BARGAINING STRUCTURE AND BARGAINING OUTCOMES

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ABSTRACT

A recent development in the analysis of strikes and contract negotiations -- strategic bargaining models with asymmetric information -- allows us to study bargaining structure and outcomes via its effects on information transfer and learning among parties to bargaining. This thesis continues this new approach and attempts to add to our knowledge of bargaining structure, both theoretically and empirically.

The whole thesis can be viewed as three main essays. In the first main essay (Chapter 2), we study learning and information transfer among unions when negotiations are sequential and there is no collusion among either unions or firms. That chapter attempts to further our understanding of relative rewards, imitation and learning. The model, which considers two union-firm bargaining pairs, generates an interest by workers in each other's wages which is based on learning their own firm's ability to pay by observing the preceding negotiations. But rather than being socially harmful, as it can be in the "informational cascade" literature, learning from actions of the others is, in a number of cases, socially beneficial. This is because learning reduces the costly mistakes made in bargaining due to asymmetric information. Using a large sample of Canadian contract negotiations for the period from 1965-1988, we find strong evidence that the more negotiations which have been concluded in the recent past in a union's industry, the less likely is a strike to occur. This can be seen as relatively convincing evidence that some social learning, with beneficial social consequences, does occur among unions negotiating wages within an industry.

In the second main essay (Chapter 3), we use a model of learning among unions to compare bargaining outcomes in various bargaining structures and examine the effects of centralization when negotiations are simultaneous. Existing formal models of bargaining structure and outcomes typically ignore one or both of two key issues: the issue of asymmetric information and the nature of bargaining process (simultaneous versus sequential negotiation). Among other things, this means that they cannot capture the implicit coordination, or social learning, in decentralized bargaining structures. Neither can they examine the wage leapfrogging phenomenon that has been suggested as a potential important disadvantage of decentralized bargaining structures. The current model allows us to examine these key issues. We found that when negotiations are simultaneous, collusion by firms or by both firms and unions reduces expected wage settlements and raises strike incidence since they reduce learning and information transfer among unions in contract negotiations.

In the model of learning among unions examined in the second main essay, there are clear first mover disadvantages for both unions and firms. Early negotiations generate valuable information about firms' ability to pay which unions in later negotiations can use to improve their wage settlements. Unions have an incentive to free ride and delay their wage settlements and let other unions conclude their negotiations first. In the third main

essay (Chapter 4), we examine this information externality and interpret the delaying of wage settlements without strikes as holdouts. As in Cramton and Tracy's model of holdouts (1992), the model predicts that holdouts should be shorter and less frequent when the wage settlement in the existing contract is lower, and when the unions are more optimistic about the firm's ability to pay. But the model also has a number of predictions about some issues on which Cramton and Tracy's model is silent, one of which is the following: as the number of unions in the model expands, the above information externality is exacerbated, generating longer holdouts in equilibrium. This implication is tested using the large sample of Canadian contract negotiations used in the first essay, yielding strong evidence that the larger the number of negotiations taking place at the same time, the greater are both holdout incidence and duration.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 2

Chapter 4

CHAPTER 1

GENERAL INTRODUCTION AND LITERATURE SURVEY

A central concern in the field of industrial relations has been the effects of institutional structures of bargaining on bargaining outcomes, such as the levels of wages and incidence of disputes, or strikes. Three main players in industrial relation systems - employers, unions and governments - are all interested in adopting the type of bargaining structures that best serves. their goals. However, discussion of the consequences of alternative bargaining structures remains speculative, to a large extent (Anderson 1982, Kochan and Katz 1988).

Since the main objective of the thesis is to add to our understanding of the consequences of alternative bargaining structures for bargaining outcomes, it is important these concepts are well understood at the outset. Kochan (1988, p. 11) defines bargaining structure as "the scope of employees and employers covered or in some way affected by the terms of a labor agreement. For example, are there a number of different employers involved in the agreement or is there just one? Does a given company bargain with one union or many?" Based on the level at which negotiations are mainly conducted, bargaining structures can be mainly classified in three types: *industry-wide,* multi-employer bargaining which is external to the firm, as practiced in much of Western Europe on wage-related issues and in the pulp and paper industry in British Columbia, Canada; *single enterprise* or firm bargaining, as typically found in USA and Canada; and *economy-wide* bargaining between trade union and employer central confederations, as in Scandinavian countries (Norway, Sweden and Denmark).

For our purpose, bargaining structures can be classified according to whether they involve a single union and firm and whether unions and/or firms cooperate in bargaining. By this classification, we have the following four alternative bargaining structures: (1) independent bargaining between a single union and firm; (2) "colluding unions", in which unions cooperate and negotiate with different firms. (This bargaining structure can be observed through the merger of unions or simply when a single union negotiates with different firms. One example is the United Auto Workers (UAW)); (3) its converse, when a single employer or a group of employers bound together in an association negotiates with different unions; (4) a case of colluding unions and firms, in which a group of cooperating unions negotiate with a group of cooperating firms. *Industry-wide* and *economy-wide* bargaining most appropriately fit in this case.

In this thesis, we are interested in the consequences of alternative bargaining structures for the bargaining outcomes: their level of wages and incidence of disputes. In general, we expect alternative bargaining structures to affect a wide range of issues. For example, centralization might slow negotiations as result of larger number of people involved and the problems associated with intra-organizational bargaining (Anderson 1982); centralization limits the ranges of issues covered in bargaining; and decentralization might hamper parties' ability to adopt to technological change (Kochan 1988).

Economic theories of bargaining structures are shaped by our understanding of labor contract negotiations and strikes in a single bargaining pair (a single employer and union). Therefore, in section 1.1 of this chapter, I will first review the three main theories of contract negotiations and strikes; in section 1.2, I will review existing empirical evidences concerning bargaining structures and outcomes; section 1.3 summarizes previous theoretical studies of bargaining structures and the contribution of this essay in our understanding of bargaining structures; section 1.4 presents the organization of this thesis.

1.1 Three Main Theories of Labor Contract Negotiations and Strikes

There are basically three main theories of contract negotiations and strikes: the model of Ashenfelter and Johnson (1969); the "joint cost" hypothesis articulated by John Kennan (1980); and strategic bargaining models.

(1) *The Model of Ashenfelter and Johnson.*

Ashenfelter and Johnson explain strikes in labor contract negotiations as the result of incorrect expectations of unions members about wage increases. They assume that union leaders know the wage increases to which the management will agree, but are unable to convince rank-and-file members of this information. Therefore, the leaders may be willing to incur a strike to maintain leadership. As the strike continues, rank-and-file members lower their initial expectations and thus their wage demands, resulting a downward-sloping "resistance curve". The firm takes as given this resistance curve and maximizes the present discounted value of profits subject to this schedule.

As David Card (1989) pointed out, by focusing on the lack of information among union members, the model of Ashenfelter and Johnson lays the groundwork for later strategic bargaining models with one-sided asymmetric information. However, one difficulty with the model of Ashenfelter and Johnson is that unions' downward-sloping resistance curve is not derived from unions' rational behavior. Later developments in strategic bargaining models are able to generate such resistance curve from unions' rational behavior. In this regard, the strategic bargaining models can been seen as an improvement upon their model.

(2) *"Joint Cost" Hypothesis.*

The "joint cost" hypothesis states that, whatever mechanism generating disputes, the incidence and expected duration of a strike should be lower, the higher joint cost of a strike to the firm and its employees. This hypothesis offers an interesting perspective on the cyclicality of strike behaviors, which is the focus of much recent empirical studies. To extent that improving labor market conditions reduce the opportunity cost of a work stoppage (for example, union members are more likely to find jobs during a stoppage), it lowers incidence of a work stoppage.

(3) *Strategic Bargaining Models.*

Strategic bargaining models can be classified as strategic bargaining models with complete information or with asymmetric information, based on whether neither party, or at least one party to the bargaining possesses some private information. Strategic bargaining models with complete information (Rubinstein 1982, 1987) predict immediate settlements and potentially describe the majority of labor contract negotiations that do not involve strikes.

Over the last decade, much effort has been devoted to strategic bargaining models with asymmetric information. In these models, strikes are viewed as a mechanism that allows one party to the bargaining to extract information from the other party. These models can be classified in terms of: (1) specification of bargaining procedural rules: whether informed, uninformed or both parties are allowed to make offers; (2) nature of private information: whether firms, unions or both possess private information. Three types of strategic models with asymmetric information are: (1) attrition models (eg. Milgrom and Weber 1985, Osborne 1985), in which compromise is not allowed and the winner takes all; (2) screening models, (Hayes 1984, Fudenberg, Levine and Tirole 1985, and Hart 1989, among others), in which uninformed parties make a sequence of offers and informed parties decide whether to accept an offer or wait for a later one; (3) signaling models (Admati and Perry 1987), in which uninformed parties make an initial offer and informed parties decide whether to accept, or reject and wait some time before making a counteroffer so as to signal to the uninformed parties about the private information. A good summary of these models is available in Kennan and Wilson (1989). The most common formulation of these strategic models is to assume that some component of profitability is unobservable to unions and and unions make a sequence of wage demands (Kennan 1986). Therefore, strikes are viewed as a mechanism that allows unions to extract information from firms, thus achieving higher wages from more profitable firms.

1.2 Empirical Evidence on Bargaining Structures and Outcomes

The consequences of alternative bargaining structures have not been a topic of much empirical research. From the existing and relatively old empirical literature on alternative bargaining structures and outcomes, we can draw the following two conclusions: (1) lower wage settlements are usually found to be associated with decentralization of collective bargaining; (2) the evidence on the effects of bargaining structures on strike incidence remains inconclusive, both on the industry level and national level.

(1) *Consequences for Wage Settlements.* Hendricks (1975) found that single-firm contracts lead to higher union wages than industry-wide contracts in the United States. Metcalf (1977), in a sample of British firms, found that decentralization of bargaining structures is associated with higher wages. Thompson, Mulvey and Farbman (1977) also found that relative earnings in decentralized industries in Great Britain are higher than in centralized industries. Recently, Machin, Stewart and Reenen (1992), using establishment level data from the 1984 Workplace Industrial Relations Survey, found that plants with multi-unionism and separate bargaining pay higher wages. A common explanation offered in the industrial relation literature is that through centralization, employers expect to decrease union whipsawing and leapfrogging, and as a result to lower labor costs and standardize wages and benefits across bargaining units affected (Anderson 1982, Kochan 1988).

(2) *Consequences for Strike Incidence.* A conventional wisdom in the industry relation literature is that centralization of bargaining structure

produces greater industrial harmony and reduces strikes. As the actual number of negotiations in an industry and the economy are reduced, the potential number of strikes are also reduced. However, empirical evidence on that issue remains fairly inconclusive. On the national level, Hibbs (1976), in an international comparative study for 15 advanced industrial economies over the period 1950-69, found that mean man-days lost per 1000 workers were highest in decentralized systems characterized by firm level bargaining and lowest in highly centralized systems typified by economy-wide bargaining. However, when the analysis was extended to control for other variables that might affect strikes, such as unemployment, profits and real wages, no such relation was found. Recently, Layard , Nickel and Jackman (1991) reported working days lost per annum and the degree of centralization across OECD countries in the 1980s in Table 6 of Chapter 1, from which no relationship between strikes and centralization can be found.

On the industry level, Perry and Angle (1981) discovered that the more fragmented the bargaining structure in the transit department in a municipality, the greater the number of strikes. However, Ross (1980) found that in the construction industry for the period 1970-1977, strikes are more pronounced in provinces characterized by centralized bargaining structures.

1.3 Economic Theories of Bargaining Structures and Outcomes

Economic theories of bargaining structures are sparse. This may, in part, be due to very complex and heterogeneous nature of bargaining structures. For example, the bargaining outcomes under different structures of bargaining will likely differ, depending on both the nature of product markets and the nature of labor markets. Very few existing economic models of bargaining structures can be classified in terms of which factor they have focused on. We now examine these two factors in turn.

(1) *Nature of Labor Markets.* Horn and Wolinsky (1988) have studied a model in which one firm negotiates with two separate unions. They used the model to study two alternative bargaining structures: 1. *independent unions*, in which two unions bargain separately and independently with the firm; and (2) *colluding unions*, in which two unions cooperate to form their bargaining strategies. This bargaining structure can be observed when unions form an encompassing union. They found that the level of wages under these two structures of bargaining depend on the degree of substitutability between the members of these two unions. When the members of the two unions are close substitutes (the marginal revenue product of one union is deceasing in the quantity of the other union members), unions can achieve higher wage levels if they bargain cooperatively to avoid the "divide-and-rule" strategies that may be followed by the management; on the other hand, when the members of two unions are strong complements, unions can achieve higher wage levels if they bargain separately instead, as it is more difficult for the firm to substitute other workers in their place during a strike.

One difficulty with the model of Horn and Wolinsky (1988) is its silence on the other important outcome: the incidence of strikes. This is not surprising since their model is a Rubinstein-type bargaining model with complete information. Therefore the outcomes are always efficient and no strikes will occur.

Jun (1989) studied a similar model except he assumes that the two unions differ in terms of their productivities and sizes. He found that unions can achieve higher wage settlements under joint bargaining when the two unions are similar in their sizes or productivities, but achieve higher wage settlements under separate bargaining instead when unions differ in sizes and productivities.

(2) *Nature of Product Markets.* Product markets can either be competitive or oligopolistic. When firms compete in oligopolistic markets, Davidson (1988) studied a model with two bargaining pairs negotiating their wages and analyzed two bargaining structures: (1) *independent unions*, in which the two unions negotiate with their firms independently; (2) *colluding unions*, in which the two unions negotiate with their firms cooperatively, for example, through merger[1]. The colluding-union bargaining structure leads to higher wages for two reasons. First, if a firm agrees to pay a high wage, its competitive position in the output market will be weakened and its competitor will respond by increasing employment. This positive externality across firms (from unions' perspective) is internalized when unions cooperate. Therefore wage settlements are higher under colluding unions. Second, the cost of a strike is lower for colluding unions than independent unions. If the colluding unions strike one firm, the other firm responds by increasing production and employment. This partially offsets the unions' loss due to the strike. This reduction in strike costs enhances the colluding unions' bargaining power and leads to even higher wages. Similar to the models of Horn and Wolinsky (1988) and Jun (1989), the model of Davidson (1988) makes no prediction about the incidence of strikes.

When product markets in an industry are competitive rather than oligopolistic, unions will have greater chance of getting high wages if they cooperate (or form a single industry union) among all unions across the entire industry so as to *take wages out of competition* in the market (Kochan 1988 and Anderson 1984).

As pointed out above, economic theories of bargaining structures are shaped by our understanding of strikes and contract negotiations in a single bargaining pair. The models of bargaining structures reviewed above (the models of Horn and Wolinsky 1988 and Jun 1989 and the model of Davidson 1988) were only possible after the development of the strategic bargaining models between a single bargaining pair, with complete information (Rubinstein 1982, 1987). Following Rubinstein (1982, 1987), all these models adopt a no-cooperative approach to bargaining and make a specific assumption about bargaining procedures. Because of complete information, they predict immediate settlements and strikes never occur.

Using the second type of theories of strikes and contract negotiations --*the joint-cost hypothesis* -- these models might be modified to explain strike incidence under alternative structures of bargaining[2]. In the model of Davidson, we expect a higher strike incidence under colluding unions, to the extent that the cost of strikes for unions is lower under colluding unions than independent unions. In the model of Horn and Wolinsky, colluding unions might reduce (increase) strike incidence when the members of the two unions are close substitutes (strong complements) since the costs of a stoppage are higher (lower).

The latest development on contract negotiations and strikes -- strategic bargaining models with asymmetric information models - views strikes as a mechanism that allows one party to the bargaining (usually unions) to extract information from the other party (usually firms). This new development allows researchers (Cheung and Davidson 1991, Kuhn and Gu 1995a 1995b) to study bargaining structures from a different and often ignored perspective: via their effects on information transfer and learning among parties to bargaining. These models have the advantage of studying both the levels of wages and the incidence of strikes. This thesis continues this new approach to bargaining structures.

1.4 Thesis Organization

This thesis is divided into five chapters. Following this introduction and literature survey, in Chapter 2, we study a model of learning and information transfer among unions in contract negotiations when negotiations are sequential and independent. The model is used to address such issues as union imitative behavior in contract negotiations. Empirical evidence, based on a large sample of contract negotiations in Canadian manufacturing industry for the period 1965-1988, are also presented in this chapter. Perhaps surprisingly, they are remarkably consistent with our model.

In Chapter 3, we study four alternative bargaining structures and compare these different structures of bargaining in terms of strikes and wage settlements, via their effects on information transfer and learning among unions. In that chapter, we assume negotiations are simultaneous when at least one side to the bargaining colludes. Kuhn and Gu (1995b) studied the case when negotiations are sequential. We find that to the extent that centralization reduces information transfer and learning among unions when negotiations are simultaneous, it raises strike incidence and reduces expected wage settlements.

Chapter 4 studies information externalities and resulting delay in settlements in contract negotiations. In the model of Chapter 2, unions in later negotiations have a second-mover advantage since they have the opportunity of acquiring information by observing the outcomes of previous negotiations. Therefore, unions have an incentive to delay wage settlements and let other unions conclude negotiations first. We model this type of delay as holdouts, an important type of labor dispute often ignored in previous studies. Empirical evidence in support of our model is presented in Chapter 4.

In the final chapter, Chapter 5, a brief summary of the findings of this thesis is presented.

NOTES

[1]Analysis of other two possible bargaining structures: colluding firms and both colluding unions and firms were not carried out in Davidson (1988).

[2]How the first type of theories of strikes and negotiations -- the model of Ashenfelter and Johnson -- contributes to our understanding of bargaining structures is still an open issue.

CHAPTER 2

LEARNING AND RELATIVE REWARDS IN SEQUENTIAL CONTRACT NEGOTIATIONS

2.1 Introduction

Recently, economists' interest in two related aspects of social behavior has revived. One of these is the apparent concern of individual human beings with their relative, as well as their absolute, rewards (e.g. Rees 1993, Frank 1985). Such concerns, which appear to be particularly relevant to the wage determination process both within and across firms, have been modelled, among others, by Oswald (1979), Frank (1984), Akerlof and Yellen (1990), Bolton (1991) and Robson (1992).

Another area of recent interest concerns the modelling of imitative, conformist, or "herd" behavior as an outcome of rational learning from others (Banerjee 1992, Bikhchandani, Hirschleifer and Welch 1992). In contrast to the above models of relative rewards, which treat these phenomena by simply introducing them into agents' utility functions[1], these models endogenously generate a related kind of behavior --imitation-- from individually rational use of information. Interestingly, however, these papers tend to focus on the negative social consequences, and unstable aggregate outcomes, which can emerge from imitative behavior.

