of $\tilde{b}$ and the delay function $\Delta(b)$ and the hiring time of the replacement workers $t(b)$ solve the following program

$$\max_{\tilde{b}, \Delta(.), t()} \int_{\underline{b}}^{\tilde{b}} \left\{ S(b;\alpha) \frac{b}{1+\delta} + \left[\frac{\delta\alpha}{1+\delta} b - M \right] e^{-rt(b)} \right\} dF(b) + \int_{\tilde{b}}^{\bar{b}} (b - w_0)\, dF(b) \tag{3.5}$$

Subject to the following constraints

$$\text{(I)} \begin{cases} \Delta(b) & \geq & \Delta_0, \\ t(b) & \geq & \Delta_0 \quad \forall b \leq \tilde{b}. \end{cases}$$

(II) for all $b, b' < \tilde{b}$

$$\begin{aligned} S(b;\alpha)\frac{b}{1+\delta} + \left[\frac{\delta\alpha}{1+\delta} b - M\right] e^{-rt(b)} \quad &\geq \\ S(b';\alpha)(b - \frac{\delta}{1+\delta} b') \quad + \quad &\left[\frac{\delta\alpha}{1+\delta} b' - M\right] e^{-rt(b')} \end{aligned}$$

The constraint **(II)** corresponds to the equilibrium incentive compatibility constraints; (i.e) It is not in the interest of a type-b firm to deviates and imitates the delay and scabs-hiring strategies of a type-b' firm in order to pay $w(b')$.

The solution of the above maximization problem uniquely identifies the equilibrium in the continuation of the game for every w_0. Let $V(w_0)$ denotes the expected value accruing to the union given some initial wage offer. The union will then select w_0 in order to maximize $V(w_0)$.

In the following two subsections, we characterize the equilibrium when replacement workers are not and are allowed. The two outcomes are then compared in section five.

3.3.1 The equilibrium without replacement workers

We first consider the game where replacement workers are not allowed. In the terminology of our model this means that $t(b) = \infty$. In this case the incentive compatibility constraint **(II)** becomes

$$U(b) \equiv e^{-r\Delta(b)}\frac{b}{1+\delta} \geq e^{-r\Delta(b')}b - e^{-r\Delta(b')}\frac{\delta}{1+\delta}b' \quad \forall b, b'.$$

Applying the envelope theorem, we obtain

$$\frac{d}{db}U(b) = \frac{d}{db}(e^{-r\Delta(b)}\frac{b}{1+\delta}) = e^{-r\Delta(b)} = (1+\delta)\frac{U(b)}{b}.$$

The solution of the equation above will be

$$U(b) = kb^{1+\delta} \text{ or } e^{-r\Delta(b)} = k(1+\delta)b^{\delta},$$

for some constant k. Since $U(\tilde{b}) \leq \frac{\delta}{1+\delta}\tilde{b}$, then $k \leq \frac{\delta}{1+\delta}\tilde{b}^{-\delta}$. The maximization problem 3.5 is now simplified. We obtain $U(\tilde{b}) = (\tilde{b} - w_0) = \frac{\delta}{1+\delta}\tilde{b}$. So we have $\tilde{b} = (1+\delta)w_0$ and $e^{-r\Delta(b)} = \delta[\frac{b}{(1+\delta)w_0}]^{\delta}$.

The union's problem will then be to select w_0 in order to maximize its expected payoff

$$\max_{w_0} w_0[1 - F(\tilde{b})] + \int_{\underline{b}}^{\tilde{b}} e^{-r\Delta(b)}w(b)\,dF(b).$$

Proposition 5 describes the equilibrium outcome of this game.

Proposition 5 *The Bargaining Game with asymmetric information, and no replacement law, will have a Perfect Bayesian Equilibrium where*

- *A firm of type $b \geq \tilde{b} = (1+\delta)w_0$ will accept the initial offer w_0 with no delays, while a firm of type $b < (1+\delta)w_0$ will rejects this offer, delays $\Delta(b)$ satisfying $e^{-r\Delta(b)} = \delta(\frac{b}{\tilde{b}})^{\delta}$ before making an acceptable counter offer $w(b) = \frac{\delta}{1+\delta}b$.*

- *w_0 is chosen to maximize the union expected payoffs*

$$w_0(1 - F[(1+\delta)w_0]) + \int_0^{(1+\delta)w_0} \frac{\delta^2}{1+\delta}[\frac{b}{(1+\delta)w_0}]^\delta b \, dF(b).$$

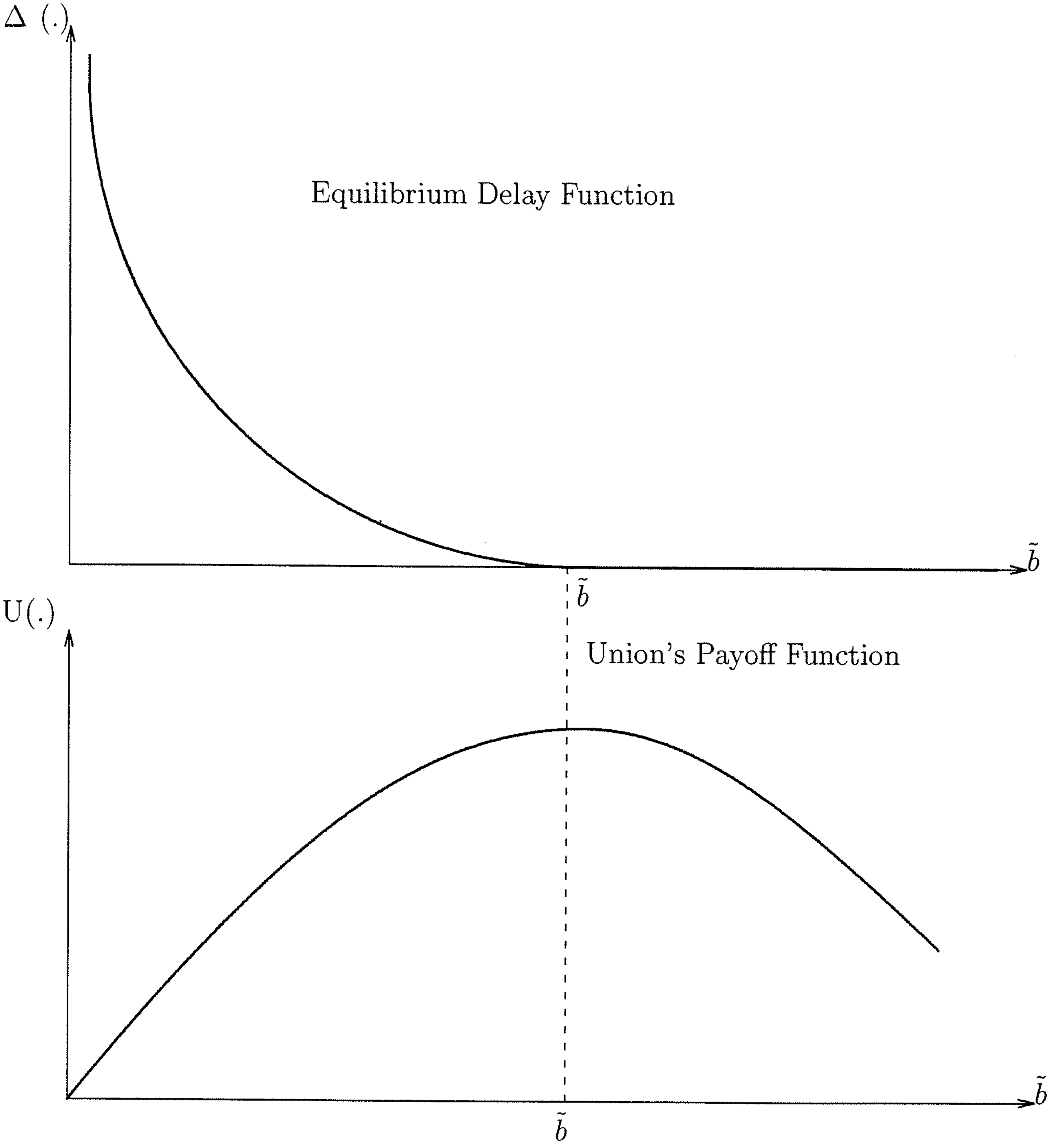

Figure 3.1: Graphic Description of the Equilibrium Outcome

A quick example might be useful at this point. Consider a uniform distribution of the firms' types over the interval $[0, 1]$. And assume that the parties on the bargaining table have the same discount factor $\delta = 1$, in this case the above proposition implies the following equilibrium outcome. The union will make the initial wage offer $w_0 = 3/8$, which corresponds the marginal type $\tilde{b} = 3/4$. A firm of type $b \geq 3/4$ will accept this offer immediately, without any delay. On the other hand, if a firm has a type $b < 3/4$ then it will delay $\Delta(b) = -\frac{1}{r} ln(\frac{4b}{3})$ and the final and acceptable wage offer will be $w = \frac{1}{2}b$.