This chapter presents a simple model and some evidence which address both these developments in the literature. The model, one of sequential wage bargaining by two unions in an industry, generates an interest by workers in each other's wages which is based not on tastes for equity, but on learning their firm's ability to pay by observing the preceding set of negotiations.[2] But rather than being socially harmful, as it is in the above "information cascades" literature, learning from the actions of others is, in a number of senses, socially beneficial in the current model. This is because learning reduces the mistakes made in bargaining due to asymmetric information. Empirical evidence of such social benefits, in the form of reduced strike incidence, is prsented in chapter three from a large panel of Canadian contract negotiations.

Section 2.2 of the chapter presents a simple example which conveys the main flavor of the results, and illustrates how sequential bargaining by two union-firm pairs in an industry can be Pareto-improving. Section 2.3 presents a more general model. Section 2.4 presents the empirical evidence.

2.2 An Example

(a) A Single Bargaining Pair.

In order to examine social learning and pattern following in sequential negotiations, a model of the bargaining process in a single negotiation is required. Our criteria for such a model here are threefold: (a) In order to address the issue of unions learning about their own firm's ability to pay from other negotiations, the model must have some private information on the firm's side; (b) Since one of our goals is to assess the implications of learning from other negotiations for the incidence of disagreements, we require a model which generates some strikes in equilibrium; and (c) the model must be simple enough to be extended easily to the context of sequential negotiations between different bargaining pairs.

The simplest bargaining model with all the above features has been analysed by Fudenberg and Tirole (1983), and is illustrated in Figure 1[3]. Before negotiations begin, nature determines whether the firm is in the good or bad state. Its profits gross of labor costs are $\pi_g > \pi_b > 0$ in these two states respectively. The firm knows its own type, but the union knows only the prior probability, p, that the firm turns out to have high profits. After the firm's type is determined, the union makes a wage demand $d \in [0,\infty)$; the firm then responds by accepting or rejecting that wage demand. Acceptance means exchange takes place at the wage demanded by the union; rejection means both parties get their alternative utility levels, which are normalized to zero.

Except in the borderline case where $p = \pi_b/\pi_g \equiv b$, this simple bargaining game has a unique perfect equilibrium, which depends on the value of the union's prior, p. Specifically, if $p > b$ the union makes a "high" wage demand of $d_1 = \pi_g$; the bad-state firm rejects this demand, while the good-state firm accepts it with probability one.[4] The probability of a strike is (1-p); the union's expected payoff is $p\pi_g$; and the firm's expected profits are zero. If $p < b$, the union demands π_b which is accepted by both types of the firm. Strike incidence in this case is zero, the union's expected payoff and the settled wage are both π_b, and firms can expect to earn a profit of $p(\pi_g-\pi_b)$.

(b) Sequential Negotiations

We now consider the case of two bargaining pairs, labelled firm 1 and union 1 (bargaining pair 1) and firm 2 and union 2 (bargaining pair 2), who bargain in sequence. For simplicity, both the bargaining pairs have the same (*ex ante*) value of p, although it is common knowledge that the states of the two firms are correlated. In particular, the joint probabilities of good and bad states in the two firms are given in Table 1, where $\alpha \in [0,1]$ indicates the degree of positive correlation between the firms.

The conditional probabilities corresponding to Table 1 are:

(1) $\text{Prob } (2G|1G) = \alpha + (1-\alpha)p$

(2) $\text{Prob } (2G|1B) = (1-\alpha)p$

where 2G indicates a good state in firm 2, etc.. Finally, we assume that union 2 observes all the outcomes of bargaining between union 1 and firm 1.

In any perfect Bayesian equilibrium (PBE) of the sequential negotiations game described above, Union 1's strategy will be exactly the same as in the one-shot game above: it has no previous negotiation from which to acquire any information, and its payoffs are unaffected by any actions taken by participants in the following negotiations. Union 2's optimal bargaining strategy however now depends on what it observes in the preceding negotiation, since this affects its optimally updated prior, p_2 that firm 2 is in the good state. We now consider union 2's optimal strategies in each of the three possible outcomes of the preceding negotiation in turn, using Table 2 to summarize the results.

(1) *Union 1 pools.* When $p < b$, union 1 makes a low wage demand, π_b, which it knows firm 1 will always accept. Union 2 then clearly learns nothing from the outcome of the previous negotiations. Since the two unions share a common prior, union 2 will thus always pool (demand π_b) as well. No strikes occur in either negotiation. This is illustrated in region I of Table 2.

(2) *Union 1 separates, strike ensues.* When p>b, union 1 adopts a "separating" strategy, i.e. makes a high wage demand of π_g. If firm 1 rejects this demand, it must be in the bad state. Union 2's updated prior that firm 2 is in the good state is then $p_2 = (1-\alpha)p < p$; its optimal strategy is of course simply to pool iff $p_2 < b$. In terms of *union 1's* prior, p, this amounts to:

$$(3) \qquad \text{Union 2 separates iff:} \quad p > \frac{b}{(1-\alpha)}$$

In region III of Table 2, union 2 thus continues to demand a "high" initial wage despite the preceding strike. In region II however, the new information conveyed by the strike in firm 1 causes union 2 to revise its initial wage demand downwards, and adopt a no-strike pooling strategy instead.[5]

(3) *Union 1 separates, no strike ensues.* Now the fact that firm 1 accepts union 1's high wage demand means it is in the good state. Union 2's updated prior, p_2, that firm 1 is in the good state is now $p_2 = \alpha + (1-\alpha)p > p$. In terms of *union 1's* prior, its optimal strategy can thus be written:

$$(4) \qquad \text{Union 2 separates iff:} \quad p > \frac{b - \alpha}{1 - \alpha}$$

Because the right hand side of (4) is less than b, union 2 will now separate throughout all of regions II and III of Table 2.

In summary, union 2's optimal bargaining strategy can be described as follows. When p<b, union 2 can learn nothing from the outcome of the preceding negotiation, and does not condition its behavior on what happens there. When $p > b/(1-\alpha)$, the outcome of the first negotiation is informative, but union 2 is so optimistic (or the firms' states are so weakly correlated) that union 2 does not change its behavior because of it. But whenever $b < p < \alpha/(1-\alpha)$ it is optimal for union 2 to condition its behaviour on union 1 in the following sense: Whenever union 1 succeeds with a high wage demand (i.e. this demand is accepted without a strike), union 2 should demand the same wage that union 1 received. Whenever union 1 "fails" with its high wage demand, union 2 makes a low demand. Put another way, union 2 adopts a "tougher" bargaining stance (making a high wage demand) when union 1 succeeds with a high wage demand than when it does not.

Other results that follow quite directly from Table 2 are as follows. First, union 2's wage demand and wage settlement (conditional on a settlement occurring) will on average be lower when there is a strike in the previous negotiations, than when there is no strike. Second, unlike wage demands, a strike in the previous negotiation has an ambiguous effect on the probability of observing a strike in the second negotiations. Such a strike causes union 2 to moderate its wage demands, which tends to reduce strikes; at the same time it implies a greater likelihood that firm 2 is in the bad state, tending to increase strikes.

Finally, is learning from others socially harmful or beneficial in this model? A simple way to answer this question is to compare outcomes for union 1 (which has no previous negotiations to learn from) to those in union 2. Interpreted this way, Table 2 indicates that the opportunity to learn from others raises union utility and reduces strikes. Intuitively, this follows from the fact that union 2 possesses better information than union 1. More surprisingly, learning from others also *reduces* the union's wage demands, and --except in the polar case of perfect correlation (α=1) where it has no effect-- also reduces the expected wage settlement and *raises* expected profits of the firm. Thus learning from others is *always* Pareto-improving in this simple example. While --as we shall see-- this very strong result does not carry over to the more general model analysed below, it does, however, illustrate in a very simple way how learning by uninformed parties can have beneficial effects for informed actors in models of this kind.

2.3 A Model

Single-stage bargaining models such as the one used in the previous section have been criticized because, by allowing one party to make a single, take-it-or-leave-it offer, they may give that party an unrealistic amount of commitment. For that reason, and also to explore the consequences of a continuum of potential states for the firm, we examine sequential union-firm negotiations using an infinite-horizon, continuum-of-states bargaining model in this section.

(a) *A Single Bargaining Pair.*

The bargaining game between firm 1 and union 1 is now an infinite-horizon one, the first two stages of which are illustrated in Figure 2. This model has been analysed by Fudenberg, Levine and Tirole (1985) and Fudenberg and Tirole (1991), among others. Briefly, Nature moves first by choosing a realization of the firm's (gross) profits $\pi \in [\underline{\pi}, \bar{\pi}]$ from the cdf $F(\pi)$, where $0 < \underline{\pi} < \bar{\pi}$. Both the firm and union know the distribution F but only the firm observes this realization. Next, in stage 1 of the bargaining game, the union makes a wage demand d_1, which the firm either accepts or rejects. If the firm accepts, the game ends and exchange takes place at the wage d_1, with payoffs $\pi - d_1$ and d_1 to the firm and union respectively. If the firm refuses, some time elapses, after which the union makes its second wage demand d_2. Acceptance of this by the firm means exchange takes place at the wage d_2, with payoffs $r(\pi - d_2)$ and rd_2 to the firm and union respectively, where $r \in (0,1)$ is the common discount factor of the firm and union.[6] Refusal of d_2 by the firm moves the game to a third stage, and so on (potentially) *ad infinitum*. Both parties' payoffs are zero if no agreement is reached in finite time.

Proposition 1 (Fudenberg, Levine and Tirole (1985); Fudenberg and Tirole (1991)). The above infinite-horizon bargaining game has (generically) unique perfect Bayesian equilibrium. The PBE displays the following properties:

(a) There exists N such that with probability 1 and offer by the union is accepted in or before period N;

(b) (*Skimming property*) In the PBE, higher-profit (π) firms accept earlier union offers than lower-profit firms.

(c) (*Monotonicity of wage demands*) The equilibrium exhibits a decreasing sequence of wage demands until one wage demand is accepted.

Since our objective here is to analyse learning from the outcomes of previous negotiations, we shall focus henceforth only on the (more likely) case in which such outcomes are informative, i.e. where the union's initial wage demand, d_1, is not always accepted. In that case, Proposition 1 implies that the union makes a sequence of wage demands, $d_1 > d_2 > \dots > d_N$, $(N>1)$. Letting z_{n+1} be the lowest profit level of the firm which accepts the wage demand d_n, the boundaries of these intervals are given by:

(5) $\bar{\pi} = z_1 > z_2 > z_3 > \dots > z_N > z_{N+1} = \underline{\pi}$

Thus z_1, z_2, ..., z_{N+1} partitions the set of the possible profit level for the firm into N subintervals. If the firm's profit is between z_{n+1} and z_n, it accepts the wage demand d_n in period n, corresponding to a delay, or strike length of n-1 periods[7].

Now we will proceed to compute the sequence of demands d_1, d_2, ...,.d_N and the cutoff profit levels z_1, z_2, ..., z_{N+1} in the unique equilibrium from differential equations. The differential equations are derived from the first order condition for the union's maximization problem in choosing the optimal wage demands.

If the firm has rejected the first n-1 wage demands d_1, d_2, ..., d_{n-1} (n=2, 3, 4, ...,.N), and thus the game proceeds to period n, the union believes that the firm's profit is less than or equal to z_n. This is so because the firm would have accepted one of these first n-1 wage demands if its profit were greater than z_n. Assume that in period n the union demands d and the firm accepts the demand if and only if its profit is greater than $\beta(d)$. The union chooses a wage demand d to maximize its expected payoff,

(6) $$V_n(z_n) = \max_d \, (F(z_n) - F(\beta(d))d + rV_{n+1}(\beta(d)),$$

subject to: $\beta(d) = \{d - r\,\sigma_{n+1}(\beta(d))\} / (1 - r)$,

where $V_{n+1}(z)$ is the union's maximal payoff in period n+1, and $\sigma_{n+1}(z)$ denotes union's optimal wage demand in period n+1 when the firm's profit is less than or equal to z. $\beta(d)$ is the profit level of the firm who is indifferent between accepting the wage demand d and accepting $\sigma_{n+1}(\beta(d))$ next period.

Differentiating $V_n(z_n)$ with respect to z_n and using the envelope theorem, we find that

(7) $$\partial V_n(z_n)/\partial z_n = f(z_n)\sigma_n(z_n),$$

where $\sigma_n(z_n)$ denote the unique solution to the union maximization problem (6). $\sigma_n(\cdot)$ is an inceasing function, and is the solution to the following first order condition,

(8) $$F(z_n) - F(\beta(d)) - f(\beta(d))\beta'(d)(d-r\sigma_{n+1}(\beta(d))) = 0$$

(Note $\partial V_{n+1}(\beta(d))/\partial\beta(d) = f(\beta(d))\sigma_{n+1}(\beta(d))$ from the envelope theorem).

Differentiating the constraint in the maximization problem (6) with respect to d, we find the derivative $\beta'(d)$ in the first order condition (8),

(9) $$\beta'(d) = \frac{1}{1 - r + r\sigma'_{n+1}(\beta(d))}.$$

In case the second order condition is also satisfied, the differential equations (8) and (9) uniquely characterize the equilibribrium of the game.

Proposition 2. a. In the unique perfect Bayesian equilirium of the infinite horizon, continuum of states bargaining game, the sequence of wage demands $d_1, d_2, \ldots, d_N$ and the cutoff profit levels $z_1, z_2, \ldots, z_{N+1}$ must satisfy the following two conditions:

(10) $d_n = (1-r)z_{n+1} + rd_n$, n = 1, 2, ..., N-1, and $d_n = \underline{\pi}$ if n = N+1;

(11) $$F(z_n) - F(z_{n+1}) - f(z_{n+1}) \frac{1}{1 - r + r\sigma'_{n+1}(z_{n+1})} (d_n - rd_{n+1}) = 0,$$

n = 1, 2, ..., N-1.

b. The optimal wage demand $\sigma_{n+1}(\cdot)$ in period n+1 satisfies,

(12) $$F(z_n) - F(x) - f(x) \frac{1-r}{1 - r + r\sigma'_{n+1}(x)} x \le 0 \text{ , for } x \ge z_{n+1}, \quad n = 1,$$

2, ...N-1. It takes strict inequaility when $x > z_{n+1}$.

A noteworthy feature of the PBE is that, except for the last period (N), $d_n < z_{n+1}$. In words, the minimum-profit firm which accepts the union's wage demand in each period has a profit strictly greater than that wage demand. This follows directly from Equation (10) in Proposition 2.

Proof. a. From the requirement of a perfect Bayesian equilibrium, the marginal firm with profit z_{n+1} is just indiffeent between accepting the demand d_n in period n and accepting d_{n+1} next period. Thus we have,

$$z_{n+1} - d_n = r(z_{n+1} - d_{n+1}), \text{ or } d_n = (1-r)z_{n+1} + rd_n.$$

Substituting (9) into (8), we have,

(13) $$F(z_n) - F(\beta(d)) - f(\beta(d)) \frac{1}{1 - r + r\sigma'_{n+1}(\beta(d))} (d - r\sigma_{n+1}(\beta(d))) = 0$$

The solution to the above equation is the union's wage demand d_n in period n. Futhermore, from the definition of z_{n+1} and d_{n+1} we have $z_{n+1} = \beta(d_n)$ and $d_{n+1} = \sigma_{n+1}(\beta(d_n))$. Subsituting these notations into Equation (13), we have Equation (11).

b. Letting x denote $\beta(d)$, (12) directly follows from the second order condition to the maximization problem (6). ■

(b) Sequential Negotiations.

We now introduce a second union-firm bargaining pair, which begins its negotiations after the first pair have concluded their negotiations. As in the preceding example, we assume that this second pair is *ex ante* identical to the first, (e.g. with the same prior distribution of gross profits, $F(\pi)$). For simplicity, we restrict attention to the case where the states of the two firms are perfectly correlated; thus firm 2's realized profits are just the same as firm 1's.[8]

After the completion of bargaining between union and firm 1, union 2 now observes the wage demand which was ultimately accepted by firm 1, and the amount of delay, or strike length after which that settlement was reached. From a previous wage settlement of d_n, union 2 should therefore infer that the gross profits of both firm 1 and 2 must lie in the interval $[z_{n+1}, z_n]$, with a cumulative distribution function of $G^n(\pi) = [F(\pi)-F(z_{n+1})]/[F(z_n)-F(z_{n+1})]$.

Proposition 3. When union 2's posterior is that firm 2's profit lies in the interval $[z_{n+1}, z_n]$, $n = 1, 2, \ldots, N$, it demands z_{n+1} and firm 2 always accepts. Thus the bargaining game ends immdiately without a strike.

Proof. Suppose, to the contrary, the game ends in two periods. In period 2, union demands z_{n+1}, which the firm always accepts. In period 1, union 2 chooses a wage demand d to maximize its (unconditional) expected payoff,

$$\text{(14)}\qquad \text{Max } V = (F(z_n) - F(\beta(d))d + rF(\beta(d))z_{n+1},$$

$$\text{subject to: } \beta(d) = (d - rz_{n+1})/(1-r), \quad \text{and}$$

$$z_{n+1} \le d \le z_n.$$

where $\beta(d)$ is the profit level of firm 2 who is just indifferent between accepting the demand d and accepting the demand z_{n+1} next period.

Differenting V in (14) with respect to d, we have

$$\text{(15)}\qquad \partial V/\partial d = F(z_n) - F(\beta(d)) - \frac{1}{1-r} f(\beta(d))\,(d - rz_{n+1})$$

$$= F(z_n) - F(\beta(d)) - f(\beta(d))\,\beta(d).$$

Letting x denote $\beta(d)$, we have,

$$\text{(16)}\qquad \partial V/\partial d = F(z_n) - F(x) - f(x)\,x$$

$$< F(z_n) - F(x) - f(x) \frac{1-r}{1- r + r\sigma'_{n+1}(x)}\, x$$

$$\le 0, \text{ when } x \ge z_{n+1}.$$

where the first inequality follows from the fact that $\sigma'_{n+1} > 0$, and the second inequality follows directly from proposition 2.

In (16), $x \geq z_{n+1}$ if and only if $d \geq z_{n+1}$, since $x = (d - rz_{n+1})/(1-r)$.

Since $\partial V/\partial d < 0$ for $d \geq z_{n+1}$, the solution to the union's maximization problem (14) is z_{n+1}. Therefore union 2 demands z_{n+1} in the first period, and the firms accepts immdeiately. The game ends in one period.

Similarly, we can prove that the game will not last more than two periods. Thus we have the proof. ■

Corollary 1: (*"leapfrogging and imitating"*) Except when the firms' profits are in lowest interval $[\underline{\pi}, z_N]$, union 2's wage demand will strictly exceed union 1's wage settlement; when the firms' profits lie in the interval $[\underline{\pi}, z_N]$, union 2 imitates union 1 by demanding the wage settlement $\underline{\pi}$ achieved in union 1.

Proof. When the firms' profits are in the interval $[z_{n+1}, z_n]$, n = 1, 2, ...,. N, union 1's wage settlement is d_n, and union 2 demands z_{n+1} ,which is greater than d_n. When the firms' profits are in $[z_{N+1}, z_N]$, both unions demand $z_{N+1} (= \underline{\pi})$.

Propositions 1 to 3 allow us to establish three main results in this section, all of which are potentially amenable to empirical testing with available data.

Proposition 4. Both wage settlments and wage demands in the second set of negotiation are decreasing functions of strike length in the first set of negotiation and increasing functions of wage settlements in the first set of negotiations.

Proof. This follows directly from Proposition 3. ■

Proposition 5. The strike incidence in the second set of negotiation is lower than in the first.

Learning by the union in the second bargaining pair reduces costly strikes. In fact, in the present model where the two firms' profits are perfectly correlated, the union in round two negotiations will never make a wage demand not acceptable to its firm. Strikes never occur in round two. In general, when the firms' profits are positively (but not perfectly) correlated, we expect that the opportunity of learning will lead to a lower strike incidence in later negotiations. This conjecture has been confirmed in Gu and Kuhn (1994a) in an infinite horizon, two states bargaining model. Unfortunately, we are unable to work out the analysis in an infinite horizon, continuum of states bargaining model.

Proposition 6. Except when the firms' profits are in the lowest interval $[\underline{\pi}, z_N]$, where wage settlments are the same in both negotiations, wage settlements in the second set of negotiation are higher than in the first.

Proof. This follows directly from Corollary 1. ■

Finally, is learning always pareto-improveing as in the example of section 1.1? From Propositions 5 and 6, learning reduces costly strikes and raises wage settlements, which leads to higher union utility. However, firm's utility in the second set of negotiation can go either way. Intuitively, lower strike incidence in the second negotiation is beneficial to the firm, but a higher wage settlements in that negotiation reduces the firm's utility. Depending on which factor is dominant, the firm's utility in the second set of negotiation can either increase or decrease. Therefore, unlike in the simple example of the previous section, learning will not always raise both unions and firms' uitlity.

In sum, comparing the current, more general model with the preceding example reveals some results which are robust to model specification and others which are not. Less robust results are those concerning the effects of social learning on wage levels: these appear to be negative in the example, and positive in the model (as is clearly illustrated by our "leapfrogging" result). Clearly, this difference results from two main factors: (a) the artificial nature of the two-state example, which leaves no room for leapfrogging above the "high" wage demand, π_g, but also (b) the simplifying assumption of perfect correlation in the model, which also tends to raise wage demands. We conjecture that a version of our model which allowed for imperfect correlation would produce ambiguous results for the effect of learning on wage levels, implying an absence of strong predictions of the current class of models for wages and profit levels of firms.

Some more robust results of our analysis here are those concerning the effects of wage settlements and strike lengths in the preceding negotiations on wage demands and settlements in the current negotiation: both the example and model strongly predict that longer strikes and lower wage settlements in the preceding negotiation reduce wage demands and settlements in the current negotiation. Another robust result is that concerning strike incidence, which should always be lower among followers than leaders. This latter prediction is assessed empirically in the next section.

2.4 Empirical Evidence

To investigate the consequences of social learning on the part of unions, we use the large sample of contract negotiations in Canada. The sample contains the data on major contract negotiations, involving 500 workers or more, in the manufacturing industry from 1964 to 1988. The summary statistics for each of the SIC (Standardized Industrial Classification) two digit and three digit manufacturing industries are given in tables 3 and 4.

In the empirical study we will focus our attention on the relation between the learning and strike incidence: by observing the contract negotiations in the relevant firms and gaining information about the firm's willingness to pay, unions reduce costly strikes due to asymmetric information. Two questions arise: what are the relevant negotiations? What measures best represent the amount of information gleaned by a union's observing the negotiations of the others, when it engages in a contract negotiation with a firm? Answers to both questions rest upon emperical investigation. In what follows We will try different model specifications and different measures of the information gleaned by a union. It turns out that our results are robust to the various model specifiactions.

In this study, two categories are used to define the set of relevant negotiations for a particular contract negotiation. In the first category, the relevant negotations are those in the same SIC two digit manufactions industry in the recent past. In the second category, the relevant negotiations are those in the same SIC three digit manufacturing industry in the recent past. As far as the measure of the information gleaned by a union is concerned, two types are used. The first is the number of relevant negotiations started in a given period of time before the current negotiation; and the second is the number of the negotiations concluded (or equivalently, the number of settlements) before the current negotiation concludes or a strike starts if the current negotiation involves a strike.

The emperical model of strike incidence estimated is the probit model and takes the following form,

(17) $$S_i^* = \alpha_o + \sum_{l=1}^{m} \alpha_l z_{-l} + \beta' X_i + \varepsilon_i ;$$

$$S_i = 1 \text{ if } S_i^* \leq 0, \quad S_i = 1 \text{ if } S_i^* > 0.$$

Where $S_i = 1$ if a strike occurred and 0 if otherwise and the error term ϵ_i has a normal distribution with mean zero and variance one. z_{-1}, $z_{-2}, \ldots,$ z_{-m} measure the amount of information gained by a union from observing the negotiations of the others. As explained above, two categories of the measure are used. In the first category, the variables z_{-1}, $z_{-2}, \ldots,$ z_{-m} are the number of negotiations started during the earlier periods 1, 2, ..., and m in the same two digit or three digit SIC manufacturing industry, before the current negotiation starts. In the second category, they are the number of negotiations concluded (or equivalently number of settlements) in the earlier periods 1, 2, ..., m in the same two digit or three digit manufacturing industry, before the current negotiation concludes or a strike starts if the negotiation involves a strike.

In the regression equation (17), X are the other explanatory variables included in the model of strike incidence. They are the monthly index of industrial production, the logarithm of the number of workers in the bargaining unit, the duration of the contract being negotiated, cubic in time, month dummies and dummies for different regions and industries.

The monthly index of industrial production (deseasonalized and detrended) captures the well - known cyclical behavior of strike incidence (see, for instance, Harrison and Stewart (1989), Vroman (1989)). The cyclical variable was constructed as the residuals from a regression of a 12-month moving average of the logarithm of the index of industrial production on a cubic spline in time, see Harrison and Stewart (1989) for details.

The size of a bargaining unit and the duration of the contract being negotiated might influence the strike incidence: both unions and firms are less willing to concede when the bargaining unit is larger and the contract duration is longer, since they both have more at stake.

A cubic in time is included in the estimation to allow for the possibility of a trend in strike incidence. Time is measured as the number of months elapsed since January 1965 at the expiry date of the old contract, divided by 100. Industry dummies and region dummies capture the industry and region fixed effects that might exist, while dummies for the month in which a settlement was reached are included to allow for possible seasonality of strikes.

Tables 5 and 6 reports regression results from the estimation of the probit model of the strike incidence when the relevant negotiations are those in the same two digit industry when a union engages in a contract negotiations with its firm. In table 5, the amount of information gleaned by a union's observing the negotiations of the others are summarized by the number of negotiations concluded in a given period of time before the current negotiation concludes. Each column in table 5 represents different specification of the model of the strike incidence. For instance, in column 1, the number of settlements in each of the past six quarters are all included. In all columns, the coefficients of the variable $z_{-1.1}$: the number of the negotiations concluded in the past month prior to a negotiation: are negative and significant. It shows that the more settlements a union observes in the past month, the lower is the probability that a costly strike occurs in its negotiation. The majority of the coefficients of the variables $z_{-1.2}$, $z_{-1.3}$ $z_{-2},\ldots,z_{-6}$ are negative but insignificant. Thus the settlements one month before a negotiation hardly have any effect on the negotiation as far as the strike incidence is concerned.

In table 6, the amount of information gleaned by observing the negotiations of the others are represented by the number of negotiations started in different periods of time before a negotiation starts. Similar to table 5, the coefficients of the variable z_{-1} are all negative, however the majority of them are only weakly significant. The majority of the coefficients of the variables z_{-2}, $z_{-3},\ldots,z_{-6}$ are negative but insignificant. Therefore, there is evidence that, like the settlements in the past month in the same two digit industry, the negotiations in the past quarter in the same two digit industry reduces the probability of a strike in a negotiation, while those beyond one quarter has very little impact on the strike incidence of a negotiation.

Tables 7 and 8 present the results from the estimation of the probit model of strike incidence when the relevant negotiations are those in the same three digit industry when a union engages in a contract negotiation. In table 7, the number of the settlements in different periods of time in the same three digit industry prior to a negotiation is included in the strike incidence equation. In table 8, the number of negotiations in the same three digit industry during different periods of time prior to a negotiation is included. The coefficients of the variable $z_{-1.1}$ in all columns of table 7 are negative and significant. It suggests that the settlements in the past one month in the same three digit industry lower the strike probability of a negotiation. Compared with those in table 5, the coefficients of $z_{-1.1}$ are larger in magnitude. Therefore the settlements in the same three digit industry, thus closer to the current negotiation, has bigger effects that those in the same two digit industry. In the same table 7, majority of the coefficients of the variables $z_{-1.2}$, $z_{-1.3}$ z_{-2}, ..., z_{-6} are negative and many are weekly significant. Therefore the settlements beyond one month has some effects on the current negotiation: reduces the strike incidence, but their effects are not as significant as the effects of the settlements in the past one month.

In table 8, the coefficients of the variable z_{-1}: the number of negotiations in the past quarter, are negative, and five out of six are significant with the rest being weekly significant. Compared with those in table 6, they are larger in magnitude. It shows the negotiations in the same three digit industry has larger effects on the current negotiation than those in the same two digit industry. The majority of the coefficients of the variables z_{-2}, ..., z_{-6} are negative but the majority of then are only weekly significant[9].

Tables 5, 6, 7, 8 together support the prediction from the model: by observing the negotiations started or settled in the recent past, unions learn about the firm's willingness to pay and reduce the costly strikes due to asymmetric information. The main empirical findings from tables 6, 7, 8, 9 are: 1). Only the settlements and negotiations in the recent past (one month in the case of settlements and one quarter in the case of negotiations) have effects on the current negotiation and reduce the probability of a strike. The settlements and negotiations distant from a negotiation have very little, if at all, effects. This is because unions learn more from the negotiations and settlements not very far in the past, and it is unlikely that unions can learn from those negotiations and settlements far in the past; 2). The settlements and the negotiations in the same three digit industry: thus closer to a negotiation, have larger and more significant effects on the probability of a strike in the negotiation than those in the same two digit industry. This is not surprising, since unions learn more from observing the negotiations in the firms closer to their own; 3). The settlements in the recent past have more significant effects on the probability of a strike in a negotiation than the negotiations.

Tables 5, 6, 7, 8 also report some other results, regarding the determinants of a strike in contract negotiations. In all tables, the coefficients of the index of industrial production are positive and but only weakly significant, suggesting some existence of the well-documented procyclical behavior of strike incidence. Tables 5, 6, 7, 8 also shows that the strike incidence is significantly higher in larger bargaining units and in the negotiations of contracts with longer durations.

To discern whether the negotiations within the same union or same region have a different effect on the strike incidence than those within a different union or different region, we have estimated the probit model by disaggregating the number of settlements z_{-i} into those within the same union vs. a different union and those within the same region vs. different region. The results are reported in Tables 9 and 10 for the two-digit industry sample. The results for the three-digit industry sample are reported in Tables 11 and 12. In the two digit industry sample (Tables 9 and 10), we didn't find that the negotiations with the same union vs. a different union or the same region vs. different region have a different impact on the strike incidence. In the three digit industry sample (Tables 11 and 12), the negotiations within the same union in the past one quarter (with a coefficient -.0077 in column 1 of Table 11) has a lower negative effect on the strike incidence than within a different union (with a coefficient -.0306 in column 1 of Table 12). This is consistent with the notion that negotiations within a different union reveal more information since negotiations within a same union may have already shared their information. Table 12 shows that the negotiations within the same region in the past quarter (with a coefficient -.0504 in column 1) have a larger negative effect on strike incidence than within a different region (with a coefficient -.0056 in column 1). This might be due to the fact that the negotiations within the same region are closer and more relevant to the current negotiation and thus reveal more information.

2.5 Summary and Extensions

Some recent models of imitation and social learning (e.g. Banerjee 1992;

Bikhchandani, Hirschleifer and Welch 1992) have emphasized the negative social consequences and potentially unstable aggregate outcomes that can arise when such learning is possible. A similar emphasis often pervades models and discussions of the effects of workers' concerns with other workers' wages.[10] In contrast, the current paper offers a model of sequential wage bargaining in which the ability to learn by observing the outcomes of previous negotiations has positive social effects. These positive effects arise from a reduction in disagreements among parties who bargain later, due to more precise information about their partner's ability to pay. Empirical evidence of such positive information spillovers is provided from a sample of Canadian union contract data. Overall, we feel our results suggest: (a) that the social learning literature might profit by recognizing and exploring potential benefits of such learning, due to mitigation of pre-existing asymmetric information problems in markets, and (b) that a number of more traditional areas of applied research, such as the analysis of union wage spillovers and strikes undertaken here, could benefit considerably by adopting a "learning" perspective.

Of course, the analysis of learning in sequential wage negotiations in this paper could be profitably extended in many directions, both theoretical and empirical. One is to examine the theoretical consequences of other bargaining models, including alternating offer models, and models with private information on both sides of the market, for the results here. Another is to consider more than two sequential negotiations. Yet another is to consider alternative industry bargaining structures, which (for example) allow the two unions to (merge or) co-operate with each other, or the two firms to do the same, as often occurs in some industries (e.g. the well-known case of the

United Auto Workers, who bargain in sequence with a series of firms (Budd, 1990). Can a learning model of sequential negotiations explain the observed covariation between bargaining structures and bargaining outcomes across industries and/or countries? We consider these questions in a companion paper (Kuhn and Gu, 1994).

Closely related to bargaining structure is the issue of timing of negotiations: Since there are clear first-mover *dis*advantages for both unions and firms in these models, which party will go first in a world where timing of negotiations is endogenous? In the case of co-operating unions, mechanisms clearly exist (such as a rotating arrangement, or a common strike fund) to even out these disadvantages over time, but what kind of "waiting game" is likely to ensue in their absence? As well, given that information revealed by negotiations likely depreciates over time, it seems likely that industry "bargaining rounds" will emerge endogenously in the current set of models, as they do in Fethke and Policano (1989). These models of timing are likely to be particularly interesting in a setting which, unlike the current one, allowed for some *ex ante* heterogeneity among the firms and unions, for example in size (are larger or smaller bargaining units likely to go first?) or in the distribution of profits (will unions target more, or less-profitable firms first?).

Another set of extensions would expand the information structure of the problem. For example, one could consider giving each of the two unions some information about a common industry shock that is unavailable to the other union. This would allow union 2 to acquire useful information from union 1's wage *demand* as well as from firm 1's response to that demand. Yet another kind of asymmetric information concerns α, the degree of correlation among the firms. In particular, workers' inability to directly observe α might explain some recent long and bitter strikes (e.g. the recent Caterpillar strike in the U.S.) in which historical patterns are broken because the degree of correlation between two industries' or firms' fortunes has been permanently altered.

In order to focus on the effects of information spillovers, this paper has abstracted completely from any possible direct product- or labor-market interactions between firms. Since these are also likely to have interesting effects on negotiation patterns over time, as well as on the optimality of co-operation among firms and unions (Horn and Wolinsky 1988, Jun 1989), their effects in the current model may also be worth exploring.

Finally, it might be interesting to explore the implications of the current model for *which* groups of workers a given union should optimally choose as its "reference group" (presumably those whose wages are most highly correlated with relevant information that is *not* publicly available), and ask whether the actual reference groups used by unions in sequential bargaining correspond to those predicted by learning models.

NOTES

[1]One exception, which endogenously generates a concern with relative status, is Cole, Mailath and Postlewaite (1992).

[2]Burgess (1988) and Fethke and Policano (1990) both model learning from other firms' wages, but not in a bargaining/strikes framework such as that used here. Perhaps somewhat surprisingly, the now-voluminous theoretical literature on noncooperative bargaining has, to date, paid very little attention to the issue of learning in sequential sets of negotiations.

[3]Both the bargaining models in this paper are variants of what Kennan and Wilson (1989) term "screening" models, in which strikes can be seen as a form of price discrimination by unions. Thus we do not, for example, consider signalling models such as Admati and Perry (1987) or Cramton (1988). Further, within the class of screening models, we restrict our attention to models which assume commitment to wage offers only within each stage of the bargaining process. This effectively excludes models cast in the mechanism design framework (e.g Hayes 1984, Card 1990). We also abstract from the issue of holdouts, analysed recently by Cramton and Tracy 1992).

[4]Of course good-state firms are indifferent between accepting and rejecting π_g in this equilibrium. Any equilibrium in which they reject π_g with positive probability however is ruled out by the union's ability to "shade" its wage demand slightly below π_g and thus guarantee acceptance by "good" firms.

[5]Note that the size of region II varies in an intuitive way with the degree of correlation (α) between the two firms: As α, approaches zero, $b/(1-\alpha)$ approaches b, reducing the interval to zero: outcomes of the preceding negotiations are uninformative. On the other hand, whenever α exceeds 1-b, region II coincides with the entire interval $p \in [b, 1]$.

[6]Setting r strictly less than 1 implicitly imposes a finite delay between offers. There appears to be some disagreement in the literature regarding whether observed strike lengths are consistent with "reasonable" periods of delay between offers. Recent calculations by Kennan and Wilson (1989, p. S110) however suggest that they may be.

[7]If the firm accepts the union's wage demand d_1 in the first period, no strike occures and the strike length is zero.

[8]Some insight into the case of imperfect, but positive correlation can be had by assuming the distributions of the two firms' profits are linked via the well-known monotone likelihood ratio property (Milgrom 1982). Unfortunately however this property alone does not adequately summarize the effects of learning from previous negotiations, which also increases the *precision* with which union 2 knows its firm's profitability. Using an infinite horizon, two states bargaining model, Kuhn and Gu (1994) have studied the effects of learning by unions when firms' profits are imperfectly correlated.