Proposition 5 describes the subgame perfect equilibrium where all type-b firms with $b \geq \tilde{b}$ will accept the union's initial offer without any delay. As for the firms of types $b < \tilde{b}$, they will reject the initial offer w_0, and will delay long enough to reveal their types, before making an acceptable offer $w(b)$, that the union will accept immediately. Figure 3.3.1 is a graphic description of the equilibrium derived in Proposition 5. It shows the negatively sloped strikes' duration curve. In particular, the implied negative correlation between strikes' durations and wage constitutes an empirically testable implication of the asymmetric information model.

3.3.2 The equilibrium with replacement workers

In this paper, we are interested in the effect of labor legislations on strike activities. With the extension introduced in the previous section, we construct a simple equilibrium in which both strikes and replacement workers may be observed on the equilibrium path. In this subsection we will characterize an equilibrium for the game with replacement workers. In order to do so, we will exploit the maximum solution of the problem 3.5. Before characterizing formally the equilibrium, we highlight its main features. The union makes an immediate initial wage offer, w_0 to a firm of type $(\tilde{b})$. A firm of type b that exceeds $\tilde{b}$ would accept the union's offer and the agreement is reached with no delays. If $b < \tilde{b}$, then the firm will reject the union's offer, and delay long enough before making an acceptable counter offer to the union. A firm with high valuation will choose to hire replacement workers, whereas a firm with low valuation will delay without hiring replacements. The firm's counter-offer fully reveals its type, and therefore it is made à la Rubinstein.

First we start with the incentive compatibility constraints. This can be rewritten using the envelope theorem, and will yield the following dynamic equation.

$$\begin{aligned}\frac{d}{db}U(b) &= (1-\alpha)e^{-r\Delta(b)} + \alpha \max\{e^{-r\Delta(b)}, e^{-rt(b)}\} \\ &= [U(b) - [\frac{\delta\alpha}{1+\delta}b - M]e^{-rt(b)}]\frac{1+\delta}{b}.\end{aligned}$$

Solving for the differential equation, we obtain the general solution of the form :

$$U(b) = b^{1+\delta}\left[\int_b^{\tilde{b}} [\frac{\delta\alpha}{1+\delta}x - M]e^{-rt(x)}\frac{1+\delta}{x^{2+\delta}}\,dx\ +\ k\right],$$

where k is an arbitrary constant that can be set using the appropriate initial condition. Since the best a type-$\tilde{b}$ firm can do while rejecting the union's offer is to make after a minimal delay Δ_0 an acceptable counter-offer, we have:

$$U(\tilde{b}) = k\tilde{b}^{1+\delta} \leq \max\{\frac{\delta}{1+\delta}\tilde{b}, \frac{\delta}{1+\delta}(1-\alpha)\tilde{b} + \delta(\alpha\tilde{b} - M)\}.$$

The optimization program 3.5 becomes,

$$\max_{\tilde{b},t(.),k} \int_{\underline{b}}^{\tilde{b}} b^{1+\delta}\left\{\int_b^{\tilde{b}} [\frac{\delta\alpha}{1+\delta}x - M]e^{-rt(x)}\frac{1+\delta}{x^{2+\delta}}\,dx\ +\ k\right\} dF(b) + \int_{\tilde{b}}^{\bar{b}} (b - w_0)\,dF(b)$$

subject to

$$\begin{aligned} k\tilde{b}^{1+\delta} &\leq \max\{\frac{\delta}{1+\delta}\tilde{b}, \delta\tilde{b} - \delta^2\frac{(1-\alpha)\tilde{b}}{1+\delta} - \delta M\}, \\ \text{and } t(b) &\geq \Delta_0. \end{aligned}$$

The optimal solution is then, for all functions $F(.)$, to

(i) Set $t(.)$ to maximize $\left[\frac{\delta\alpha}{1+\delta}b - M\right] e^{-rt(b)}$. It follows that

$$\begin{aligned} t(b) &= \Delta_0 \quad \text{if } \tfrac{\delta\alpha}{1+\delta}b \geq M, \\ t(b) &= \infty \quad \text{Otherwise.} \end{aligned}$$

In other words, whenever a firm hires replacement workers, it will do it at the start of the strike rather than delaying before hiring replacement workers.

(ii) Set k so that the first constraint holds with equality.

(iii) $\tilde{b}$ is such that

$$\tilde{b} - w_0 = \frac{\delta\tilde{b}}{1+\delta} + \delta\max\{0, \frac{\delta\alpha}{1+\delta}\tilde{b} - M\}$$

Solving for $U(b)$ and $\Delta(b)$, we can compute the delay before a settlement is reached for every type-b firm and the expected payoff to the union given every initial w_0 . This corresponds to the Perfect Bayesian Equilibrium described in the proposition 6 shown below.

Proposition 6 *The bargaining game with asymmetric information, and where replacement workers are allowed, has a Perfect Bayesian Equilibrium with the following characteristics:*

- *If* $w_0 > \frac{M}{\alpha\delta}$ *then*
  - *(i) All firms with type* $b \geq (w_0 - \delta M)\frac{1+\delta}{1-\delta^2\alpha}$ *accept the initial offer with no delays to agreement.*
  - *(ii) All firms with type* $b \in \left[\frac{(1+\delta)M}{\alpha\delta}, (w_0 - \delta M)\frac{1+\delta}{1-\delta^2\alpha}\right]$ *reject* w_0 *, hire replacement workers after the minimal delay* Δ_0 *and make an acceptable counter-offer* $w(b) = \frac{\delta}{1+\delta}(1-\alpha)b$ *after delaying* $\Delta(b)$ *such that* $e^{-r\Delta(b)} = \delta(\frac{b}{\tilde{b}})^{\delta}$.

(iii) *All firms with type* $b < \frac{(1+\delta)M}{\alpha\delta}$, *reject* w_0 *and make an acceptable counter-offer (without hiring scabs)* $w(b) = \frac{\delta}{1+\delta}b$ *after a delay given by* $e^{-r\Delta(b)} = \delta[\,(1-\alpha)(\frac{b}{\bar{b}})^\delta + \alpha(\frac{b}{\hat{b}})^\delta\,]$ *with* $\hat{b} = \frac{(1+\delta)M}{\alpha\delta}$

- *If* $w_0 \leq \frac{M}{\alpha\delta}$ *then no replacement workers are observed and*

  (i) *All firms with type* $b \geq (1+\delta)w_0$ *accept the union's initial offer, with no delays occurring.*

  (ii) *All firms with type* $b < (1+\delta)w_0$ *reject* w_0 *and make a counter-offer* $w(b) = \frac{\delta}{1+\delta}b$ *after delaying* $\Delta(b)$ *such that* $e^{-r\Delta(b)} = \delta(\frac{b}{\bar{b}})^\delta$.

Proposition 6 distinguishes among three different intervals of firms' types. High type-b firms will always immediately accept the union's initial offer w_0. On the other hand, among firms who are willing to support a strike to signal their types, only very low type-b firms will not hire replacement workers (Figure 3.3.2).

In the first period, the union selects w_0 in order to maximize its expected payoff. Since the firm accepts w_0 if $b \geq (1+\delta)w_0$, the union gets w_0 with probability $1 - F[(1+\delta)w_0]$. Otherwise, the firm would reject the offer and, depending on the value of w_0 and its own type-b, will choose whether to hire replacement workers or not, before making $w(b)$ defined as in equation 3.4. Formally, the union will choose w_0 to maximize its expected payoff $V(w_0)$ given by

$$V(w_0) = \begin{cases} w_0(1 - F[(1+\delta)w_0]) + \int_{\underline{b}}^{(1+\delta)w_0} e^{-r\Delta(b)} w(b)\, dF(b) & \text{if } w_0 \leq \frac{M}{\alpha\delta}, \\ w_0(1 - F[(1+\delta)w_0]) + \int_{\underline{b}}^{(1+\delta)w_0} \delta e^{-r\Delta(b)} w(b)\, dF(b) & \\ \quad + \int_{\underline{b}}^{\frac{(1+\delta)M}{\alpha\delta}} \delta e^{-r\Delta(b)} w(b)\, dF(b) & \text{if } w_0 > \frac{M}{\alpha\delta}. \end{cases}$$

Using the equilibrium delays and offers derived in proposition 4, the union's expected utility can be written more explicitly in terms of w_0, the firm's type distribution, and the other parameters of the model δ, M and α.