[9]We have also estimated the probit models in Tables 5, 6, 7, 8 by including $z_{-1.1}$ only, and $z_{-1.1}$ and $z_{-1.2}$. The results are very similar to the other specifications in those tables.

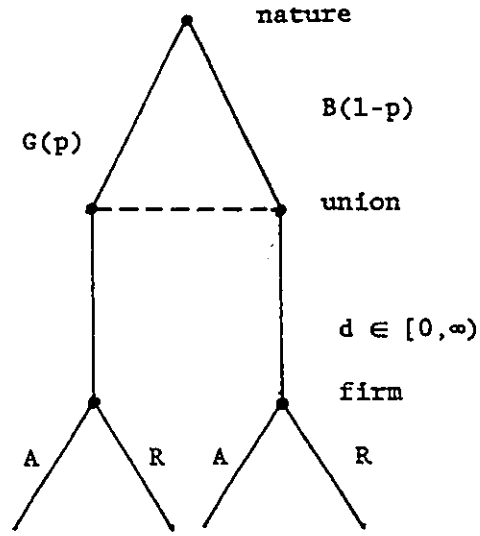
[10]The following quotes from widely-cited industrial relations and personnel management texts give the general flavor of these concerns:

"...wage increases negotiated by one union may become a target to be exceeded by a second or third union, which in turn may require adjustment in the first settlement, in a cycle of more expensive negotiations.... These pathological bargaining structures are themselves a major contributing to wage inflation." (Bok and Dunlop 1970, p. 291)

"There is no single factor in the whole field of labor relations that does more to break down morale, create individual dissatisfaction, encourage absenteeism, increase labor turnover and hamper production than obviously unjust inequalities in the wage rates paid to different individuals in the same labor group within the same plant." (Kochan and Barocci 1985, p. 249)

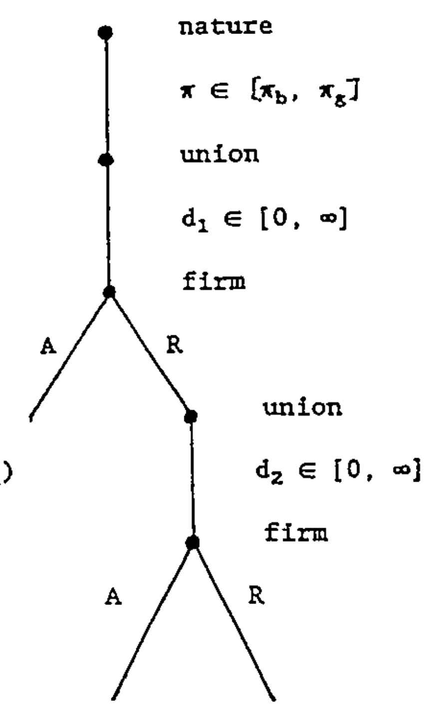
For a model-based discussion of the detrimental effects of workers' concerns with wage relativities, see for example Bhaskar (1990).

FIGURE 1: **The One-Shot Bargaining Game: One Stage**



Payoffs (Union, firm): $(d, \pi_g\text{-}d)$ (0,0) $(d, \pi_b\text{-}d)$ (0,0)

FIGURE 2: **The One-Shot Bargaining Game: Infinite Horizon**



Payoffs (Union, firm): $(d_1, \pi\text{-}d_1)$

$(rd_2, r[\pi - d_2])$

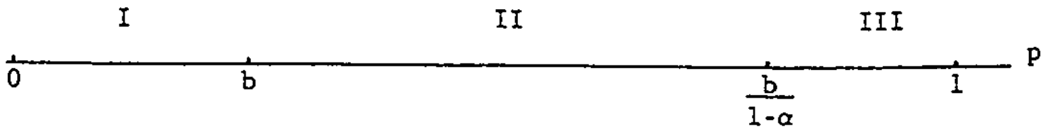
bargaining continues (d_3, etc.)

TABLE 1

Joint Probabilities of "Good" and "Bad" States at Firms 1 and 2

Firm 1's State:	Firm 2's State: Good	Firm 2's State: Bad	
Good	$\alpha p + (1-\alpha)p^2$	$(1-\alpha)p(1-p)$	p
Bad	$(1-\alpha)p(1-p)$	$\alpha(1-p) + (1-\alpha)(1-p)^2$	(1-p)
	p	(1-p)	1

TABLE 2: SEQUENTIAL BARGAINING OUTCOMES, TWO-STATE EXAMPLE



(a) Wage demands and acceptance decisions

	I	II	III
Union 1	demand π_b	demand π_g	demand π_g
Firm 1, good state	accept π_b	accept π_g	accept π_g
Firm 1, bad state	accept π_b	reject π_g	reject π_g
Union 2	demand π_b	demand π_g if firm 1 accepts demand π_b if firm 1 rejects	demand π_g
Firm 2, good state	accept π_b	accept π_g, accept π_b	accept π_g
Firm 2, bad state	accept π_b	reject π_g, accept π_b	accept π_g

(b) Other Outcomes

	I	II	III
Pair 1:			
Strike Probability	0	(1-p)	(1-p)
E(Wage Settlement)*	π_b	π_g	π_g
E(Profits)	$p(\pi_g - \pi_b)$	0	0
E(Utility)	π_b	$p\pi_g$	$p\pi_g$
Pair 2:			
Strike Probability	0	$(1-\alpha)p(1-p)$	(1-p)
E(Wage Settlement)*	π_b	$\{[\alpha p+(1-\alpha)p^2]\pi_g+[1-p]\pi_b\}/\{[\alpha p+(1-\alpha)p^2]+[1-p]\}$	π_g
E(Profits)	$p(\pi_g - \pi_b)$	$(1-p)(1-\alpha)p(\pi_g-\pi_b)$	0
E(Utility)	π_b	$p[\alpha+(1-\alpha)p]\pi_g + (1-p)\pi_b$	$p\pi_g$

* conditional on a settlement occurring

Table 3 - Summary Statistics: Two Digit Manufacturing Industries

Industry[a]	First settlement	Last Settlement	Number of Obs.	Number of Strikes	Average Unit Size[b]	Average Duration[c]
1	64/07/01	88/12/05	391	55	1071	25.5
2	65/05/01	88/08/20	48	2	905	23.9
3	64/12/01	87/08/09	84	21	868	34.6
4	64/02/01	88/10/11	36	4	771	28.3
5	64/10/01	88/09/26	147	31	904	27.9
6	66/11/03	75/06/16	8	0	595	32.3
7	64/05/01	88/07/05	148	11	1839	28.1
8	64/07/01	88/10/19	71	23	5068	24.0
9	68/03/01	86/06/27	22	7	571	21.8
10	65/06/01	88/11/27	400	75	1060	28.2
11	64/08/01	88/05/12	103	8	964	23.6
12	65/07/01	88/09/01	263	68	1682	30.0
13	64/04/01	88/12/10	80	10	870	30.2
14	64/06/10	88/12/05	123	31	1100	27.1
15	64/04/01	88/12/08	401	127	1857	30.3
16	64/05/01	88/06/23	315	69	1179	26.5
17	65/04/01	88/03/10	111	25	688	27.0
18	76/07/04	88/06/01	9	1	516	19.1
19	64/11/01	88/11/25	114	21	751	22.8
20	66/05/01	88/11/17	45	7	732	25.5
All	64/02/01	88/12/10	2919	596	1312	27.6

a. Twenty SIC two-digit manufacturing industries are: 1. food and beverages; 2. tobacco; 3. rubber and plastics; 4. leather; 5. textiles; 6. knitting mills; 7. clothing; 8. wood; 9. furniture; 10. paper; 11. printing and publishing; 12. primary metals; 13. metal fabricating; 14. machinery; 15. transportation equipment; 16. electrical products; 17. nonmetallic minerals; 18. petroleum and coal; 19. chemical products; 20. miscellaneous manufacturing.

b. Average number of workers in bargaining units.

c. Average duration of contracts being negotiated, days.

Table 4 - Summary Statistics: Three Digit Manufacturing Industries

SIC Code[a]	First Settlement	Last Settlement	Number of Obs.	Number of Strikes	Avg. Unit Size[b]	Average Duration[c]
101	64/10/22	88/11/12	77	8	1806	25.4
102	65/07/01	88/08/03	47	12	1902	22.8
103	65/08/01	88/06/11	13	2	1011	25.1
104	65/06/01	88/12/02	21	1	933	24.1
105	66/05/01	88/08/29	21	1	536	23.0
107	64/07/01	88/05/07	61	10	621	25.2
108	65/04/01	87/08/14	80	10	637	24.2
109	65/06/01	88/12/05	71	11	811	30.5
153	65/05/01	88/08/20	48	2	905	23.9
162	64/12/01	87/08/09	84	21	868	34.6
172	70/06/12	75/01/06	3	1	505	26.3
174	66/10/01	88/10/11	18	2	693	23.6
175	64/08/01	78/10/10	6	1	880	32.0
179	64/02/01	88/03/01	9	0	944	36.0
181	65/12/01	88/09/26	53	8	1005	28.2
182	66/08/01	87/08/13	5	0	557	34.6
183	64/10/01	88/01/22	64	15	960	26.6
186	76/01/09	---	1	0	520	24.0
188	72/02/25	87/11/14	13	3	710	32.4
189	71/07/06	87/05/08	11	5	523	26.2
239	66/11/03	75/06/16	8	0	595	32.3
243	64/09/01	87/06/25	88	5	1760	25.9
244	64/07/01	88/06/13	31	2	3008	32.9
245	64/05/01	79/02/20	7	1	586	28.7
246	65/06/01	88/07/05	15	3	1003	28.7
248	72/10/14	---	1	0	600	36.0
249	66/02/01	79/01/31	6	0	717	32.0
251	64/07/01	88/10/19	52	19	6713	24.4

Table 4 - Summary Statistics: Three Digit Manufacturing Industries (Continued)

SIC	First Settlement	Last Settlement	Number of Obs.	Number of Strikes	Avg. Unit Size	Average Duration
252	69/09/01	88/10/15	10	2	567	22.3
256	68/06/23	83/11/19	6	2	596	25.8
259	80/12/12	85/01/15	3	0	500	20.0
261	68/03/01	86/06/27	13	5	567	21.3
266	69/04/01	77/03/18	9	2	576	22.6
271	65/06/01	88/11/24	372	72	1092	28.4
273	70/06/05	88/11/27	10	1	801	27.9
274	65/08/01	88/06/25	18	2	523	24.1
286	67/02/27	86/05/10	24	1	644	20.3
287	65/04/01	88/05/12	49	1	1093	23.6
289	64/08/01	87/11/15	30	6	1008	26.2
291	65/07/01	88/06/27	103	28	2214	30.2
292	66/02/01	88/06/03	31	5	815	33.5
294	65/11/01	77/06/16	9	1	593	31.7
295	66/05/01	88/09/01	93	28	1736	28.1
296	66/07/21	87/04/10	17	5	888	30.9
397	65/08/01	78/04/23	10	1	730	30.9
301	65/12/01	88/07/06	18	3	670	25.8
302	65/12/01	86/12/13	13	2	700	26.7
304	65/03/01	88/12/10	30	3	1114	34.7
305	68/06/10	87/12/19	10	0	889	30.9
308	70/03/01	75/05/03	4	0	688	21.8
309	64/04/01	81/06/12	5	2	678	33.6
311	65/02/01	88/10/30	39	17	1774	28.1
315	64/06/01	88/06/10	77	14	805	26.5
316	73/01/31	88/12/05	2	0	535	36.0
318	68/09/01	88/11/24	5	0	612	26.4
321	64/06/11	88/12/02	94	27	1454	28.1
323	64/12/01	88/12/03	79	35	5120	31.8

Table 4 - Summary Statistics: Three Digit Manufacturing Industries (Continued)

SIC	First Settlement	Last Settlement	Number of Obs.	Number of Strikes	Avg. Unit Size	Average Duration
324	73/06/15	88/04/15	11	3	635	29.5
325	65/02/01	88/11/19	89	31	820	34.1
326	66/04/01	88/12/08	35	11	917	28.5
327	64/04/01	88/11/10	90	19	999	28.5
329	68/09/01	71/06/01	3	1	500	32.0
331	74/09/15	85/06/19	5	3	542	26.4
332	64/08/01	88/06/21	66	15	846	28.8
334	65/11/10	87/02/22	37	3	957	21.5
335	65/07/01	88/06/23	130	25	1166	26.8
336	64/06/01	87/05/11	37	14	2720	27.0
338	64/08/01	78/08/20	15	2	678	22.9
339	64/05/01	88/02/21	25	7	598	27.6
352	65/06/01	77/06/07	7	0	855	22.3
355	69/04/01	82/11/06	7	1	564	25.1
356	65/04/01	88/03/10	80	19	718	28.3
359	65/07/01	80/05/07	17	5	524	23.5
365	76/07/04	88/06/01	9	1	516	19.1
373	65/11/01	67/12/20	2	0	500	24.0
374	70/07/07	83/03/27	8	0	549	22.1
376	66/03/01	68/03/31	2	2	500	24.0
378	64/11/01	88/11/25	65	10	855	21.9
379	65/05/01	88/10/14	37	11	639	24.3
391	66/12/19	87/11/27	23	5	823	23.7
393	72/04/20	88/11/17	19	2	652	26.1
399	66/05/01	74/07/15	3	0	537	36.0
ALL	64/02/01	88/12/10	2919	596	1312	27.6

a. Standard Industrial Classfication.
b. Average number of workers in bargaining units.
c. Average duration of contracts being negotiated, days.

Table 5 - Learning and Strike Incidence: SIC Two Digit Manufacturing Industries
(Number of Settlements)

Dependent Variable: Strike Dummy Probit Estimation

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
$z_{-1,1}$	-.0567 (-2.996)	-.0515 (-2.771)	-.0509 (-2.737)	-.0490 (-2.663)	-.0488 (-2.670)	-.0435 (-2.402)
$z_{-1,2}$	-.0219 (-1.034)	-.0221 (-1.046)	-.0210 (- .997)	-.0218 (-1.034)	-.0240 (-1.137)	-0250 (-1.184)
$z_{-1,3}$	-.0201 (- .950)	-.0173 (- .817)	-.0168 (- .799)	-.0243 (-1.155)	-.0223 (-1.072)	-.0310 (-1.510)
z_{-2}	-.0189 (-1.580)	-.0210 (-1.759)	-.0203 (-1.696)	-.0227 (-1.906)	-.0227 (-1.909)	----
z_{-3}	-.0080 (- .589)	-.0061 (- .451)	-.0057 (- .423)	-.0023 (- .175)	----	----
z_{-4}	.0124 (1.062)	.0133 (1.143)	.0123 (1.060)	----	----	----
z_{-5}	-.0090 (- .687)	-.0124 (- .960)	----	----	----	----
z_{-6}	-.0259 (-1.616)	----	----	----	----	----
Ind. Prod.	1.7170 (2.130)	1.5929 (1.982)	1.4884 (1.861)	1.4959 (1.872)	1.4381 (1.814)	1.3875 (1.752)
Size	.1818 (4.264)	.1771 (4.184)	.1798 (4.252)	.1751 (4.155)	.1710 (4.102)	.1740 (4.208)
Contract Duration	.0298 (7.344)	.0312 (7.744)	.0315 (7.840)	.0312 (7.804)	.0314 (7.900)	.0314 (7.934)
Sample Size	2691	2716	2725	2749	2785	2815
Log-likelihood	-1254.30	-1264.61	-1266.28	-1273.81	-1292.20	-1308.51

Notes

1. t-statistics are in parentheses.
2. Variables: z_{-i} (i=2,3,4,5,6) = number of negotiations concluded in the earlier period i in the same SIC two-digit industry before the current negotiation concludes or a strike starts if the negotiation involves a strike. The length of a period is one quarter; $z_{-1,j}$ (j=1,2,3) = number of negotiations concluded in the earlier first, second and third months; Ind. Prod = monthly index of industrial production, deseasonalized and detrended; Size = log of the number of workers in a bargaining unit.
3. All equations include a cubic in time, 4 region dummies, 11 month dummies and 16 industry dummies. Five regions are Ontario, Quebec, BC, Maritime and Prairies.

Table 6 - Learning and Strike Incidence: SIC Two Digit Manufacturing Industries
(Number of Negotiations)

Dependent Variable: Strike Dummy — Probit Estimation

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
z_{-1}	-.0179 (-1.952)	-.0128 (-1.432)	-.0159 (-1.793)	-.0161 (-1.845)	-.0153 (-1.792)	-.0155 (-1.819)
z_{-2}	-.0009 (- .077)	-.0032 (- .282)	-.0045 (- .389)	-.0049 (- .434)	-.0052 (- .454)	----
z_{-3}	-.0088 (- .694)	-.0057 (- .455)	-.0080 (- .649)	-.0077 (- .627)	----	----
z_{-4}	-.0113 (- .825)	-.0065 (- .483)	-.0018 (- .133)	----	----	----
z_{-5}	.0287 (2.909)	.0262 (2.687)	----	----	----	----
z_{-6}	-.0550 (-3.317)	----	----	----	----	----
Ind. Prod.	1.4127 (1.763)	1.2632 (1.578)	1.3790 (1.733)	1.3569 (1.717)	1.2711 (1.614)	1.2552 (1.594)
Size	.1758 (4.126)	.1831 (4.327)	.1730 (4.101)	.1768 (4.202)	.1718 (4.123)	.1744 (4.211)
Contract Duration	.0302 (7.457)	.0314 (7.804)	.0314 (7.804)	.0312 (7.812)	.0314 (7.894)	.0317 (7.969)
Sample Size	2697	2723	2732	2750	2790	2812
Log-likelihood	-1251.58	-1268.22	-1276.62	-1281.84	-1301.45	-1311.20

Notes

1. t-statistics are in parentheses.
2. Variables: z_{-i} = number of negotiations started in the earlier period i in the same SIC two-digit industry before the current negotiation starts. The length of a period is one quarter; Ind. Prod = monthly index of industrial production, deseasonalized and detrended; Size = log of the number of workers in a bargaining unit.
3. All equations include a cubic in time, 4 region dummies, 11 month dummies and 16 industry dummies. Five regions are Ontario, Quebec, BC, Maritime and Prairies.