$$V(w_0) = \begin{cases} w_0[1 - F[(1+\delta)w_0]] + \int_{\underline{b}}^{(1+\delta)w_0} \frac{\delta^2}{1+\delta}[\frac{b}{(1+\delta)w_0}]^\delta b\, dF(b) & \text{if } w_0 \leq \frac{M}{\alpha\delta}, \\ w_0[1 - F[(1+\delta)w_0]] + \int_{\underline{b}}^{(1+\delta)w_0} \frac{\delta^2}{1+\delta}[\frac{b}{(1+\delta)w_0}]^\delta (1-\alpha) b\, dF(b) & \\ \quad + \int_{\underline{b}}^{\frac{(1+\delta)M}{\alpha\delta}} \frac{\delta^2}{1+\delta}\alpha[\frac{\alpha\delta}{(1+\delta)M} b]^\delta b\, dF(b) & \text{if } w_0 > \frac{M}{\alpha\delta}. \end{cases}$$

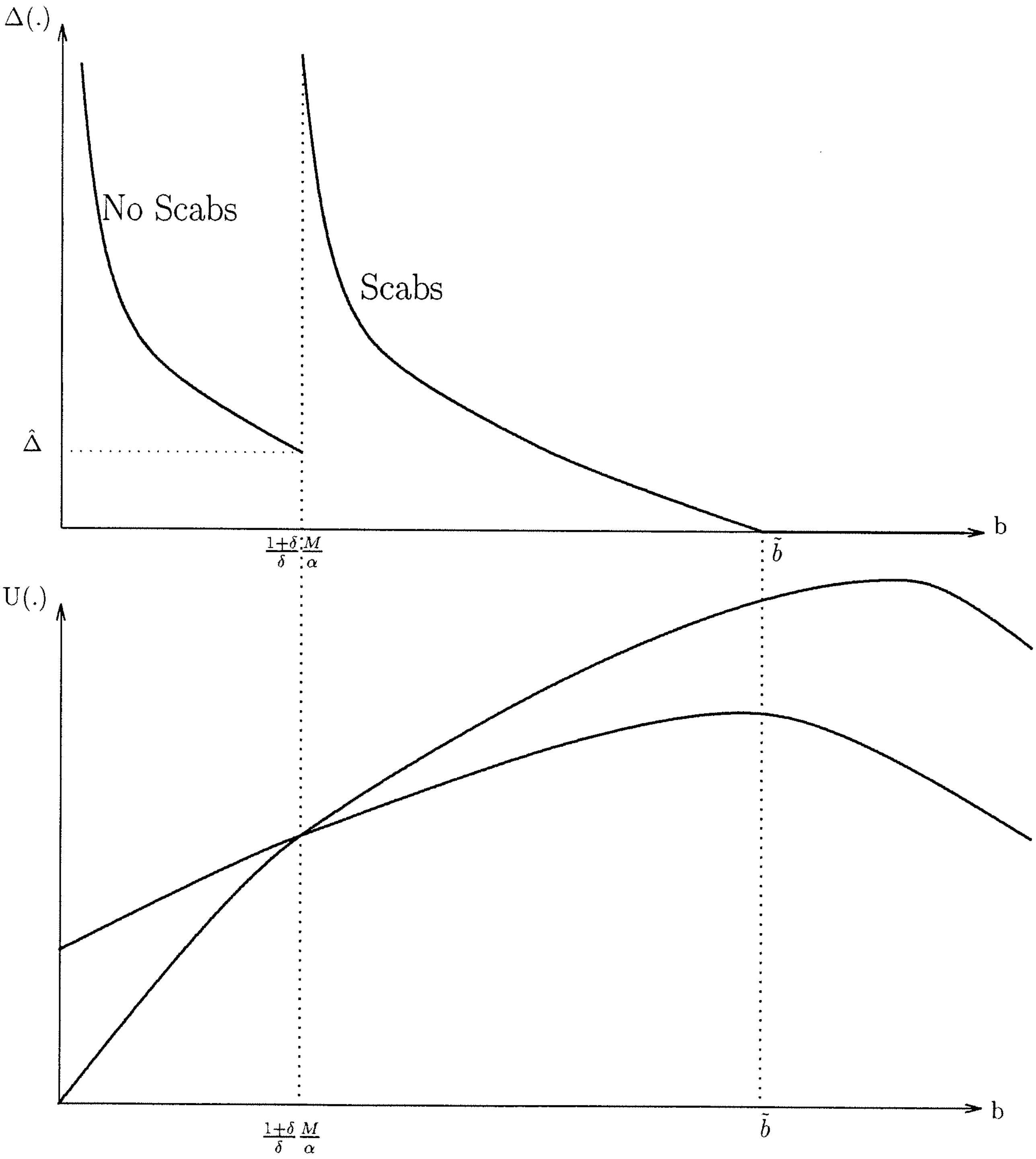

Figure 3.2: The Equilibrium Outcome With Replacement Workers.

3.4 Comparing the equilibrium outcomes

In this section we examine the effects of allowing replacement workers on the equilibrium outcome. The existence of multiple equilibria clearly limits the value of any comparative statics; Nevertheless, we can obtain results by comparing the outcomes of the semi-pooling equilibrium of the bargaining game considered in this paper. Whether the replacement laws are introduced to reduce work disputes, and/or reduce the ability of the union to share some of the rents with the firm, it will be only effective, in the context of our model, if it is able to reduce w_0 that maximizes the union's expected utility. Since both strike incidence and duration are decreasing in w_0 we start this section by proving that, in equilibrium, introducing replacement laws will reduce w_0 . We state the main results in the following proposition.

Proposition 7 *Allowing for replacement workers will*

(i) decrease the likelihood of a strike

(ii) decrease the average strike duration

(iii) increase the welfare of the firm, irrespective of its type

(iv) decrease the expected bargaining gain for the union

First we derive the first order condition for the union's maximization problem when no replacement workers are allowed.

$$\frac{dV(.)}{d\tilde{b}} = \frac{1}{1+\delta}(1-F(\tilde{b})) - (1-\delta)\tilde{b}f(\tilde{b}) - \int_0^{\tilde{b}} \frac{\delta^3}{1+\delta}(\frac{b}{\tilde{b}})^{1+\delta} dF(b) = 0 \tag{3.6}$$

Now we derive the first order conditions when replacement workers are allowed.

$$\begin{aligned}
\frac{dV(.)}{d\tilde{b}} &= \frac{1-\alpha\delta^2}{1+\delta}[1-F(\tilde{b})] - [\frac{1-\alpha\delta^2}{1+\delta}\tilde{b} + \delta M]f(\tilde{b}) \\
&\quad -(1-\alpha)\int_0^{\tilde{b}} \frac{\delta^3}{1+\delta}(\frac{b}{\tilde{b}})^{1+\delta} dF(b) + \frac{\delta^2}{1+\delta}(1-\alpha)\tilde{b}f(\tilde{b}) \\
&= \frac{1-\alpha\delta^2}{1+\delta}[1-F(\tilde{b})] - (1-\delta)\tilde{b}f(\tilde{b}) - \delta M f(\tilde{b}) \\
&\quad -(1-\alpha)\int_0^{\tilde{b}} \frac{\delta^3}{1+\delta}(\frac{b}{\tilde{b}})^{1+\delta} dF(b)
\end{aligned} \tag{3.7}$$

For simplicity and more clear presentation, we will perform the comparative statics when $\delta = 1$, this is the case when offers and counter-offers can be made instantaneously, with no time friction. The key to prove the Proposition 7 is to show that the marginal type $\tilde{b}$ (and consequently w_0) will decrease when replacement workers are allowed. Let $\tilde{b}^*$ be the optimal that satisfies the union's first order condition 3.6 when no replacement workers are allowed, and $\tilde{b}^{*s}$ the solution satisfying the first order condition 3.7 when we allow for replacement law.

Proof of proposition 7 :

(i) We evaluate the first derivative of the union's payoff function (equation 3.7) at $b = \tilde{b}^*$. Combining the two conditions, 3.6 and 3.7, will give

$$\frac{dV(.)}{d\tilde{b}}\Big|_{b=\tilde{b}^*} = -Mf(\tilde{b}^s) \ < 0 \tag{3.8}$$

Equation 3.8 implies that the union payoff function, when replacement workers are allowed, is decreasing at $\tilde{b}^*$ the maximum when the firm cannot hire replacements. Because the payoff function is concave, this will be true only if $\tilde{b}^{*s} \leq \tilde{b}^*$. Since the probability of a strike occurring is $F(\tilde{b})$, and $F(\tilde{b}^{*s}) \leq F(\tilde{b}^*)$ this proves proposition $7.(i)$.

(ii) To see the effect on the strike duration, we show this in two steps; Strike duration depends on whether the firm hires replacement workers or not. We will show that the duration will be reduced in both events.