Table 7 - Learning and Strike Incidence: SIC Three Digit Manufacturing Industries
(Number of Settlements)

Dependent Variable: Strike Dummy

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
$z_{-1,1}$	-.1105 (-4.179)	-.1097 (-4.178)	-.1083 (-4.122)	-.1035 (-3.995)	-.1004 (-3.916)	-.0936 (-3.714)
$z_{-1,2}$	-.0494 (-1.669)	-.0496 (-1.675)	-.0466 (-1.581)	-.0466 (-1.568)	-.0475 (-1.602)	-.0510 (-1.706)
$z_{-1,3}$	-.0557 (-1.825)	-.0547 (-1.789)	-.0542 (-1.777)	-.0656 (-2.111)	-.0585 (-1.921)	-.0676 (-2.252)
z_{-2}	-.0152 (- .970)	-.0165 (-1.053)	-.0153 (- .974)	-.0180 (-1.147)	-.0187 (-1.198)	----
z_{-3}	-.0312 (-1.350)	-.0321 (-1.392)	-.0320 (-1.382)	-.0197 (- .932)	----	----
z_{-4}	.0224 (1.308)	.0225 (1.323)	.0188 (1.128)	----	----	----
z_{-5}	-.0236 (-1.077)	-.0253 (-1.190)	----	----	----	----
z_{-6}	-.0154 (- .590)	----	----	----	----	----
Ind. Prod.	1.7958 (2.168)	1.7428 (2.111)	1.6520 (2.008)	1.6357 (1.984)	1.5215 (1.856)	1.5097 (1.842)
Size	.1188 (2.419)	.1130 (2.317)	.1147 (2.353)	.1113 (2.291)	.1159 (2.422)	.1204 (2.531)
Contract Duration	.0304 (7.180)	.0313 (7.434)	.0318 (7.585)	.0315 (7.528)	.0319 (7.670)	.0318 (7.692)
Sample Size	2608	2633	2640	2662	2707	2736
Log-Likelihood	-1189.55	-1198.61	-1200.08	-1206.38	-1226.34	-1240.32

Notes:

1. t-statistics are in parentheses.
2. Variables: z_{-i} ($i=2,3,4,5,6$) = number of negotiations concluded in the earlier period i in the same SIC three-digit manufacturing industry before the current negotiation concludes or a strike starts if the negotiation involves a strike. The length of a period is one quarter; $z_{-1,j}$ ($j=1,2,3$) = number of negotiations concluded in the earlier first, second and third months; Ind. prod. = monthly index of industrial production, deseasonalized and detrended; Size = log of number of workers in a bargaining unit.
3. All equations include a cubic in time, 4 region dummies, 11 month dummies and 54 three-digit industry dummies. Five regions are Ontario, Quebec, BC, Maritime and Prairies.

Table 8 - Learning and Strike Incidence: SIC Three Digit Manufacturing Industries
(Number of Negotiations)

Dependent Variable: Strike Dummy

Independent Variables	(1)	(2)	(3)	(4)	(5)	(6)
z_{-1}	-.0256 (-2.230)	-.0198 (-1.778)	-.0263 (-2.408)	-.0271 (-2.554)	-.0222 (-2.166)	-.0202 (-1.983)
z_{-2}	-.0233 (-1.348)	-.0220 (-1.288)	-.0244 (-1.438)	-.0257 (-1.537)	-.0284 (-1.697)	---
z_{-3}	-.0370 (-1.738)	-.0361 (-1.706)	-.0398 (-1.916)	-.0389 (-1.886)	---	---
z_{-4}	-.0150 (- .688)	-.0058 (- .275)	.0040 (.196)	---	---	---
z_{-5}	.0393 (3.113)	.0387 (3.091)	---	---	---	---
z_{-6}	-.0656 (-2.069)	---	---	---	---	---
Ind. Prod.	1.3547 (1.666)	1.2895 (1.587)	1.3717 (1.695)	1.3736 (1.703)	1.42892 (1.602)	1.2604 (1.568)
Size	.1004 (2.050)	.1097 (2.255)	.0974 (2.011)	.1018 (2.112)	.1096 (2.300)	.1174 (2.478)
Contract Duration	.0319 (7.545)	.0323 (7.695)	.0324 (7.703)	.0322 (7.686)	.0321 (7.716)	.0323 (7.787)
Sample Size	2613	2638	2646	2663	2702	2733
Log-Likelihood	-1194.06	-1207.30	-1216.18	-1221.46	-1239.47	-1252.57

Notes:

1. t-statistics are in parentheses.
2. Variables: z_{-i} (i=1,2,3,4,5,6) = number of negotiations started in the earlier period i in the same SIC three-digit manufacturing industry before the current negotiation starts. The length of a period is one quarter; Ind. prod. = monthly index of industrial production, deseasonalized and detrended; Size = log of number of workers in a bargaining unit.
3. All equations include a cubic in time, 4 region dummies , 11 month dummies and 54 three-digit industry dummies. Five regions are Ontario, Quebec, BC, Maritime and Prairies.

Table 9 - Learning and Strike Incidence: SIC Two Digit Manufacturing Industries

(Number of Settlements, Same vs. Different Union)

Dependent Variable: Strike Dummy — Probit Estimation

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Within a Same Union:						
z_{-1}	.0025 (.184)	.0005 (.036)	.0004 (.029)	.0039 (.292)	-.0006 (- .046)	.0032 (.250)
z_{-2}	.0005 (.022)	.0018 (.079)	.0017 (.076)	-.0001 (- .003)	.0023 (.109)	----
z_{-3}	.0311 (1.184)	.0273 (1.039)	.0275 (1.053)	.0369 (1.480)	----	----
z_{-4}	.0254 (1.122)	.0189 (.840)	.0173 (.810)	----	----	----
z_{-5}	-.0186 (- .687)	-.0037 (- .141)	----	----	----	----
z_{-6}	.0843 (2.634)	----	----	----	----	----
Within a Diff. Union:						
z_{-1}	.0254 (2.039)	.0180 (1.474)	.0184 (1.511)	.0188 (1.561)	.0133 (1.132)	.0113 (.972)
z_{-2}	-.0227 (-1.547)	-.0246 (-1.685)	-.0241 (-1.663)	-.0243 (-1.678)	-.0226 (-1.581)	----
z_{-3}	.0313 (2.082)	.0297 (1.991)	.0297 (1.994)	.0274 (1.859)	----	----
z_{-4}	-.0252 (-1.527)	-.0272 (-1.666)	-.0258 (-1.613)	----	----	----
z_{-5}	.0044 (.282)	.0042 (.280)	----	----	----	----
z_{-6}	.0187 (1.216)	----	----	----	----	----
Sample Size	2691	2716	2725	2749	2785	2815
Log-likelihood	-1254.83	-1268.24	-1269.44	-1277.79	-1299.15	-1314.43

Notes

1. t-statistics are in parentheses.
2. Variables: z_{-i} (i=2,3,4,5,6) = number of negotiations concluded in the earlier period i in the same SIC two-digit industry before the current negotiation concludes or a strike starts if the negotiation involves a strike. The length of a period is one quarter.
3. All equations include monthly index of industrial production, log of the number of workers in a bargaining unit, contract duration, a cubic in time, 4 region dummies, 11 month dummies and 16 industry dummies. Five regions are Ontario, Quebec, BC, Maritime and Prairies.

Table 10 - Learning and Strike Incidence: SIC Two Digit Manufacturing Industries

(Number of Settlements, Same vs. Different Region)

Dependent Variable: Strike Dummy — Probit Estimation

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Within a Same region:						
z_{-1}	-.0160 (- .853)	-.0185 (- .993)	-.0186 (- .998)	-.0161 (- .871)	-.0214 (-1.169)	-.0187 (-1.036)
z_{-2}	.0423 (1.827)	.0441 (1.912)	.0452 (1.970)	.0431 (1.876)	.0447 (1.971)	—
z_{-3}	.0342 (1.302)	.0305 (1.171)	.0299 (1.151)	.0253 (.985)	—	—
z_{-4}	-.0285 (-1.111)	-.0284 (-1.115)	-.0283 (-1.118)	—	—	—
z_{-5}	-.0135 (- .538)	-.0072 (- .290)	—	—	—	—
z_{-6}	.0696 (2.568)	—	—	—	—	—
Within a Diff. Region:						
z_{-1}	.0300 (2.347)	.0254 (2.018)	.0256 (2.035)	.0275 (2.234)	.0230 (1.902)	.0213 (1.768)
z_{-2}	-.0469 (-2.759)	-.0491 (-2.889)	-.0491 (-2.898)	-.0489 (-2.897)	-.0471 (-2.824)	—
z_{-3}	.0284 (1.723)	.0278 (1.695)	.0278 (1.702)	.0291 (1.794)	—	—
z_{-4}	-.0040 (- .245)	-.0053 (- .326)	-.0037 (- .238)	—	—	—
z_{-5}	.0058 (.337)	.0063 (.370)	—	—	—	—
z_{-6}	.0068 (.381)	—	—	—	—	—
Sample Size	2691	2716	2725	2749	2785	2815
Log-likelihood	-1251.74	-1264.40	-1265.61	-1273.02	-1294.12	-1313.14

Notes

1. t-statistics are in parentheses.
2. Variables: z_{-i} (i=2,3,4,5,6) = number of negotiations concluded in the earlier period i in the same SIC two-digit industry before the current negotiation concludes or a strike starts if the negotiation involves a strike. The length of a period is one quarter.
3. All equations include monthly index of industrial production, log of the number of workers in a bargaining unit, contract duration, a cubic in time, 4 region dummies, 11 month dummies and 16 industry dummies. Five regions are Ontario, Quebec, BC, Maritime and Prairies.

Table 11 - Learning and Strike Incidence: SIC Three Digit Manufacturing Industries
(Number of Settlements, Same vs. Different Union)

Dependent Variable: Strike Dummy — Probit Estimation

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Within a Same Union:						
z_{-1}	-.0077 (- .443)	-.0093 (- .540)	-.0116 (- .683)	-.0092 (- .547)	-.0120 (- .736)	-.0159 (-1.000)
z_{-2}	-.0655 (-1.978)	-.0698 (-2.109)	-.0685 (-2.082)	-.0922 (-2.202)	-.0731 (-2.279)	----
z_{-3}	-.0285 (- .735)	-.0264 (- .681)	-.0286 (- .738)	-.0127 (- .362)	----	----
z_{-4}	.0313 (1.066)	.0314 (1.077)	.0269 (.946)	----	----	----
z_{-5}	-.0065 (- .176)	-.0151 (- .419)	----	----	----	----
z_{-6}	-.0484 (- .910)	----	----	----	----	----
Within a Diff. Union:						
z_{-1}	-.0306 (-1.698)	-.0301 (-1.689)	-.0301 (-1.694)	-.0289 (-1.637)	-.0300 (-1.720)	-.0315 (-1.824)
z_{-2}	-.0241 (-1.140)	-.0255 (-1.203)	-.0263 (-1.246)	-.0289 (-1.363)	-.0246 (-1.179)	----
z_{-3}	.0274 (.990)	.0269 (.975)	.0300 (1.097)	.0264 (1.007)	----	----
z_{-4}	-.0280 (- .988)	-.0311 (-1.101)	-.0224 (- .849)	----	----	----
z_{-5}	.0175 (.633)	.0234 (.875)	----	----	----	----
z_{-6}	.0091 (.316)	----	----	----	----	----
Sample Size	2608	2633	2640	2662	2707	2736
Log-likelihood	-1201.72	-1210.87	-1212.11	-1217.74	-1237.79	-1254.51

Notes

1. t-statistics are in parentheses.
2. Variables: z_{-i} (i=1,2,3,4,5,6) = number of negotiations concluded in the earlier period i in the same SIC three-digit industry before the current negotiation concludes or a strike starts if the negotiation involves a strike. The length of a period is one quarter.
3. All equations include monthly index of industrial production, log of the number of workers in a bargaining unit, contract duration, a cubic in time, 4 region dummies, 11 month dummies and 54 industry dummies. Five regions are Ontario, Quebec, BC, Maritime and Prairies.

Table 12 - Learning and Strike Incidence: SIC Three Digit Manufacturing Industries
(Number of Settlements, Same vs. Different Region)

Dependent Variable: Strike Dummy | Probit Estimation

Independent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Within a Same region:						
z_{-1}	-.0509 (-1.884)	-.0515 (-1.912)	-.0530 (-1.972)	-.0462 (-1.738)	-.0468 (-1.784)	-.0413 (-1.588)
z_{-2}	-.0028 (- .078)	-.0035 (- .097)	-.0001 (- .004)	-.0044 (- .123)	-.0068 (- .193)	—
z_{-3}	-.0261 (- .542)	-.0264 (- .548)	-.0269 (- .561)	-.0342 (- .721)	—	—
z_{-4}	-.0563 (-1.165)	-.0585 (-1.215)	-.0601 (-1.260)	—	—	—
z_{-5}	-.0490 (-1.063)	-.0489 (-1.065)	—	—	—	—
z_{-6}	-.0437 (- .885)	—	—	—	—	—
Within a Diff. Region:						
z_{-1}	-.0056 (- .313)	-.0050 (- .284)	-.0041 (- .234)	-.0044 (- .258)	-.0071 (- .422)	-.0136 (- .803)
z_{-2}	-.0619 (-2.375)	-.0628 (-1.405)	-.0634 (-2.444)	-.0660 (-2.556)	-.0628 (-2.474)	—
z_{-3}	.0191 (.685)	.0176 (.639)	.0192 (.699)	.0274 (1.053)	—	—
z_{-4}	.0089 (.376)	.0076 (.324)	.0145 (.644)	—	—	—
z_{-5}	.0204 (.767)	.0214 (.830)	—	—	—	—
z_{-6}	.0082 (.248)	—	—	—	—	—
Sample Size	2608	2633	2640	2662	2707	2736
Log-likelihood	-1200.45	-1209.57	-1211.19	-1217.11	-1237.45	-1254.44

Notes

1. t-statistics are in parentheses.
2. Variables: z_{-i} (i=2,3,4,5,6) = number of negotiations concluded in the earlier period i in the same SIC three-digit industry before the current negotiation concludes or a strike starts if the negotiation involves a strike. The length of a period is one quarter.
3. All equations include monthly index of industrial production, log of the number of workers in a bargaining unit, contract duration, a cubic in time, 4 region dummies, 11 month dummies and 54 industry dummies. Five regions are Ontario, Quebec, BC, Maritime and Prairies.

CHAPTER 3

BARGAINING STRUCTURE AND BARGAINING OUTCOMES
THE CASE OF SIMULTANEOUS NEGOTIATIONS

3.1 Introduction

A central concern in the field of industrial relations has been the effects of the institutional structures of bargaining on bargaining outcomes, such as the level of wages and the incidence of disputes, or strikes. A common theme in the literature, dating back to at least Ross and Hartman (1960), is that, for variety of reasons, one might expect centralized bargaining structures in which individual unions and/or firms merge to bargain with their partners, to produce greater industrial harmony than decentralized systems and reduce overall wage levels. The structure of bargaining is viewed as so crucial that increased centralization of bargaining is frequently cited as almost a panacea to problems in collective bargaining in Canada (Anderson 1982). Empirical evidence on this issue, both on the industry level (e.g. Hendericks 1975, Kochan and Block 1977, Perry and Angle 1981, Ross 1986) and the national level (Bean 1985, Freeman 1988, Jackman et. al. 1991, Freeman and Gibbons 1993, Katz 1992) remains fairly inconclusive, however.

Economic theories of bargaining structures are shaped by our understanding of contract negotiations and strikes in single bargaining pair. There are basically three major theories of bargaining and strikes: the model of Ashenfelter and Johnson (1969); the "joint cost" hypothesis articulated by Kennen (1980) and strategic bargaining models with asymmetric information developed by Hayes (1984), Morton (1983), Sobel and Takahashi (1983), and Fudenberg and Tirole (1983). The latest development on bargaining and strikes, the strategic bargaining model with asymmetric information, combines elements of both the Ashefelter-Johnson model and the joint-cost hypothesis. It views strikes as a mechanism used by one party to bargaining to extract information from the other party in the presence of asymmetric information. According to the usual formulation of theses models, some aspects of firms' profitability are unobservable to unions. Unions use strikes to extract higher wages from more profitable firms.

This latest development on bargaining and strikes allows researchers to study bargaining structure and outcomes in terms of the impacts of alternative bargaining structure on the effectiveness of information revelation and information transfer (Cheung and Davidson 1991, Kuhn and Gu 1995b). If alternative structure of bargaining affects bargaining outcomes (the incidence of strikes and wage settlements) via its effectiveness of information revelation and information transfer in contract negotiations, one key issue is whether bargaining at different firms take place simultaneously or sequentially. This will have important effects on the incidence of strikes and wage settlements, since we might expect that sequential negotiations are more effective in information transfer than simultaneous negotiations. In chapter two and Kuhn and Gu (1995a), we have demonstrated, both theoretically and empirically, that in sequential negotiations the outcomes of previous negotiations are, in general, informative to the current bargaining parties. Kuhn and Gu (1995b) applied the model developed in Kuhn and Gu (1995a) to study information transfer and bargaining structures when bargaining at different bargaining pairs begins at different times. Cheung and Davidson

(1991) studied information transfer and bargaining structures when all bargaining pairs bargain at the same time, in particular, they investigated one bargaining structure in which a single union bargains simultaneously with two firms[1]. However, the issue of information transmission under the other alternative bargaining structures remains unexplored when negotiations are simultaneous.

The goal of this chapter is to study the issue of information transfer and compare bargaining outcomes in four different industry bargaining structures when negotiations are simultaneous: (1) a base case with sequential negotiations and no cooperation among either unions or firms; (2) a "colluding unions" in which a single union negotiates with different firms simultaneously; (3) its converse, where a single employer or group of employers bound together in an association negotiates with different unions simultaneously; and (4) a case of colluding unions and firms in which a group of cooperating firms negotiate with a group of cooperating unions. In the industrial relations literature, these four bargaining structures are sometimes called decentralized, multiple union-single firm, single union-multiple firm and centralized bargaining structures respectively.

The main findings of this chapter are as follows: (1) collusion by uninformed parties (unions) has an ambiguous effect on strike incidence and raises expected wage settlements; (2) collusion by informed parties (firms) raises strike incidence but reduces expected wage settlements. The intuition here is when a group of cooperating employers negotiate with different unions simultaneously, it effectively prevents unions from acquiring information by observing the outcomes in previous negotiations, thus limiting information transfer among unions. This has two important effects: first, it prevents unions from negotiating a better wage settlement due to their improved information about firms' ability to pay, or leapfrogging over the settlements reached by other unions; second, it raises the incidence of strikes because unions are now more likely to resort to strikes to extract information about firms' ability to pay; (3) similar to collusion by informed parties (firms), collusion by both uninformed parties and uninformed parties raises the incidence of strikes and reduces expected wage settlements. These results contrast with those in Kuhn and Gu (1995b) where negotiations are sequential. In Kuhn and Gu (1994), they found that under no circumstances does the model predict an unambiguous increase in the incidence of strikes with centralization.