If $\hat{b} \leq b < \tilde{b}^{*s}$ then the firm will delay $\Delta(b) = -(1/r)ln(\frac{b}{\tilde{b}^{*s}})$. If the firm is not allowed to hire replacement workers, its delay function is given by $\Delta(b) = -(1/r)ln(\frac{b}{\tilde{b}^*})$. But it was shown in part (i) that $\tilde{b}^{*s} \leq \tilde{b}^*$, it follows immediately that the strike duration is shorter when scabs are allowed.

If $b < \hat{b}$ then the firm's delay is given by $\Delta(b) = -(1/r)ln\{(1-\alpha)(\frac{b}{\tilde{b}^{*s}}) + \alpha(\frac{b}{\hat{b}})\}$ which is lower than $\Delta(b) = -(1/r)ln(\frac{b}{\tilde{b}^*})$ if $\tilde{b}^{*s} \leq \tilde{b}^*$.

(iii) Since strike incidence decreases, with lower initial offer w_0, all firms of type-b such that $b \geq \tilde{b}^s$ will have higher payoffs. When strikes occur, their duration is reduced, which also improves the payoffs of firms who experience strikes.

(iv) Let $V^{ns}(\tilde{b})$ and $V^{s}(\tilde{b}^{s})$ be the union's payoff before replacement workers are allowed and after replacement workers are introduced to the model. The assumption made on the distribution function guarantees concavity. Moreover, we know that $V^{ns}(\hat{b}) = V^{s}(\hat{b})$ at $\hat{b} = \frac{1+\delta}{\delta}\frac{M}{\alpha}$, all we have to show is that when these two functions cross, the slope of V^{ns} is steeper than the slope of V^{s}. Again this is satisfied using the assumption stated above.

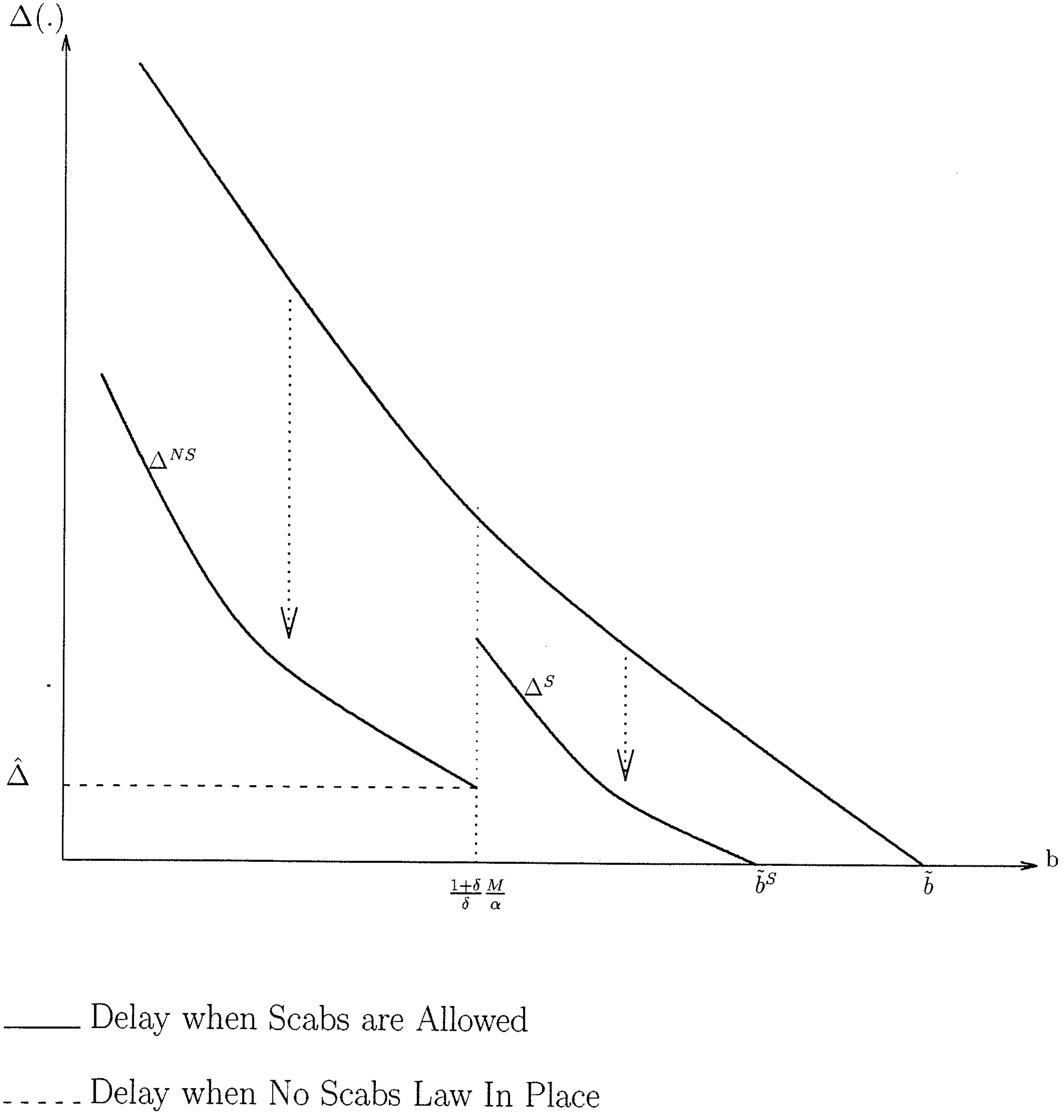

Figure 3.3: Delay Functions with and without the Scab Laws

3.5 Discussion

The model in this paper is a simple extension of the signaling literature. It formalizes a significant fact that has been ignored by previous bargaining models. By allowing the firms to hire replacement workers, the firms can endogenize this decision and consequently their status–quo payoffs during a conflict with their unions. In allowing for this possibility, we think that the signaling models will be more able to explain some of the empirical findings. The main prediction of the model, is the effect of the labor law, in particular, the replacement law on the strike activities. We show that in general, introducing replacement law will diminish the frequency and duration of strikes, by decreasing the initial wage offers by the unions. This comes as a result of a credible threat made by the firm to hire replacement workers in the event of a strike. Although this will increase efficiency by reducing conflicts and delays, the firm might use the replacement law to enhance its bargaining position, and reduce the effectiveness of the union in sharing rents with the firm, and this consequently will lead to distributional effects of the replacement law.

A natural application of the model is its implication on the wage bargaining outcomes, and the correlation of wages and strike durations. Kennan and Wilson (1989) studied three alternative game theoretical models of bargaining, that were characterized in terms of their predictions about the incidence, mean duration, settlement rates of strikes and the terms of wage settlements. Then the predictions were compared with the general features observed in empirical studies. General conclusions were drawn, of concern in here is the difficulties that the signaling models faced with the settlement rates and the negative concession curve. We believe that some of the criticism over the shortfalls of this literature in terms of the correlation between wage settlements and strike duration can be answered using our model. Kennan and Wilson (1989) proposed a two population model to explain why the relationship between wage settlements and strike duration might be weak, even if each population predicts that longer strikes should be associated with lower wage settlements. This is exactly what the model in this paper suggests. The model predicts a negatively sloped wage duration curve for each sub–population, and one of these curves lies everywhere above the other. Since Card (1990), in his empirical work applied to the Canadian union sector, did not allow for unobserved heterogeneity in his specification, it is possible that a wage–duration relationship might appear in his results if heterogeneity were introduced. The fixed effect model that McConnell (1989) used in controlling for the bargaining unit effect does perform better in exhibiting a negative slopped concession curve, which suggests that there is some omitted variable, proxied by the bargaining pair effect, which is positively correlated with both wages and strikes. Our model goes further in formalizing the heterogeneity in the population and suggests the need to incorporate the replacement law effects within these econometric studies, to take into account the shift in the wage–duration curve that takes place when the bargaining firm is allowed to hire replacement workers if the union goes on strike. .

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3.6 Appendix

3.6.1 Proof of proposition 1

the proof follows directly from lemma 1. We can distinguish two cases.