The results of this chapter, together with those in Kuhn and Gu (1995b), suggest that we must be careful about the nature of negotiations (sequential v.s. simultaneous) in studying bargaining structures. To the extent centralization reduces information transfer among unions, it raises strike incidence. When negotiations are simultaneous, centralization greatly inhibits information transmission in contract negotiations, leading to an unambiguous increase in strike incidence in the cases of colluding firms and both colluding firms and unions.

The results of this chapter and Kuhn and Gu (1995b) also suggest that there are many dimensions of centralization, some of which will not unambiguously reduce strike incidence, such as the aspect of information transmission studied in this chapter and Kuhn and Gu (1995b). The mixed empirical evidence on centralization and strike incidence may be due to the complexity of the heterogeneous nature of centralization itself.

As a theoretical contribution, we solved two versions of multiplayer bargaining problem with asymmetric information: one of which is when a single informed party (firm) bargains simultaneously with two uninformed parties (unions); the other is when a single uninformed party (union) bargains with two informed parties (firms). It is interesting to note that in both versions of the multiplayer bargaining model there exist two symmetric perfect Bayesian equilibria even though we assume only uninformed parties make wage demands. This contracts sharply with bargaining model between a single bargaining pair in the presence of asymmetric information, which has a unique perfect Bayesian equilibrium if uninformed parties are assumed to make all the offers.

The rest of the chapter is organized as follows: in section 3.2, we present a sequential bargaining model between a single firm and union. The model is studied, among others, by Fudenberg, Levine and Tirole (1983); in sections 3.3 to 3.6, we investigate the four alternative bargaining structures; section 3.7 compares these bargaining structures in terms of expected wage settlements and strike incidence; concluding discussions are in section 3.8.

3.2 A Sequential Bargaining Game Between a Single Bargaining Pair

Consider a contract negotiation between a single firm and a single union. The firm is in either a good state or bad state. Its profits gross of labor costs are $\pi_g > \pi_b > 0$ in these two states respectively. The states of the firm are only known to the firm and the union never observes the firm's states. However, the union has a prior p, that the firm is in the good state. Bargaining takes place in two periods. In each period the union makes a wage demand, which the firm either accepts or rejects. Specifically, the game is described in figure 1 and the sequence of moves is defined as follows:

Nature moves first by choosing the firm to be in one of the two states: good and bad states. With probability p the firm is in the good state, and with probability 1-p the firm is in the bad state. The firm observes the move by Nature, but the union doesn't. After the firm's state is determined by Nature, the union, without knowing the state of the firm, makes a wage demand $d_1 \in [0, \infty)$; the firm then responds by either accepting or rejecting that wage demand. If the firm accepts, the game ends and exchange takes place at the wage d_1. The union's payoff is d_1 and the firm gets its profit net of the wage payment d_1; If the firm rejects, the game proceeds to period two.

In the second period (also last period), the union makes a second wage demand d_2, to which the firm responds. If the firm accepts, the game ends. The payoffs are $r(\pi_g - d_2)$ and $r(\pi_b - d_2)$ for the firm in the good and bad states respectively. The union's payoff is rd_2. r $(0<r<1)$ is the common discount factor; if the firm rejects, no production takes place and both union and firm get their alternative utility levels, which are normalized to be zero.

A perfect Bayesian equilibrium of the game consists of: (1) strategies of the union; (2) strategies of the firm; and (3) beliefs of the union such that after every history of the game the strategies are optimal given the beliefs and the union's beliefs are consistent with the strategies in the sense that they are derived using Bayes' law.

We proceed to solve the game by backward induction: first, we compute the union's demands and firm's responses in period two after every history of the game in which the game doesn't end in period one (Lemma 1); second, we characterize the firm's responses in period one (Lemma 2); finally, we detremine the union's wage demands in period one (Lemma 3).

Assume that the union has a posterior p_2 that the firm is in the good state in period two before it makes a wage demand. The posterior p_2 is a function of the union's wage demand d_1 and the firm's response $R \in \{Y, N\}$ in the first period, that is, $p_2 = p_2(d_2, R)$, where Y indicates firm's acceptance and N indicates firm rejection.

The following lemma characterizes the union's demands and firm's responses in period one.

Lemma 1. Given the union's posterior $p_2(d_1, R)$, it makes a high wage demand $d_2 = \pi_g$ if $p_2 > \pi_b/\pi_g$ ($\equiv b$); makes a low wage demand $d_2 = \pi_b$ if $p_2 < b$; and randomizes between π_b and π_g if $p_2 = b$. The firm accepts a wage demand if and only if it is less than or equal to its profit[2].

Proof. It follows directly from the fact that period two is the final period of the game. ■

Given the union demands either π_b or π_g, the expected second-period payoffs for the firm in the bad state are zero regardless of the union's belief. It therefore bases its decision in the first period purely on current payoffs, which requires it to accept a wage demand if and only if the demand is less than or equal to its profit. When the firm is in the good state, its responses in the first period are characterized in Lemma 2.

Lemma 2. 1. if $d_1 \leq d^*$ ($\equiv (1-r)\pi_b + r\pi_g$), the firm in the good state always accepts;

2. if $d_1 > \pi_g$, it rejects;

3. if $d_1 \in (d^*, \pi_g]$, it rejects always when $p < b$; and rejects with probability α ($\equiv \frac{(1-p)b}{p(1-b)}$) when $p > b$[3].

Proof. See Appendix.

Now we can compute the union's optimal wage demand in the first period, which is given in Lemma 3.

Lemma 3. 1. The union demands π_b if $p < b$; 2. it demands d^* ($\equiv (1-r)\pi_g+r\pi_b$) if $b < p < \frac{b(1-rb)}{b + r - 2rb}$ ($\equiv p^{(1)}$); 3. it demands π_g if $p > p^{(1)}$.

Proof. See Appendix.

Combining Lemma 1, 2 and 3, we have proposition 1, which characterizes the (generically) unique perfect Bayesian equilibrium of the sequential bargaining game between a single bargaining pair[4].

Proposition 1. There exists a (generically) unique equilibrium for the bargaining game between a union and a firm. In the equilibrium the strategies of the union and firm are those specified in lemma 1, 2 and 3, while the union's posterior at the second period is,

$$p_2(d_1, R) = \begin{cases} p, & d_1 \le \pi_b,\ R = Y \\ 1, & d_1 \le \pi_b,\ R = N \\ 1, & \pi_b < d_1 \le d^*,\ R = Y \\ 0, & \pi_b < d_1 \le d^*,\ R = N \\ 1, & d^* < d_1 \le \pi_g,\ R = Y \\ b, & d^* < d_1 \le \pi_g,\ R = N \\ 1, & d_1 > \pi_g,\ R = Y,\ N. \end{cases}$$

Note. The posteriors after the histories ($d_1 \le \pi_b$, R = N) and ($d_1 > \pi_g$, R = Y, or N) are out of equilibrium beliefs and are thus not defined using Bayes' law. They can take on any value and the pair of strategies and beliefs in Proposition 1 still forms a perfect Bayesian equilibrium.

To understand the equilibrium, let us consider the unique outcome of the game. If $p < b$, the union makes a low wage demand in the first period, which is always accepted by the firm. No delay occurs; if $b < p < p^{(1)}$, the union demands d^* in the first period and lowers its demand to π_b in the second period if its first period demand is rejected. The firm accepts the first period demand if it is in the good state, and accepts the second period demand if it is in the bad state; if $p > p^{(1)}$, the union makes a high wage demands π_g in both periods. The firm accepts the first period demand with probability $1 - \alpha$, and always accepts the second period demand if it is in the good state. It never accepts if it is in the bad state.

3.3 Non-cooperative Negotiations

Consider two bargaining pairs, labelled firm 1, union 1 (bargaining pair 1), and firm 2, union 2 (bargaining pair 2) which bargain in sequence and in a similar fashion as the single pair in section 3.2. This seems to be a natural definition of non-cooperative negotiations. An alternative definition will be to assume that the two independent bargaining pairs bargain simultaneously. But in practice simultaneous bargaining in which no information transfer will occur is rare in non-cooperative negotiations. Furthermore, in our setting the union in the second pair can achieve a higher wage settlement and reduce strike incidence (in fact, strikes never occur in the second bargaining pair) after observing the outcomes in the first bargaining pair. If we allow both parties to bargaining to choose the timing of bargaining, the two pairs will negotiate in sequence (Gu and Kuhn 1995). Therefore, for both practical and theoretical reasons, two bargaining pairs will likely bargain in sequence.

For simplicity, we assume that two firms are identical and their profits are perfectly correlated. The firms' profits are firms' private information, but the two unions have a common prior about the firms' profits: the firms are in the good state with probability p and in the bad state with probability 1-p.

The perfect Bayesian equilibrium of the bargaining game between the first pair is the same as between a single bargaining pair. It is given in Proposition 1. The equilibrium of the bargaining game between the second pair however depends on what union 2 observes in the preceding bargaining round, since this affects its optimally updated prior that firm 2 is in the good state. In particular, it will observe one of the six possible outcomes (high or low wage settlements and three possible strike durations) in the first pair. We now consider the equilibrium of game between the second pair in each case in turn. In the discussion, strike duration is defined to be zero, one and two periods respectively, when the firm accepts first-period, second-period demands and never accepts.

(1) *Wage settlement* π_b *and no strikes.* This outcome occurs when $p < b$, union 1 demands π_b in the first period and firm 1 always accepts. Union 2 clearly learns nothing from the outcome of round 1 negotiations. Its posterior is same as its prior. Since two unions share a common prior, union 2 will demand π_b in the first period as well, which firm 2 always accepts. Therefore, as in the first pair, the wage settlement is π_b, and no strike occurs.

(2) *Wage settlement* π_b *and strike duration of one period.* When $b < p < p^{(1)}$, union 1 demands d^* in the first period and π_b in the second period. The firm rejects in the first period and accepts in the second period. Union 2 now concludes that firm 1 is in bad state and so is firm 2. It demands π_b in the first period and firm 2 always accepts. The wage settlement is π_b and and no strike occurs in the second pair.

(3) *Wage settlement* d^* *and no strikes.* When $b < p < p^{(1)}$, union 1 demands d^* in the first period the firm accepts. Union 2 now concludes that both firms are in the good state. It demands π_g in the first period and firm 2 accepts. The wage settlement is π_g and no strike occurs in the second pair.

(4) *Wage settlement* π_g *and no strikes.* The fact that union 1 achieved a high wage settlement π_g reveals that firm 1 is in the good state. Due to perfect correlation between the firms' profits, firm 2 is also in the good

state. Union 2 will demand π_g in the first period and firm 2 always accepts. The wage settlement is π_g and no strike occurs in the second period.

(5) *Wage settlement π_g and strike duration of one period.* As in (4), the firms are in the good state. Union 2 demands π_g and firm 2 accepts. The wage settlement is π_g and no strike occurs in the second pair.

(6) *Strike duration of two periods.* This occurs only if firm 1 is in the bad state. Union 2 demands π_b and firm 2 accepts. The wage settlement is π_b and no strike occurs in the second pair.

In all cases except in case (1), the firms' states are perfectly revealed after the conclusion of the negotiation between the first pair. In the negotiation between the second pair, the union either mimics (in cases 1, 2, 4, 5) or leapfrogs (in cases 3 and 6) over the wage settlement set by the preceding negotiations. Strikes never occur in the second bargaining pair[5].

Finally, if extend the model to more than two bargaining pairs, which bargain in sequence. The bargaining after the second pair will simply follow the pattern set by the second pair. This phenomenon is called pattern bargaining in industrial relation.

3.4 Union Collusion

Consider the two bargaining pairs in section 3.3. Rather than modelling the two unions as separate players, we now model them as a single player, who bargain with two independent firms simultaneously. The two cooperative unions behave to maximize their joint payoff. For simplicity, we again assume that the states of the firms are perfectly correlated. Formally, the bargaining game between the two cooperating unions and two independent firms can be described as follows:

Nature moves first by choosing the states of the two firms: with probability p they are in a good state and with probability 1-p they are in a bad state. The firms learn the states chosen by Nature while the unions never observe the states of the firms. After the states of the firms are determined, the unions proposes a vector of wage demands (d_1, d_1) in the first period, where $d_1 \in [0, \infty)$ and $d_2 \in [0, \infty)$ are wage demands for firm 1 and firm 2 respectively. After observing both wage demands d_1 and d_2, the two firms respond simultaneously by either accepting or rejecting the relevant wage demand, without knowing the response of the other firm. If both firms accept, the game ends and the exchange takes place at the wages demanded by the unions; if one firm accepts and the other rejects, negotiations with the firm who accepts ends, while the negotiations with the rejecting firm continues to the second period; if neither firm accepts, negotiations with both firms proceed to the second period.

In the second and final period, the union makes a second wage demand to the firms who have rejected the first period demands. If the firm accepts, exchange takes place at the wage demanded by the union with one period delay. If the firm rejects, both the firm and union get their alternative utility level zero.

We will solve the game by backward induction. First, we compute the unions' demands and firms' responses in period two after every history of the game in which the game does not end in the first period (Lemma 4); second, we determine the firms' response to all possible wage demands in the first period (Lemma 5); Finally, we compute the unions' optimal wage demands in the first period (Lemma 6).

As in the bargaining game between a single bargaining pair, the firm in the bad state accepts a wage demand if and only if it is less than or equal to its profit. Therefore, only the optimal strategies of the firms in good state remain to be determined.

Before the unions make wage demands in the second period, they observe the history of the game (d_1, d_2, R_1, R_2) and update their prior using Bayes law, where $R_1 \in \{Y, N\}$ and $R_2 \in \{Y, N\}$ are firms 1 and 2's responses in the first period. Given the unions' updated prior p_2, the wage demands and the firms' responses in the second period are given in Lemma 4.

Lemma 4. The unions demand π_b if $p_2 < b$, demand π_g if $p_2 > b$, and randomize between π_b and π_g if $p_2 = b$. The firms accept a wage demand if and only if it is less than or equal to its profit.

Proof. This follows directly from the fact that the second period is the final period of the game. ■

Lemma 5 characterizes the firms' equilibrium response to all possible wage demands in the first period. In lemma 5, i, j denote generic names for firms 1 and 2, and d^* denotes $(1-r)\pi_b + r\pi_g$.

Lemma 5. When the firms are in the good state, in any PBE the equilibrium responses in period one must have the following feature:

(1) If $d_i \leq \pi_b$, firm i accepts and firm j follows the responses specified in Lemma 2;

(2) if $\pi_b < d_i \leq \pi_g$ and $\pi_b < d_j \leq \pi_g$, the equilibrium responses depend upon the union's prior p: a. when $p < b$, there exist two equilibrium responses: the non-coordination responses are for both firms to accept always, and the coordination responses are for both to accept if and only if $d_i \leq d^*$ and $d_j \leq d^*$; b. when $p > b$, the two firms always accept;

(3) if $d_i > \pi_g$, firm i rejects and firm j follows the responses specified in Lemma 2.

Proof. See Appendix.

Lemma 6 characterizes the unions' wage demands in the first period. We will restrict our attention to symmetric wage demands since the two firms in our model are symmetric. In lemma 6, $p^{(2)}$ denote $\frac{(1-r)\pi_b}{\pi_g - r\pi_b}$.

Lemma 6. When the firms adopt the non-coordination responses, the unions demand $(d_1, d_2) = (\pi_g, \pi_g)$ if $p > p^{(2)}$, and (π_b, π_b) if $p < p^{(2)}$; when the firms adopt the coordination responses, the unions demand (π_g, π_g) if $p > b$ and (π_b, π_b) if $p < b$.

Proof. See Appendix.

If we allow asymmetric wage demands, the unions will demand (d^*, π_g) or (π_g, d^*) in stead of (π_b, π_b) in the first period when $p^{(2)} < p < b$ and the firms adopt the coordination responses. To prove this, recall that the coordination responses call for both firms in the good state to accept such a demand, which yields the unions' joint payoff $p(d^* + \pi_g) + 2(1-p)r\pi_b$. On the other hand, when the unions demand (π_b, π_b), they get a lower joint payoff $2\pi_b$.

Combining Lemma 4, 5 and 6, we have Proposition 2, which characterizes the two equilibrium outcomes of the game. The first outcome obtains when the firms adopt the non-coordination responses, while the second outcome obtains when the firms adopt the coordination responses.

Proposition 2. There exist two symmetric perfect Bayesian equilibrium outcomes for the bargaining game with union collusion.

(1) (*Non-coordination responses by the firms*) If $p < p^{(2)}$, the unions demand (π_b, π_b) in the first period and the two firms always accept; if $p > p^{(2)}$, the unions demand (π_g, π_g) in the first period and (π_b, π_b) in the second period. The firms accept the first period demands if they are in the good state, and accept the second period demands if they are in the bad state;

(2) (*Coordination responses by the firms*). If $p < b$, the unions demand (π_b, π_b) in the first period and the two firms always accept; if $p > b$, the unions demand (π_g, π_g) in the first period and (π_b, π_b) in the ꟷnd period. The firms accept the first period demands if they are in the good state, and accept the second period demands if they are in the bad state;

3.5 Firm Collusion

We now consider a model which is the mirror image of the preceding one. Specifically, two firms are modeled as a single player, who bargain simultaneously with two noncooperative unions to maximize their joint payoffs. Such bargaining structure can be observed when a number of employers form an association to coordinate their bargaining strategies.

Formally, the game can be described as follows. Bargaining takes place in two periods. In the first period the two unions submit a wage demand simultaneously, to which the firms respond by either accepting or rejecting. If the firms accept a union's demand, bargaining with that union ends and exchange takes place at the wage demanded by the union; if the firms reject a union's demand, bargaining with that union proceeds to period two.

In the second period the unions whose demands were rejected in period one submit a second wage demand, to which the firms respond. If the firms accept, exchange takes place at the wages demanded by the unions, with one period delay; if the firms rejects, both parties to the bargaining get their alternative utility level zero.

A history of the game at the beginning of period two is defined by (d_1, d_2, R_1, R_2), where d_1 and d_2 are the unions' demands and $R_1, R_2 \in \{Y, N\}$ are the firms' responses in period one[6].

We will again solve the game by backward induction. Lemma 7 characterizes the unions' demands and firms' responses in the second period, given the unions' common posterior $p_2(d_1, d_2, R_1, R_2)$. The firms' responses and unions' demands in the first period are given in Lemma 8 and 9 respectively.

Lemma 7. In the second period, the unions demand π_b if $p_2 < b$, demand π_g if $p_2 > b$, and randomize between π_b and π_g if $p_2 = b$. Firms accept a wage demand if and only if it is less than or equal to the profit.