(i) if $\delta b - \delta^2 b + \delta^2 P \geq \frac{\delta}{1+\delta}(1-\alpha)b + \delta\alpha b - \delta M$ then from lemma 1 we have

$$P = \delta b - \delta^2 b + \delta^2 P$$

solving this for P we get

$$P = \frac{\delta}{1+\delta} b \tag{3.9}$$

(ii) if $\delta b - \delta^2 b + \delta^2 P < \frac{\delta}{1+\delta}(1-\alpha)b + \delta\alpha b - \delta M$ then

$$P = \frac{\delta}{1+\delta}(1-\alpha)b + \delta\alpha b - \delta M \tag{3.10}$$

from both equations 3.9 and 3.10 we can distinguish the range of the parameters α and M that would result in either the use of replacement workers or continuing to negotiate without using the firm's threat to hire replacement workers. Mainly, in order not to hire replacements we need

$$\frac{\delta}{1+\delta} b \geq \frac{\delta}{1+\delta}(1-\alpha)b + \delta\alpha b - \delta M$$

which yields to the condition stated in the proposition, $b \leq (\frac{1+\delta}{\delta})\frac{M}{\alpha}$ .... □

3.6.2 Proof of proposition 2

Along the equilibrium path, Incentive Compatibility (IC) constraints have to be satisfied for each firm type. From the defined payoffs in equation 3.1, these constraints for each type, b and b' respectively, can then be written as

For type-b :

$$S(b;\alpha)b - [e^{-r\Delta(b)}w(b) + e^{-rt(b)}M] \geq S(b';\alpha)b - [e^{-r\Delta(b')}w(b') + e^{-rt(b')}M]$$

For type-b' :

$$S(b';\alpha)b' - [e^{-r\Delta(b')}w(b') + e^{-rt(b')}M] \geq S(b;\alpha)b' - [e^{-r\Delta(b)}w(b) + e^{-rt(b)}M]$$

Adding up those two equations, and after simplification we get

$$S(b;\alpha)(b-b') \geq S(b';\alpha)(b-b')$$

Given that $b > b'$, the proposition is then satisfied. As for the second part of the proof, it follows directly from the above inequality together with the IC constraint of the firm of type-b'.

Chapter 4

Description of the Contract Data

4.1 Introduction

In this appendix I describe in details the source of the data used in the empirical chapter of the thesis. I describe the variables in the data set and I derive simple descriptive statistics. I examine their distribution through time and across industries.

The contract data is drawn from information on collective bargaining agreements reached in the unionized sector in Canada. The sample is derived from two sources: For agreements reached between 1964 and 1985, the data was provided by T. Lemieux.[1] This set is then updated, by merging it with data made available by Labour Canada, including contracts settled since 1978. These agreements are set at the firm level, and therefore contains micro characteristics that can not be found in aggregate data. Aggregate data, covering industrial wages, unemploymnent rate, prices and output were obtained from different *CANSIM* series. Aggregate Consumer Price index, 1986=100, was derived from *CANSIM* D484000. Average hourly earnings of employees paid by the hour, firms of all sizes, by industry and by province are also obtained by merging different *CANSIM* matrices.

The contract data consists of a sample of union contracts negotiated in Canada between the year 1964 and 1993. It contains hourly wage rates, employment, cost of living adjustment (COLA) conditions, and related informations such as strike activities and contracts durations, for agreements covering 500 and more employees. The newer data set contains additional information that was not available to previous studies; mainly

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[1] This is basically the contract data studied by Abowd and Lemieux (93), and earlier by Card (89)

four different wage types were recorded (base, low, mid and high) for each contract prior to 1990. Nevertheless, in order to make use of the whole sample, only base wage records were merged with the old data set. In most contracts, the base wage rate is earned by relatively low skilled group: often janitors and cleaners. Construction industry was excluded prior to 1983, and the cut off for agreements subject to the Canada Labour Code was lowered to 200 and more employees in the 1987 settlement year. The data is organized hierarchically: First by a bargaining unit identifying number, then by settlement date, calendar month, and finally by wage type.

There is one record per month of any given agreement. So a 24 month contract would consists of 24 records, each record has over 100 variables, including base wage rate, cola type and cola cap, number of employees covered by the contract, contract duration, strike frequency, the wage effective date, the contract settlement date and expiration date.

4.2 SIC Mapping

In the original wage tape, the bargaining units are classified by their 3-digits industry codes. Since some of the additional merged data are only defined for 2-digits industries, We had to find the corresponding industry groups. The aggregation to the 2-digits industry codes was done using the mapping in Table 4.1.

Table 4.1: 2-digits and 3-digits SIC codes

2-Digits SIC	Industry Name	Interval of 3-Digits SIC
10	Food Industries	(101,109)
11	Beverage Industries	(111,119)
12	Tobacco Products Industries	(121,129)
15	Rubber Products Industries	(151,159)
16	Plastic Products Industries	(161,169)
17	Leather and Allied Products Industries	(171,179)
18	Primary textile Industries	(181,189)
19	Textile Products Industries	(191,199)
24	Clothing Industries	(243,249)
25	Wood Industries	(251,259)
26	Furniture and Fixture Industries	(261,269)
27	Paper and Allied Products Industries	(271,279)
28	Printing, Publishing and Allied Industries	(281,289)
29	Primary Metal Industries	(291,299)
30	Fabricated Metal Products Industries	(301,309)
31	Machinery Industries	(311,319)
32	Transportation Equipment Industries	(321,329)
33	Electrical/Electronic Products Industries	(331,339)
35	Non-Metallic Mineral Products Industries	(351,359)
36	Refined Petroleum/Coal Products Industries	(361,369)
37	Chemical and Chemical Products Industries	(371,379)
39	Other Manufacturing Industries	(391,399)

Collective bargaining agreement in the public sector were excluded from the data, only agreements from the manufacturing sector were considered. The overall sample covers 22 2-digits industries, 82 3-digits industries, 584 bargaining units and 3646 contract agreements. Those contracts are distributed unevenly over the different industries. Most of the contracts are in the Food, Transportation, and the Electrical/Electronics products industries (36% of total contracts). These industries actually contains about 37% of the bargaining units in the sample. Paper and Allied Products industries cover more contracts than any other industry in the sample, with a relatively small number of bargaining units, reflecting the industry wide bargaining process particular to this industry.

As I explain in the next sections, a correction for the contract variation across industries and over time is used when descriptive statistics are computed. Table 4.2 summarizes the structure of the sample data in question; The bargaining units and contracts distribution.

Table 4.2: Contracts Distribution

2-digit SIC code	2-digit name	nb of 3-digits industries	nb of units	nb of contracts
10	Food Industries	8	64	415
11	Beverage Industries	3	10	75
12	Tobacco Products Industries	1	6	55
15	Rubber Products Industries	2	16	81
16	Plastic Products Industries	2	6	20
17	Leather and Allied Products Industries	4	6	45
18	Primary textile Industries	3	30	147
19	Textile Products Industries	2	13	49
24	Clothing Industries	6	23	170
25	Wood Industries	4	16	93
26	Furniture and Fixture Industries	2	4	24
27	Paper and Allied Products Industries	3	77	549
28	Printing, Publishing and Allied Industries	2	19	119
29	Primary Metal Industries	6	44	354
30	Fabricated Metal Products Industries	5	25	107
31	Machinery Industries	2	25	133
32	Transportation Equipment Industries	7	92	520
33	Electrical/Electronic Products Industries	7	64	377
35	Non-Metallic Mineral Products Industries	4	17	123
36	Refined Petroleum/Coal Products Industries	1	1	12
37	Chemical and Chemical Products Industries	5	17	126
39	Other Manufacturing Industries	3	9	52
All Industries		82	584	3646

4.3 Descriptive Statistics

I have made additional restriction to the sample, in particular, contracts from the auto industry, and the public sector were excluded from the analysis mainly because of the distinct bargaining pattern which characterizes the auto industry and the public sector. The resulting sample contains 3521 contracts negotiated by 571 firm-union pairs. In this section, I will describe some of the important variables in the data set; I will explain how they were created, and present their sample means and standard deviations over the time span and across the industries.

4.3.1 Wages

Each contract is associated with one wage measure. In the data, the contract is a series of monthly nominal wages, W_{ijt}, where i is the bargining unit identifier, j refers to the contract in place and t is the month in effect. Using a price index, P_t, I constructed for each contract, j, a series of monthly real wages, and took the average over the life of the contract. Let T be the length of the contract in months, the log-real wage for the contract is defined as $w_{ij} = log[\frac{1}{T}\sum_{t=1}^{T}(W_{ijt}/p_t)]$.

Aggregate industry and provincial wages were obtained from different CANSIM matrices. These wage series were merged to the initial contract data. Industry wage is considered as a measure of the alternative wage for the workers. Since contracts covers many periods, and the bargaining parties are conscious about the long term consequences of their wage agreement, average industry wage (over the life of the contract) were constructed in order to ameliorate the measure of the alternative wages available.

The following set of tables contain cross sectional (Table 4.3) and time series (Table 4.4) sample means of these different wage measures. As documented in Table 4.2, contracts are unevenly distributed over both industries and the sample span. In order to take into account the uneven distribution of contracts over the sample period, average contract (industry) wages are represented by the estimated industry coefficients from regressing wages on industry dummies and year dummies, with the year effects normalized to sum to zero. Equivalently, average yearly wages are represented by the estimated year dummy coeficients from regressing wages on industry dummies and year dummies, with the industry effects normalized to sum to zero.

Table 4.3: Cross Sectional Wages

2-digit SIC code	2-digit Name	Contract wages	Industry wages
10	Food Industries	2.27	2.27
11	Beverage Industries	2.58	2.53
12	Tobacco Products Industries	2.48	2.67
15	Rubber Products Industries	2.26	2.38
16	Plastic Products Industries	2.24	2.33
17	Leather and Allied Products Industries	1.84	1.98
18	Primary textile Industries	2.01	2.02
19	Textile Products Industries	2.16	2.10
24	Clothing Industries	1.90	1.94
25	Wood Industries	2.46	2.39
26	Furniture and Fixture Industries	2.14	2.13
27	Paper and Allied Products Industries	2.45	2.60
28	Printing, Publishing and Allied Industries	2.38	2.47
29	Primary Metal Industries	2.37	2.59
30	Fabricated Metal Products Industries	2.34	2.42
31	Machinery Industries	2.33	2.47
32	Transportation Equipment Industries	2.37	2.55
33	Electrical/Electronic Products Industries	2.19	2.34
35	Non-Metallic Mineral Products Industries	2.32	2.46
36	Refined Petroleum/Coal Products Industries	2.40	2.72
37	Chemical and Chemical Products Industries	2.32	2.45
39	Other Manufacturing Industries	2.08	2.18
All Industries		2.27	2.36

Beverages and Tobacco industries had the highest level of real wages, while Leather and Clothing industries had the lowest. The overall sample average log-real wage was 2.27. When we consider the wage evolution over time, an upward trend in real wages is apparent in the early years of the sample, with a very flat performance throughout the 1980s and early 1990s.

Table 4.4: Time Series Wages

Year	Wages		
	Contract	Industry	Provincial
1963	1.94	2.09	2.06
1964	2.00	2.10	2.08
1965	2.00	2.09	2.09
1966	2.01	2.10	2.11
1967	2.02	2.13	2.15
1968	2.05	2.16	2.17
1969	2.08	2.20	2.20
1970	2.12	2.25	2.26
1971	2.17	2.30	2.31
1972	2.19	2.33	2.34
1973	2.21	2.35	2.37
1974	2.22	2.36	2.41
1975	2.26	2.41	2.47
1976	2.31	2.46	2.52
1977	2.34	2.48	2.55
1978	2.35	2.46	2.53
1979	2.37	2.47	2.53
1980	2.37	2.47	2.52
1981	2.39	2.46	2.53
1982	2.40	2.46	2.54
1983	2.41	2.47	2.51
1984	2.42	2.47	2.50
1985	2.42	2.47	2.49
1986	2.41	2.46	2.48
1987	2.40	2.45	2.46
1988	2.40	2.44	2.46
1989	2.40	2.45	2.45
1990	2.40	2.45	2.45
1991	2.41	2.43	2.45
1992	2.41	2.44	2.46
1993	2.42	2.45	2.47
1994	2.40	2.47	2.48
All	2.27	2.36	2.39

4.3.2 Employment

The data on employment is available from the contract wage tape. In this tape each contract is associated with a number of employees. This is the number of employees covered by the collective agreement in the bargaining unit at the date of settlement. Unlike wages, information is not provided on how employment changes through out the contract duration. In order to give a quick view on the size of employment in the data set we have, Table 4.5 shows the number of employees covered by the collective bargaining agreements, in different 2-digits industries.

Besides looking at the total coverage Table 4.5 emphasizes what is mainly the employment level at the bargaining unit. Since negotiations occur on the plant level, this is the employment measure that is of concern to the bargaining parties. I used the same techniques as in the wages section, in order to account for the year to year variation of contract negotiations within industries and the uneven distribution of contracts in the sample period. This is again done by regressing the average employment (averaged over all contracts in effect in a given year) over industry and year dummies, with the usual restriction of restricting the effects to sum to zero. Table 4.6 describes average contract employment by year.

Table 4.5: Cross Sectional Employment Coverage

SIC2	Industry name	Employmnent coverage	Employment per Contract
10	Food Industries	451,770	1,151
11	Beverages	61,645	949
12	Tobacco Industry	48,350	917
15	Rubber Products Industries	17,155	850
16	Plastic Products Industries	35,760	927
17	Leather and Allied Products Industries	138,563	907
18	Primary textile Industries	39,544	798
19	Textile Products Industries	69,624	907
24	Clothing Industries	345,810	2,041
25	Wood Industries	458,675	5,040
26	Furniture and Fixture Industries	13,665	628
27	Paper and Allied Products Industries	545,990	986
28	Printing, Publishing and Allied Industries	112,785	984
29	Primary Metal Industries	534,658	1,531
30	Fabricated Metal Products Industries	90,985	908
31	Machinery Industries	140,870	1,115
32	Transportation Equipment Industries	1,017,714	1,986
33	Electrical/Electronic Products Industries	453,604	1,231
35	Non-Metallic Mineral Products Industries	83,971	703
36	Refined Petroleum/Coal Products Industries	6,140	610
37	Chemical and Chemical Products Industries	93,569	776
39	Other Manufacturing Industries	37,795	756

Table 4.6: Time Series Average Contract Employment

year	employment	std error
63	2,250	1197.84
64	1,467	324.09
65	1,340	205.07
66	1,502	202.48
67	1,526	220.54
68	1,223	167.97
69	1,220	203.52
70	1,516	172.68
71	898	195.21
72	1,294	193.22
73	1,193	168.55
74	1,002	180.82
75	1,217	173.30
76	1,259	170.95
77	1,094	172.09
78	1,130	158.86
79	1,268	181.77
80	1,037	169.00
81	1,132	207.50
82	1,306	186.04
83	1,156	198.30
84	1,216	178.71
85	1,042	216.10
86	832	206.00
87	1,408	197.86
88	886	197.63
89	807	255.05
90	1,365	198.93
91	712	217.86
92	1,004	258.58
93	1,503	246.40
94	810	1038.93
all years	1207	258.18

4.3.3 Indexation

An important characteristic of union contracts, is the indexation clause. Among the 3641 contracts in our sample, 1278 contracts have an explicit *COLA* clause, that ties up the nominal wages to a price index. There are many different types of *COLA*, the most frequent indicates how many cents a wage should increase for each given point change in the price index (i.e one cent increase in COLA for each 0.3 point increase in the CPI). Some contracts also includes Trigger condition, which indicates that *COLA* generation commences only if either prices increased by a certain number of points (or percentage points or value) or if the amount calculated according to the formula exceeds a specified number of cents per hour. One more restriction, called a Cap (or a maximum), sometimes applies to the calculation of *COLA*. The Cap assures that *COLA* cannot exceeds a specified amount, or specified percentage of the wage in effect at the beginning of the collective agreement.

The occurence of a *COLA* clause and its generosity vary among contracts, industries and years. In the following tables, we calculates the average percentage of *COLA* clauses for each 2-digit industry. This is done by taking into account the uneven distribution of wages withing each industry by regressing *COLA* clauses over industry and year effects and constraining the year effect to sum to zero.

A quick look at these tables indicates how much variation within industries the frequency of indexation exhibits. Aside from the Refined Petroleum and Coal Products Industries (sic2 = 36), where we have only one bargaining unit (Shell Canada) with 12 contracts, the indexation frequency, goes from a low of 3.3 and 2.6 percent in the Tobacco industries and Printing and Publishing industries, to a high of 61 and 62 percent in Transportation Equipment Industries and Fabricated Metal Products industries. What is worth noting too is the fact that industries with high degrees of indexation have low standards relative the standard errors of industries with low degree of indexation. This might means that indexation, when very high, is an industry wide phenomenon.

A casual study of Table 4.7 reveals some interesting facts concerning the evolution of indexation. For the *COLA* clause, we notice its absence until 1967, when the frequency of indexation started to climb slowly till early seventies, a period of high inflation. The

Table 4.7: Cross Sectional Description of Indexation Incidence

2-digit Industry	Industry name	Indexation incidence	st err. Indexation
10	Food Industries	0.124070	0.01979684
11	Beverages	0.546116	0.04676070
12	Tobacco Industry	0.033764	0.05421712
15	Rubber Products Industries	0.559970	0.04486968
16	Plastic Products Industries	0.534920	0.08999931
17	Leather and Allied Products Industries	0.189358	0.05989764
18	Primary textile Industries	0.211436	0.03343402
19	Textile Products Industries	0.431596	0.05740171
24	Clothing Industries	0.232250	0.03095703
25	Wood Industries	0.263890	0.04211068
26	Furniture and Fixture Industries	0.311501	0.08201696
27	Paper and Allied Products Industries	0.101940	0.01777864
28	Printing, Publishing and Allied Industries	0.026021	0.03686578
29	Primary Metal Industries	0.609248	0.02148188
30	Fabricated Metal Products Industries	0.627289	0.03884058
31	Machinery Industries	0.546590	0.03494242
32	Transportation Equipment Industries	0.614944	0.01775084
33	Electrical/Electronic Products Industries	0.474922	0.02085281
35	Non-Metallic Mineral Products Industries	0.467453	0.03638565
36	Refined Petroleum/Coal Products Industries		
37	Chemical and Chemical Products Industries	0.113231	0.03589821
39	Other Manufacturing Industries	0.150669	0.05572697
	All Industries		

degree of indexation in 1975 reached an unprecedented maximum of 61 percent. In 1981 again indexation rose to around 60 percent only to subside afterwards to more moderate levels of about 40% on average.