Proof. This follows directly from the fact period two is the final period of the game.

Lemma 8 characterizes the firms' responses in period one when they are in the good state. If the firms are in the bad state, they will accept a demand if and only if it is less than or equal to the profit π_b.

Lemma 8. (1) If $d_i \leq \pi_b$, the firms accept d_i and respond to d_j according to Lemma 2;

(2) if $\pi_b < d_i \leq \pi_g$, and $\pi_b < d_j \leq \pi_g$, the firms' responses depend on the prior p: when $p < b$, the firms accept both demands iff $d_i + d_j \leq 2d^*$; when $p > b$, they accept both demands if $d_i + d_j \leq 2d^*$, and accept both demands with probability $1 - \alpha$ otherwise;

(3) if $d_i > \pi_g$, the firms reject d_i, the response to d_j depends on the prior p: if $p < b$, the firms accept iff $d_j \leq d^{(1)}$; if $p > b$, they accept always if $d_j \leq d^{(1)}$, accept with probability $1 - \alpha$ if $d^{(1)} < d_j \leq \pi_g$[7], and never accept otherwise.

In Lemma 8, $\alpha = \frac{(1-p)b}{p(1-b)}$, $d^{(1)} = \max\{\pi_b, (1-2r)\pi_g + 2r\pi_b\}$, and $d^* = (1-r)\pi_g + r\pi_b$

Proof. See Appendix.

To maximize their joint payoff, the firms respond to the wage demands less than π_g in period one as if they were single firm and responding to a demand $d_i + d_j$ by a single union (compare Lemma 2 vs. Lemma 8).

Lemma 9 characterizes unions' symmetric demands in period one. For brevity, we will assume that the common discount factor $r \geq .5$[8].

Lemma 9. There exist two symmetric equilibrium demands in the first period[9]. They are,

(1) unions demand π_b if $p < b$, and π_g if $p > b$;

(2) unions demand π_b if $p < b$, d^* if $b < p < p^{(1)}$, and π_g otherwise, where $d^* = (1-r)\pi_g + r\pi_b$ and $p^{(1)} = \frac{b(1-rb)}{b+r-2rb}$.

We will call the first equilibrium demands non-coordination demands and the second coordination demands.

Proof. See Appendix.

Proposition 3 describes the two PBE outcomes of the game. The first obtains when the unions adopt the non-coordination demands in period one, and the second obtains when the unions use the coordination demands.

Proposition 3. There exist two symmetric PBE outcomes for the bargaining game with firm collusion:

(1) (*Non-coordination demands*) if $p < b$, the two unions demand π_b in period one and firms always accept; if $p > b$, the unions demands π_g in both periods. The firms in the good state accept both demands with probability $1-\alpha$ in period one and accept always in period two. The firms in the bad state

never accept;

(2) (*Coordination demands*). If $p < b$, the unions demand π_b in period one and firms always accept; if $b < p < p^{(1)}$, the unions demand d^* in period one and π_b in period two. The firms in the good state accept in period one and the firms in the bad state accept in period two; if $p > p^{(1)}$, unions demand π_g in both periods. The firms in the good state accept with probability $1-\alpha$ in period one, and accept always in period two. The firms in the bad state never accept.

3.6 Union and Firm Collusion

In this section, we study a model in which both firms and unions cooperate to maximize their joint payoffs. The bargaining takes place in a similar fashion as in sections 3.4 and 3.5.

Since period two is the final period of the game, unions' demands and firms' responses in period two are again given in Lemma 7. In period one, the firms respond according to Lemma 9, since it characterizes exactly the two cooperative firms' responses in period one. In Lemma 9, the firms respond to the wage demands less than π_g in period one as if they were single firm and responding to a demand $d_i + d_j$ by a single union. Therefore, in period one, the two cooperative unions behave as if they were a single union and bargaining with a single firm.

In sum, when both firms and unions cooperate, there exists a unique PBE outcome. The two bargaining pairs achieve a same outcome, the one obtained in the bargaining between a single pair studied in section 3.2.

3.7 Bargaining Outcomes under Alternative Structures

In this section, we will compare different bargaining structures in terms of wage settlements and strike incidence. The wage settlement is assumed to be equal to the union's alternative utility level zero if no agreement is reached after two periods[10].

The wage settlements and strike incidence under different bargaining structures are shown in Figure 4. The wage settlements are computed under the assumption that the discount factor is close to one, because we are only interested in the wage settlements when the time elapsed between two consecutive demands approaches zero[11].

Comparing the wage settlements and strike incidence in Figure 4, we can prove the following three theorems.

Theorem 1. Collusion by both unions and firms lowers expected wage settlements and raises strike incidence.

Theorem 2. Collusion by firms alone lowers expected wage settlements and raises strike incidence.

Theorem 3. Collusion by unions alone increases expected wage settlements, but has an ambiguous effect on strike incidence.

Theorems 1 and 2 have a very intuitive interpretation: in the sequential negotiations with no cooperation among either unions or firms (called decentralized bargaining structure), unions are able to leapfrog over the wage settlements in previous rounds after observing the outcomes in the earlier rounds and obtaining better information about the firms' profits. The collusion by firms and simultaneous negotiations limit information transfer and learning among unions, thus preventing unions from leapfrogging over each other and lowering expected wage settlements. However, this limited information transfer among unions raises the probability of costly mistakes or strikes.

3.8 Conluding Discussion

In this chapter, we used a sequential bargaining model with incomplete information to study information transfer and compare bargaining outcomes under various bargaining structures. We found that collusion by firms and simultaneous negotiations limit information transfer and learning among unions in contract negotiations, thus lowering expected wage settlements and raising strike incidence. This contrasts with the results in Kuhn and Gu (1995b), in which they found under no circumstances does the model predict an unambiguous increase in strike incidence when negotiations are sequential.

Throughout this chapter we assume that firms' profits follow a two-point distribution and bargaining takes place in two periods. It seems likely that the three theorems in this chapter will still hold when bargaining takes place in more that two period or infinite number of periods. This is because the main forces behind these results - *collusion by firms and simultaneous negotiations limit information transfer among unions*, will still be in effect.

When firms' profits follow a uniform distribution in stead of a two-point distribution, we have proven Theorems 1 and 2 and obtained a theorem different from Theorem 3 -- union collusion unambiguously raises strike incidence and lowers expected wage settlements.

APPENDIX

I. Proof of Lemma 2.

1. Consider a wage demand d_1, below d^*. If the firm accepts d_1, it gets $\pi_g - d_1$; if it rejects, it gets at most $r(\pi_g - \pi_b)$ when the union makes a low wage demand of π_b in the second period. Therefore it is optimal for the firm to accept such a demand if $\pi_g - d_1 \geq r(\pi_g - \pi_b)$, or equivalently $d_1 \leq d^*$.

2. Acceptance of a wage demand d_1 greater than π_g yields a negative payoff for the firm. The fir

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2. Acceptance of a wage demand d_1 greater than π_g yields a negative payoff for the firm. The firm is thus better off rejecting that demand and guaranteeing itself a nonnegative payoff.

3. Finally, consider a wage demand $d_1 \varepsilon (d^*, \pi_g]$. We will consider two cases $p < b$ and $p > b$ separately.

(1) $p < b$. If the firm follows its equilibrium response and rejects the demand, the union's posterior p_2 in the second period equals its prior p, since the firm in the bad state also rejects such a demand. Because $p_2 < b$, the union makes a low wage demand π_b in the second period. The firm's expected payoff is thus $r(\pi_g - \pi_b)$, which is greater than its payoff $\pi_g - d_1$ when it deviates and accepts the demand d_1. Therefore, It is optimal for the firm to reject a demand d_1 if $d_1 \varepsilon (d^*, \pi_g]$.

To prove the above response is unique, we need show that it is not part of an equilibrium for the firm to accept a wage demand $d_1 \varepsilon (d^*, \pi_g]$. Suppose, to the contrary, the firm accepts such a demand in an equilibrium, yielding an expected payoff of $\pi_g - d_1$. Using Bayes law, the union's posterior p_2 is given by $p_2(d_1, N) = 0$ and $p_2(d_1,Y) = 1$. If the firm deviates and rejects such a demand, the union makes a low wage demand π_b in the second period since its posterior is $p_2(d_1, N) = 0$. Therefore, the firm will deviate since it gets a higher payoff $r(\pi_g - \pi_b)$. A contradiction. We conclude that the firm's unique response is to reject $d_1 \in (d^*, \pi_g]$, when $p < b$.

(2) *p> b.* First, consider a wage demand d_1, in (d^*, π_g). The firm's optimal response is to adopt a completely mixed action and rejects such a demand with probability α. The probability α must be such that the union is indifferent between demanding π_b and π_g in the second period. This is true when the union's posterior after a rejection $p_2(d_1, N)$ equals b:

(A1) $$p_2(d_1, N) = \frac{p\alpha}{p\alpha + (1-p)} = b.$$

Therefore,

(A2) $$\alpha = \frac{(1-p)b}{p(1-b)}.$$

For the firm to adopt a mixed response in the first period, it must be indifferent between accepting and rejecting the demand d_1,

(A3) $$\pi_g - d_1 = r\beta(\pi_g - \pi_b),$$

where β is the probability that the union makes a low wage demand π_b, and $1-\beta$ is the probability that the union makes a high wage demand π_g in the second period.

Solving equation (A3), we have,

$$\text{(A4)} \qquad \beta = \frac{\pi_g - d_1}{r(\pi_g - \pi_b)}.$$

To show the above (completely) mixed response is unique, suppose, to the contrary, the firm accepts such a demand with certainty in equilibrium, which yields a expected payoff of $\pi_g - d_1$. Since the firm in the bad state always rejects the demand, the union's posterior $p_2(d_1, R)$ equals 1 if $R = Y$, and it equals 0 if $R = N$. Therefore, if the firm deviates and rejects the demand in the first period, the union will believe that the firm is in the bad state and make a low demand π_b. The firm gets a higher expected payoff $r(\pi_g - \pi_b)$, since $r(\pi_g - \pi_b) > \pi_g - d_1$. A contradiction.

Similarly, we can rule out the firm's rejection to be part of an equilibrium. If the firm rejects with probability 1 in equilibrium, the union's posterior $p_2(d_2, N)$ equals p, since the firm in the bad state always rejects such a demand. The union makes a high wage demand π_g in the second period, and the firm gets a expected payoff zero. The firm will deviate and accept the demand since it gets a higher payoff $\pi_g - \pi_b$. Combining the above arguments, we conclude the completely mixed response is unique.

Now, consider a wage demand d_1, equal to π_g. By a similar argument as when the demand d_1 is in (d^*, π_g), we can rule out the firm's acceptance to be part of an equilibrium. Therefore, in equilibrium the firm rejects the demand with probability $\gamma \varepsilon (0,1]$. This is optimal when the union makes a high wage demand π_g in the second period. The union will make such a demand when its posterior $p_2(\pi_g, N)$ is no less than b,

$$\text{(A5)} \qquad p_2(\pi_g, N) = \frac{p\gamma}{p\gamma + (1-p)\gamma} \geq b.$$

Therefore, we have

(A6) $$\gamma \geq \frac{(1-p)b}{p(1-b)} .$$

But in equilibrium, we must have,

(A7) $$\gamma = \frac{(1-p)b}{p(1-b)}.$$

Suppose, to the contrary, the firm rejects π_g with probability $\gamma > \frac{(1-p)b}{p(1-b)}$. The union can reduce its wage demand a bit and demands $\pi_g - \varepsilon$, which is accepted with probability $\frac{(1-p)b}{p(1-b)}$. As long as ε is small enough, the union will indeed do so and get a higher payoff.

We conclude that the firm in the good state rejects $d_1 \in (d^*, \pi_g]$ with probability $\alpha = \frac{(1-p)b}{p(1-b)}$. ■

II. Proof of Lemma 3.

Given the firm's responses in period one, the three wage demands that might be optimal are π_b, d^*, π_g.

If the union demands π_b, the firm always accepts. The union's expected payoff is π_b;

if the union demands d^* in the first period, the firm accepts if it is in the good state. It rejects the demand d^* and accepts a second period demand

π_b if it is in the bad state. The union's expected payoff is $pd^* + r(1-p)\pi_b$;

if the union demands π_g in the first period, the firm in the bad state rejects. The firm in the good state also rejects if $p < b$, and rejects with probability α if $p > b$. Therefore the union's expected payoff is $r\pi_b$ if $p < b$, and is $p(1-\alpha)\pi_g + rp\alpha\pi_g$ if $p > b$.

The union's expected payoffs from the three wage demands are plotted against its prior p in Figure 2. The figure shows that the wage demands given in lemma 3 are indeed optimal. ∎

III. Proof of Lemma 5

(1) When union i makes a demand $d_i \leq \pi_b$ in period one, firm i always accept irrespective of its state. Bargaining between union i and firm i will not reveal any information about the firms' profits. Therefore firm j and union j will behave as if they were the only bargaining pair.

(2) If $\pi_b < d_i \leq \pi_g$ and $\pi_b < d_j \leq \pi_g$, the payoff tables for the two firms are shown in Figure 3. Recall that the firms always reject such demands when they are in the bad state. Therefore, if the two firms in the good state reject such wage demands, the union's posterior in period two is $p_2 = p$. They demand π_b when $p_2 = p < b$, and π_g if $p_2 > b$. The two firms in the good state accept both demands, yielding expected payoffs $r(\pi_g - \pi_b)$ and zero respectively. If one firm accepts and the other rejects such demands, the unions conclude that the firms are in the good state and demands π_g in period two, since only firms in the good state might accept such demands. Therefore the firm who rejects in period one gets a payoff zero in period two.

From the payoff tables in Figure 3, we can prove that the firms' responses in Lemma 5 are indeed equilibrium responses.

(3). Firm i always rejects a wage demand $d_i > \pi_g$, since acceptance yields a negative payoff. As in (1), bargaining between bargaining pair i reveals no information about the states of the firms. Firm j and union j will behave as if they were the only bargaining pair.

IV. Proof of Lemma 6

(1) If $p > b$, the firms have unique responses in period one. Two symmetric demands that might be optimal are π_b and π_g. When the unions demand π_b, their joint payoffs are $2\pi_b$; when they demand π_g, their joint payoffs are $2p\pi_g + 2(1-p)r\pi_b$. The unions will demand π_g in period one.

(2) If $p < b$, the firms have two equilibrium responses in period one: (a). if the firms adopt the non-coordination responses, the unions' joint payoffs are $2\pi_b$ and $2p\pi_g + 2(1-p)r\pi_b$ when they demand π_b and π_g respectively[12]. Therefore the unions demand π_b if $p < p^{(2)}$ and π_g if $p^{(2)} < p < b$; (b). if the firms adopt the coordination responses, the unions' joint payoffs are $2\pi_b$, $2pd^* + 2(1-p)r\pi_b$, and $2r\pi_b$ when they demand π_b, d^*, and π_g respectively. The unions will demand π_b in period one to maximize the joint payoffs.

Combining (1) and (2), we have Lemma 6. ■

V. Proof of Lemma 8

(1). Suppose the firms in the good state accept a demand $d_i \le \pi_b$ in equilibrium. The firms' joint payoffs are at least $(\pi_g - d_i) + \max\{\pi_g - d_j, 0\}$, where the second term is firm j's payoff. If the firms deviate and reject d_i, the unions will conclude that the firms are in the good state and demand π_g in period two, since the firms would accept if they were in the bad state. The firms' joint payoffs are at most $0 + \max\{\pi_g - d_j, 0\}$. Therefore the firms accept $d_i \le \pi_b$.

Since the firms always accept $d_i \le \pi_b$, irrespective of their states, bargaining with union i reveals no information about the states of the firms. The firms and union j will thus behave as if they were the only bargaining pair.

(2). If $\pi_b < d_i \le \pi_g$ and $\pi_b < d_j \le \pi_g$, it is never in the firms' interest to accept one demand and reject the other. Suppose, on the contrary, firm i accepts and firm j rejects in equilibrium. Union 2 concludes that the firms are in the good state and demands π_g. The firms' joint payoffs are $\pi_g - d_i$. If the firms deviate and accept both demands in period, their joint payoffs are $(\pi_g - d_i) + (\pi_g - d_j)$, which is higher.

Therefore, the two firms will either accept or reject both demands in period one. The rest of the proof is similar to Lemma 2.

(3). The firms must reject union i's demand $d_i > \pi_g$, since acceptance of such a demand yields a negative payoff. Given this fact, we can prove the firms' responses to union j's demand d_j are indeed optimal. The proof is again similar to Lemma 2 and thus omitted. ■

VI. Proof of Lemma 9

We will determine the unions' equilibrium demands in period one for the following three cases separately: (1) $p < b$, (2) $b < p < p^{(1)}$ and (3) $p > p^{(1)}$.

(1) *p < b.* When union i demands d_i and union j demands d_j in period one, union i's expected payoff function is given by,

$$\text{(A8)}\quad V_i(d_i, d_j) = \begin{cases} d_i & \text{if } d_i \le \pi_b \\ pd_i + r(1-p)\pi_b & \text{if } d_j \le \pi_b \text{ and } \pi_b < d_i \le d^* \\ p(1-\alpha)d_i + rp\alpha\pi_g & \text{if } d_j \le \pi_b \text{ and } d^* < d_i \le \pi_g \\ pd_i + r(1-p)\pi_b & \text{if } \pi_b < d_i,\ d_j \le \pi_g \text{ and } d_i+d_j \le 2d^* \\ r\pi_b & \text{if } \pi_b < d_i,\ d_j \le \pi_g \text{ and } d_i+d_j < 2d^*. \end{cases}$$

Therefore, the unique symmetric equilibrium demands are π_b when $p < b$[13].

When $p > b$, union i's expected payoff function is given by,

$$\text{(A9)}\quad V_i(d_i, d_j) = \begin{cases} d_i & \text{if } d_i \le \pi_b \\ pd_i + r(1-p)\pi_b & \text{if } d_j \le \pi_b \text{ and } \pi_b < d_i \le d^* \\ p(1-\alpha)d_i + rp\alpha\pi_g & \text{if } d_j \le \pi_b \text{ and } d^* < d_i \le \pi_g \\ pd_i + r(1-p)\pi_b & \text{if } \pi_b < d_i,\ d_j \le \pi_g \text{ and } d_i+d_j \le 2d^* \\ p(1-\alpha)d_i + rp\alpha\pi_g & \text{if } \pi_b < d_i,\ d_j \le \pi_g \text{ and } d_i+d_j < 2d^*. \end{cases}$$

The three symmetric wage demands that might be in equilibrium are π_b, d^*, and π_g. π_b cannot be equilibrium demands, because the unions will deviate and demand d^* instead.