4.3.4 Strikes

The contract data that I am using does not have detailed information on strikes activities in the manufacturing sector considered. Still, we can indirectly infer from different variables in the data set some indicators on strikes incidences and durations. In fact the data set contains a variable that describes the stage at which the agreement was settled; examples are direct bargaining, mediation,... Some actually contains strikes, like Mediation after work stoppage, work stoppage, bargaining after work stoppage. I used these three values of stage settlement, and constructed a strike dummy that takes the value 1 when those stages involving strikes occur. Expiry dates and settlement dates can also be informative when asking questions about general delays in reaching particular agreements. Previous research (e.g Card (89)) used data from *Strikes and Lockouts in Canada (SLC)* to obtain more information on the duration of the strike, because this information was not available directly from the wage tape. Since this paper concentrates more on strike incidence rather than strike duration, no attempt was made to merge the wage tape with other data sources containing information on the duration of the dispute. Note that Card found that in the year 1981 strikes in the wage tape were over-reported. Nevertheless,he suggests that over the whole sample of his study strikes incidences were about 2

Among the 3646 contracts in the data set, 677 contracts were reached after a work stoppage has occured. The strike frequency is then studied in more details according to the industry affiliation. Also the evolution of strikes throughout the sample set is considered in the next two tables. It is very clear that strikes variation is very important among industries, some industries are traditional characterized by high level of conflicts, in our sample, contracts in the Plastic industries, the Furniture and Fixture industries and the Transportation industries involved lots of strikes. On the other hand, the Tobacco industry witnessed the minimum level of conflicts. As for the variation of strikes through time, the first half of the 1970s stands in particular as a high conflict period, reaching a maximum of 35 percent in 1975. Also a significant number of contracts signed in 1981 did involve strikes. The eighties in general was stable in terms of strikes; Except for 1981, the strike level remained around 14 percent during this period.

Table 4.9: Time Series Description of Strikes and Indexation Incidence

year	strike incidence	st err. Strikes	Indexation incidence	Std. error Indexation
1963	0.000	0.000		
1964	0.096	0.059		
1965	0.098	0.037		
1966	0.131	0.037		
1967	0.176	0.040	0.130580	0.04185591
1968	0.158	0.030	0.100800	0.03171587
1969	0.174	0.037	0.160698	0.03858102
1970	0.204	0.031	0.193054	0.03263093
1971	0.220	0.035	0.226947	0.03697217
1972	0.148	0.035	0.172962	0.03661719
1973	0.269	0.030	0.373927	0.03182803
1974	0.264	0.033	0.560000	0.03420997
1975	0.352	0.031	0.609983	0.03285758
1976	0.216	0.031	0.341182	0.03229855
1977	0.130	0.031	0.358599	0.03261646
1978	0.103	0.029	0.332435	0.03004327
1979	0.222	0.033	0.479892	0.03449407
1980	0.141	0.031	0.474991	0.03191836
1981	0.318	0.038	0.590922	0.03935903
1982	0.087	0.034	0.408940	0.03532258
1983	0.151	0.036	0.415889	0.03758042
1984	0.141	0.032	0.400593	0.03389954
1985	0.198	0.039	0.453242	0.04101381
1986	0.118	0.037	0.344323	0.03918182
1987	0.157	0.036	0.426558	0.03760638
1988	0.119	0.036	0.388938	0.03756891
1989	0.181	0.046	0.395734	0.04850716
1990	0.146	0.036	0.449037	0.03781634
1991	0.051	0.040	0.378747	0.04147862
1992	0.216	0.047	0.409488	0.04932063
1993	0.017	0.045	0.429646	0.04684412
1994	0.000	0.000	0.624280	0.19859371

Table 4.8: Cross Sectional Description of Strikes Incidence

2-digit industry	industry name	strike incidence	st err. strikes
10	Food Industries	0.126	0.020
11	Beverages	0.139	0.044
12	Tobacco Industry	0.029	0.051
15	Rubber Products Industries	0.186	0.042
16	Plastic Products Industries	0.270	0.085
17	Leather and Allied Products Industries	0.084	0.057
18	Primary textile Industries	0.114	0.032
19	Textile Products Industries	0.236	0.054
24	Clothing Industries	0.038	0.030
25	Wood Industries	0.182	0.040
26	Furniture and Fixture Industries	0.299	0.078
27	Paper and Allied Products Industries	0.192	0.018
28	Printing, Publishing and Allied Industries	0.070	0.035
29	Primary Metal Industries	0.216	0.021
30	Fabricated Metal Products Industries	0.140	0.037
31	Machinery Industries	0.180	0.033
32	Transportation Equipment Industries	0.270	0.018
33	Electrical/Electronic Products Industries	0.171	0.020
35	Non-Metallic Mineral Products Industries	0.180	0.035
36	Refined Petroleum/Coal Products Industries	0.089	0.110
37	Chemical and Chemical Products Industries	0.155	0.034
39	Other Manufacturing Industries	0.137	0.053
	All Industries	0.159	0.043

Table 4.11: Time Series Description of Canadian Unemployment Rates and Gross domestic product

Year	Unemployment rate	GDP Index	Std. error
1963	4.60000	39.970882	28.4068
1964	3.80000	49.677791	8.1428
1965	3.00000	56.072739	5.0138
1966	2.59167	60.500248	4.2242
1967	2.94167	61.496435	4.0680
1968	3.40000	65.965825	4.0330
1969	3.39167	70.759818	3.9817
1970	4.24167	68.516369	3.9630
1971	4.49167	72.045648	3.9552
1972	4.59167	77.680586	3.9336
1973	4.04167	83.526831	3.9082
1974	3.84167	84.108583	3.9169
1975	5.01667	78.690075	3.8425
1976	5.10000	83.515522	3.8121
1977	5.80833	85.268830	3.8741
1978	6.14167	88.807631	3.9789
1979	5.50000	92.465513	4.0202
1980	5.45000	89.458286	4.0670
1981	5.56667	94.844679	4.0963
1982	8.41667	82.879246	4.1676
1983	9.43333	88.921715	4.2344
1984	9.28333	103.421626	4.2992
1985	8.79167	110.372684	4.3614
1986	8.00833	109.637714	4.3778
1987	7.55833	116.547657	4.3637
1988	6.70000	123.866268	4.3540
1989	6.61667	125.727471	4.3577
1990	7.05000	121.565689	4.3577
1991	9.05000	115.943185	4.3614
1992	9.94167	120.447298	4.4386
1993	9.91667	128.452001	4.5712
1994	9.15000		
1995	8.33333		
.	6.11414		

initial contracts can be enforceable and are able to monitor the *ex post* renegotiation process. The design of rules that govern this process are summarized by the default options in the case of renegotiation breakdown and the authority delegation. (ii) MacLeod and Malcomson [1993] propose another form of contracts; *Long-term Renegotiation-Proof Contracts* which are conditioned on sufficient external variables to ensure renegotiation never occurs.

Chapter 2 tests the predictions of contract theory on the wage determination and the impact of renegotiation on its evolution. We test whether the effect of labor market conditions on wage formation adhere more to the spot market description of the labor market rather than the contract approach. In simple competititive models, wages are negotiated continuously which implies that the current labor market conditions play a significant role in wage determination. On the other hand, contract models predict that it is rather the wage history experienced by workers that affects their current wages. We use strike activities as a proxy to wage renegotiation. We present an empirical analysis of the effect of strikes on the evolution of wages, based on data from union wage settlements in the Canadian manufacturing sector. This chapter explores the determinants of strike incidence based upon a switching regime model. We correct for the strike endogeneity in cross a section by using sample selection methods and instrumental variables. We then consider the fixed effect method usually used with longitudinal data. We extend this method by allowing the time invariant (fixed) specific effect to have a differential impact in the two regimes. Following Chamberlain [1982] and Lemieux [1997] we present a panel data estimator that is robust to both non-random selection and to differential characteristic (observed and unobserved) rewards in the strike and the non-strike regimes.

The empirical findings of the chapter cast some doubts on the use of fixed-effects models in estimating strike effect on wages. There is also evidence that wage rigidity depends on strike activity. We find a significant effect of previous wages on current wage determination, this effect is reduced in importance when a strike is observed relative to the effect of contemporaneous labor market conditions. Beaudry and DiNardo [1991] reached a similar conclusion by examining cyclical movements in real wages. Using

Table 4.10: Cross Sectional Gross Domestic Product Index

SIC2	Industry name	GDP Index	Std. error
10	Food Industries	97.041	2.288
11	Beverages	88.811	3.615
12	Tobacco Industry	80.935	5.951
15	Rubber Products Industries	81.647	4.217
16	Plastic Products Industries	101.844	5.636
17	Leather and Allied Products Industries	102.017	3.709
18	Primary textile Industries	92.333	3.836
19	Textile Products Industries	91.315	5.814
24	Clothing Industries	97.632	3.085
25	Wood Industries	105.986	3.872
26	Furniture and Fixture Industries	93.321	5.554
27	Paper and Allied Products Industries	84.897	3.715
28	Printing, Publishing and Allied Industries	89.544	4.198
29	Primary Metal Industries	116.018	2.718
30	Fabricated Metal Products Industries	91.083	3.217
31	Machinery Industries	69.307	4.237
32	Transportation Equipment Industries	107.239	2.586
33	Electrical/Electronic Products Industries	177.547	2.547
35	Non-Metallic Mineral Products Industries	100.804	3.841
36	Refined Petroleum/Coal Products Industries	101.629	7.645
37	Chemical and Chemical Products Industries	98.947	3.673
39	Other Manufacturing Industries	92.495	4.320

4.3.5 Gross Domestic Product and Unemployment

Industry output was merged to the data. The data was obtained from separate CANSIM series, which includes GDP at factor cost by industry in 1986 prices. It is monthly, seasonaly adjusted data. GDP from 3-digit industries were used; Whenever a 3-digit GDP was not found, the corresponding, more aggregate, 2-digit GDP was used instead. I transformed the data found in the CANSIM series (the unit of measurement is Millions of dollars), by constructing an output index. Formally I normalize by deviding by the 1980 GDP at factor cost levels (for both the 2- and 3-digit measures).

As a measure of the labour market conditions, unemployment series from CANSIM, in particular, the Canadian (aggregate) unemployment rate from 1963-1995 for 25 and above years old were merged with the contract data. In the next tables a complete description of these variables is presented.

Discussion

In this thesis we present an analysis of wage determination and strike activities in the labor market. Many previous studies and casual observations suggest that the wage-employment combinations do not correspond to the intersection of demand and supply presented in the standard spot market equilibrium. We argue that contracts play an important role in resource allocation and in wage determination in long-term relationships once we move away form the frictionless world of textbook markets. Non-cooperative bargaining theory provides us with a useful framework to discuss labor negotiations. We use asymmetric information bargaining models to study the impact of changes in the institutions governing these negotiations on conflict incidences and durations. In this thesis, we concentrate on the relationship specific under-investment problem as a motivation for contracts. We then test the implications of these contracts on wage dynamics, and we contrast our results with the predictions of the spot market model. We also study in details labor negotiations in the case of asymmetric information, and apply this model to understand the impact of specific labor laws on labor market activities.

In Chapter 1, we review the recent developments in the theory of incomplete contracts and their role in inducing efficient investment. One function of contracts is to facilitate trade between parties when relationship-specific investments occur. Once these investments have been incurred each party becomes "locked-in" and therefore vulnerable to opportunistic behavior from the other party (Williamson [1979, 1985]). Any bargaining or contract renegotiation affecting the division of the gains will have an element of bilateral monopoly. Future uncertainty, observable but unverifiable investments, will lead to a lot of difficulties in predicting future contingencies, and so contracts will be incomplete. In such situations, Hart and Moore [1988] show that in general *ex-post* contract renegotiation may prevent the implementation of first-best outcomes.

However, the recent literature exploits the properties of non-cooperative bargaining theory to suggest two alternative solutions for the under-investment problem when both parties make specific investments: (i) Aghion, Dewatripont and Rey [1994] propose *short-term Contracts with Renegotiation Design* as one solution. They assume that individual data from the CPS and the PSID they found that individual wages move with market conditions in a manner consistent with a contract model rather than a spot market model. Further work by the same authors suggest more evidence against the competitive model by looking at the joint behavior of hours and wages. This contrast earlier work by Abowd and Card [1989] which found that relative variation in earnings and hours changes among workers with the same employer over time is inconsistent with the pattern of earnings smoothing implied by the implicit contract models. Our results using Canadian data lead more support to the contract model and can be viewed as a continuation of this line of research.

Chapter 3 concentrates on the process of contract negotiation between workers and firms. We highlight the importance of the institutions governing the bargaining process and how changes in these institutions might affect the bargaining outcome. Bargaining models studying conflicts that arise during negotiations emphasize the importance of the parties payoffs (threat points) during the disputes, and recognize their effect on the bargaining outcomes. Recently a great deal of progress in the theoretical analysis of disputes has been made by focusing on one-sided asymmetric information over the size of the bargaining surplus (Grossman and Perry [1986] and Admati and Perry [1987]). We consider a class of imperfect information models, the signaling models, where the union is not fully informed about the firm's type it is facing, and we incorporate the firm replacement strategy and analyze its effect on the wage outcome and the strike activity.

A *Bayesian Perfect Equilibrium* is derived for the bargaining game, and the implications of the replacement laws are studied. Under the assumptions of our model, we show that the possibility of replacement workers increases in the strike threat payoff of the firm and has a negative effect on wage settlements. Further, since hiring replacement workers is an alternative signalling device to reveal private information in the asymmetric information bargaining game, the possibility of replacement workers reduces strike incidence and strike duration.

We believe that some of the criticism over the shortfalls of the signalling models in terms of predicting a negative correlation between wage settlements and strike durations can be answered using our model. Kennan and Wilson [1989] proposed a two population model to explain why the wage-strike duration relationship might be weak in the data, even if each population predicts that longer strikes should be associated with lower wage settlements. Our model suggests the need to incorporate the replacement law effect within these econometric studies to take into account the shift in the wage-duration curve that takes place when the bargaining firm is allowed to hire replacement workers if the union goes on strike. Furthermore, by varying the parameters capturing labor specificity and hiring and firing costs, the model could generate some of the observed cross sector variation in the use of replacement workers and the consequences on strike activities. It could be a useful framework for future empirical work on the impact of such laws on labor market activities.

Synthèse

Cette thèse est une étude à la fois théorique et empirique de la détermination des salaires et de l'activité de grève dans le marché du travail. Nous avons essayé d'expliquer l'incidence des grèves sur l'évolution des salaires, d'estimer cet effet et finalement de développer un modèle théorique qui formalise quelques aspects des politiques gouvernementales dans le marché du travail. Comme déjà mentionné dans l'introduction de la thèse, nous avons fait appel à des modèles d'équilibre partiels qui diffèrent des modèles standard du marché "spot". En particulier, nous avons vu que la théorie des contrats peut servir comme un cadre assez puissant pour dégager des prédictions testables sur l'évolution des salaire et, de même, l'incidence des grève sur cette evolution. D'autre part, la théorie de négociation non-coopérative nous aide à comprendre les grèves et à développer d'avantage une formalisation simple des interventions gouvernementales et des lois régissant les conflits de travail.

Après un bref survol des récents développements en théorie des contrats incomplets, nous avons cherché à tester les principales prédictions de cette théorie, à savoir la dynamique des salaires et l'incidence des grèves sur l'évolution des salaires. Les modèles standards d'équilibre concurrentiel indiquent que les salaires sont renégociés périodiquement et sont déterminés principalement par les forces du marché du travail. Les résultats du Chapitre 2 ne supportent pas cette proposition. Nous avons utilisé des méthodes d'estimation robustes aux problèmes d'endogénéité et à la différence dans les effets des caractéristiques observables et non observables sur les salaires. Contrairement à la théorie concurrentielle, nous avons trouvé que les salaires sont généralement prédeterminés par les salaires précédents; les conditions du marché du travail ont un effet moins significatif tant qu'on n'observe pas de grèves. Ce résultat s'inscrit dans le même contexte que d'autres études qui démontrent de l'évidence empirique supportant la théorie des contrats plutôt que les modèles concurrentiels (voir Beaudry et DiNardo [1991, 1995]).

L'autre contribution de cette thèse est de formaliser, dans le cadre des modèles de négociation non-coopérative, les lois du travail et ensuite leurs effets sur l'activité de grève et la distribution des revenus entre les firmes et les employés. L'asymétrie d'information est nécessaire pour expliquer la grève comme un mécanisme pour révéler de l'information. Dans le Chapitre 3 nous développons un modèle de négociation bilatérale, entre une firme et ses employés, avec information asymétrique. Les prédictions du modèle indiquent que la mise en oeuvre des lois permettant aux entreprises de remplacer les travailleurs en grève par d'autres, aura comme conséquence de réduire l'incidence des grèves, réduire la durée des grèves et finalement changer la distribution des revenus en faveur des firmes.