(2) $b < p < p^{(1)}$. Given the payoff function $V_i(d_i, d_j)$ in (A9), we can show that both d^* and π_g are symmetric equilibrium demands.

(3) $p > p^{(1)}$. It is straightforward but tedious to show that the unique symmetric equilibrium demands are π_g.

Combining (1), (2), and (3), we have Lemma 9. ∎

NOTES

[1]Contrary to the usual formulation of the strategic bargaining models with asymmetric information, they assumes that it is the union rather than the firm who possesses private information. An unattractive feature of their formulation is that it yields an upward-sloping concession schedule, which tends to be rejected by recent empirical studies (McConnel 1989, Card 1990).

[2]When the union makes a wage demand equal to the firm's profit, the firm is indifferent between acceptance and rejection. But in equilibrium the firm must accept the demand with certainty. Assume, on the contrary, that the firm rejects a wage demand with a positive probability when the demand is equal to its profit, then the union can always increase its expected payoff by shading its wage demand a bit such that the firm accepts with probability one.

[3]Throught this chapter, we will ignore borderline cases.

[4]The equilibrium is generically unique, because when $p = b$ or $p = p^{(1)}$, the union have several optimal wage demands.

[5]This follows from our simplifying assumption of perfect correlations between firms' profits. If the firms' profits are not perfectly correlated, strikes may occur in the second pair (Kuhn and Gu 1995a).

[6]Given the history of the game takes this form, we are assuming that a union observes the wage demand of the other union and the firms' response to it.

[7]The two unions demand π_b with probability $\frac{\pi_g - d_j}{2r(\pi_g - \pi_b)}$, and demand π_g with a complementary probability.

[8]We are only interested in the case where the discount factor r approaches 1, or the time elapsed between two consecutive demands is very short.

[9]There exist other asymmetric wage demands. For example, when $p > p^{(1)}$, $(\pi_g + \varepsilon, \pi_g - \varepsilon)$ is equilibrium wage demands as long as ε is small.

[10]Our results are independent of this assumption.

[11]When $r = 1$, we have $p^{(1)} = b$ and $\frac{(1-r)\pi_b}{\pi_g - r\pi_b} = 0$ in Figure 4.

[12]Theses are the only wage demands that might be optimal.

[13]Note there are only two symmetric demands, π_b and d^*, which might be in equilibrium .

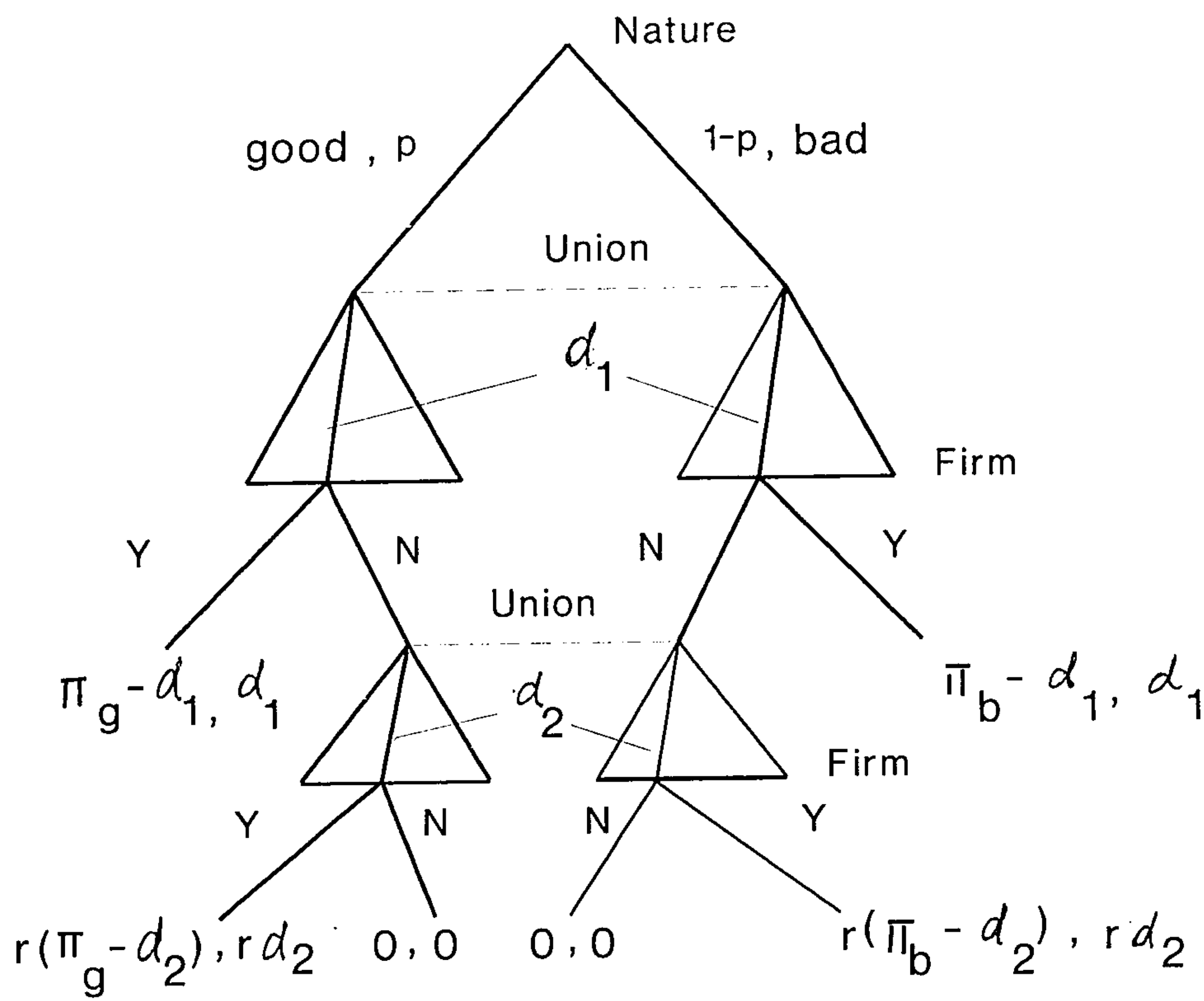

Figure 1. Bargaining Game Between A Single Pair

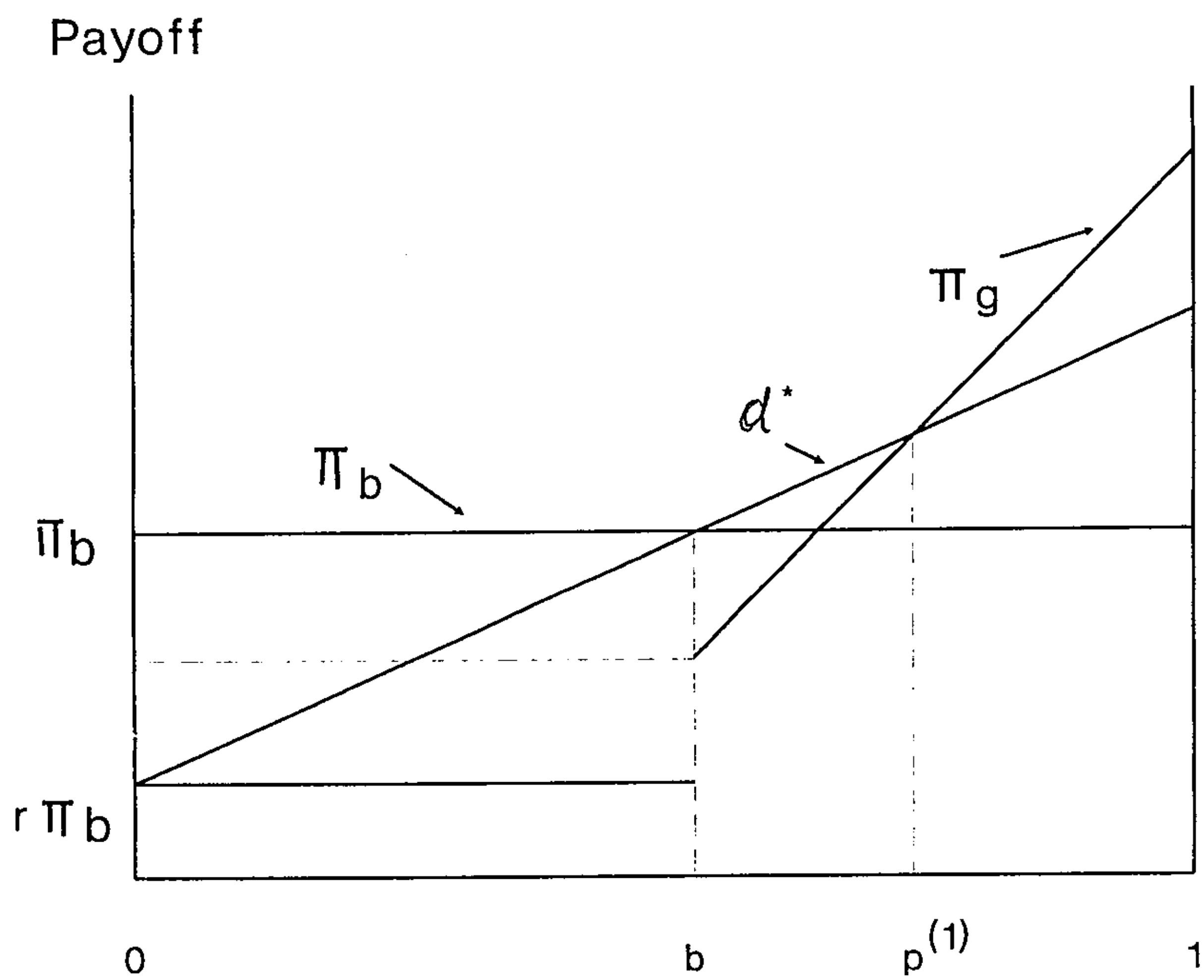

Figure 2. Union's Payoff From different Offers

Figure 3. Payoff Tables for the Firms in Good State

a. p < b

Firm 2

Firm 1	Y	N
Y	$\pi_g - d_1$, $\pi_g - d_2$	$\pi_g - d_1$, 0
N	0, $\pi_g - d_2$	$\delta(\pi_g - \pi_b)$, $\delta(\pi_g - \pi_b)$

b. p > b

Firm 2

Firm 1	Y	N
Y	$\pi_g - d_1$, $\pi_g - d_2$	$\pi_g - d_1$, 0
N	0, $\pi_g - d_2$	0, 0

Figure 4. Wage Settlements and Strike Incidence Under Different Bargaining Structures

a. Sequential Negotiations without Collusion.

1. First pair

Wage Settlements	π_b	$pd^*+(1-p)\pi_b$	$p\pi_g+0$
Strike Incidence	0	$1-p$	$1-p+p\alpha$

Axis: 0, b, $p^{(1)}$, 1

2. Second pair

Wage Settlements	π_b	$p\pi_g+(1-p)\pi_b$	$p\pi_g+(1-p)\pi_b$
Strike Incidence	0	0	0

Axis: 0, b, $p^{(1)}$, 1

b. Union Collusion (Outcomes for Each Pair)

1. Non-coordination responses

Wage Settlements	π_b	$p\pi_g+(1-p)\pi_b$
Strike Incidence	0	$1-p$

Axis: 0, $\frac{(1-\delta)\pi_b}{\pi_g-\delta\pi_b}$, $p^{(1)}$, 1

2. Coordination responses

Wage Settlements	π_b	$p\pi_g+(1-p)\pi_b$
Strike Incidence	0	$1-p$

Axis: 0, b, $p^{(1)}$, 1

Figure 4. (Continued)

c. Firm Collusion (Outcomes for Each Pair)

1. Non-coordination demands

	0 – b	b – 1
Wage Settlements	π_b	$p\pi_g+(1-p)0$
Strike Incidence	0	$1-p+p\alpha$

0 b $p^{(1)}$ 1

2. Coordination demands

	0 – b	b – $p^{(1)}$	$p^{(1)}$ – 1
Wage Settlements	π_b	$pd^*+(1-p)\pi_b$	$p\pi_g+0$
Strike Incidence	0	$1-p$	$1-p+p\alpha$

0 b $p^{(1)}$ 1

d. Union and Firm Collusion (Outcomes for Each Pair)

	0 – b	b – $p^{(1)}$	$p^{(1)}$ – 1
Wage Settlements	π_b	$pd^*+(1-p)\pi_b$	$p\pi_g+0$
Strike Incidence	0	$1-p$	$1-p+p\alpha$

0 b $p^{(1)}$ 1

CHAPTER 4

A THEORY OF HOLDOUTS IN WAGE BARGAINING

4.1 Introduction

Understanding the determinants of union bargaining outcomes has long been a central issue in labor and macroeconomics. Recently, this issue has taken on a new relevance as the institutional structures of wage bargaining in many countries are undergoing dramatic changes (e.g. Freeman and Gibbons 1994), and as a number of newly independent countries seek advice on the design of their industrial relations systems.

Until recently, a significant gap in research on union bargaining has been the tendency of most models to ignore an important option available to the parties involved. That option is simply to continue working under the terms of preexisting agreements after they expire (i.e. to "hold out"), rather than proceeding immediately to a strike or lockout. As a result, these models generated results whose applicability to real-world contract negotiations were questionable, and which differed considerably from results when that option is allowed (see, e.g. Fernandez and Glazer 1991). As another consequence, with the recent exception of Cramton and Tracy (1992, 1994), very little has been learned about the role of holdouts in wage bargaining, especially compared to other bargaining outcomes, such as wages and strikes.

In this paper, we seek to further our understanding of union wage bargaining by proposing and testing a new model of holdouts. A key distinguishing feature of the model is its focus on the interactions between multiple bargaining pairs in an industry: in contrast to Cramton and Tracy, who treat strikes and holdouts as alternative threats a single union can impose on a single firm, we model holdouts as a delaying tactic employed by unions to obtain information from other bargaining outcomes in their industry. More specifically, if unobservable aspects of firms' ability to pay are correlated within industries, a union can acquire valuable information about its own firm's ability to pay by observing the bargaining outcomes of other unions (Kuhn and Gu 1994a). When a number of contracts expire at the same time, an information externality, similar to those in recent sequential learning models (Rob 1991; Bolton and Harris 1993) arises: each union has an incentive to delay its settlement and let the other unions conclude their negotiations first[1].

Like Cramton-Tracy's model, our *sequential learning* model of holdouts predicts that holdouts should be shorter and less frequent when the wage settlement in the existing contract is lower, and when unions are more optimistic about the firm's ability to pay. More novel features of our model include the following: First, it is capable of generating, in a very simple fashion, holdouts which are *followed* by strikes (in our data, strikes almost never occur in the absence of a prior holdout). Second, while allowing for the possibility, the model does not require the *ad hoc* assumption of a production inefficiency during holdouts to generate holdouts. Third, the model predicts (a) an increasing hazard rate for holdouts; (b) increasing holdout duration with the length of the contract being negotiated; and (c) increasing holdout duration with the number of bargaining pairs negotiating simultaneously in an industry, as the information externality identified above is exacerbated by the addition of more bargaining pairs.

We examine these implications using a large sample of contract negotiations in Canadian manufacturing industries for the period from 1965 to 1988. While perhaps best seen as suggestive rather than conclusive, and while not necessarily inconsistent with other models of holdouts, the results are remarkably consistent with our view of holdouts as a "waiting game" that is played among a group of unions. If so, these results also illustrate the importance of the *context of other negotiations in the industry* as a determinant of labor bargaining outcomes-- a context which to date has been relatively neglected by economists.[2] As this context can be heavily influenced by the nature of a country's industrial relations system (consider, for example, variations in the timing, coordination, and centralization of wage bargaining both within and across industries), analyses which --like the present one-- address this context may have useful implications for both the design of new industrial relations systems and the reform of old ones.[3]

Section 4.2 of the paper presents a model with two bargaining pairs, in which the bargaining pairs negotiate their contracts simultaneously. The model illustrates unions' incentives to delay their wage settlements (or hold out), in order to gain better information about their firms' ability to pay by observing the bargaining outcomes in other unions. To determine how long to hold out, unions trade off the benefits of learning from others against the cost associated with delayed wage settlements. Section 4.3 investigates how holdout durations vary with existing wage settlements, contract durations and unions' beliefs about firms' ability to pay. Section 4.4 extends the model to the case of more than two bargaining pairs, demonstrating that as the number of bargaining pairs expands, expected holdout durations increase. Section 4.5 describes the data used in our empirical analysis. Section 4.6 presents the results of that analysis, and Section 4.7 concludes.

4.2 A Model

Consider two bargaining pairs: bargaining pair one (union 1 and firm 1) and bargaining pair two (union 2 and firm 2). The existing contracts for both pairs have expired at the same date, and both are negotiating the wage to be paid during a contract of duration T. Informally, the game between the two unions and firms can be described as follows: at each instant, each union decides whether to start to play a negotiation game with its firm, conditional on its not having started by that date. To focus on the main issue of the paper --the incentive by unions to hold out in order to learn about their firms' ability to pay from bargaining outcomes in other unions-- we shall use a very simple negotiation game. In this game, the firm has private information about its ability to pay, and the union makes a take-it-or-leave-it offer, to which the firm responds. This negotiation game has been analyzed by Fudenberg and Tirole (1983), and has been used by Kuhn and Gu (1994a) as an example to illustrate social learning and strikes.

Formally, the game is described as follows: Time is continuous from 0 to T, and the discount rates for both unions and firms are r. First, at (or before) time 0 (the expiration date of the previous contracts), nature determines whether the firms are in the good or bad state. Their profits gross of labor costs are $\pi_g > \pi_b > 0$ in these two states respectively. The firms know their own states, but the unions do not. However, the unions share a common prior distribution over the joint probabilities of the states in the two firms, which is described in Table 1: the probability that firm 1 is in the good state, g_1, equals the sum of the joint probabilities p_{11} and p_{12}; b_1, b_2 and g_2 are defined analogously. The conditional probabilities corresponding to Table 1 are:

(1) $$P(2G|1G) = p_{11} / (p_{11} + p_{12})$$

(2) $$P(2G|1B) = p_{21} / (p_{21} + p_{22})$$

(3) $$P(1G|2G) = p_{11} / (p_{11} + p_{21})$$

(4) $$P(1G|2B) = p_{12} / (p_{12} + p_{22})$$

Where 1G indicates a good state in firm 1, etc.. We assume, without loss of generality, that firm one is at least as likely to be in the good state as firm two, i.e. $g_1 \geq g_2$; and we restrict our attention to the case of positive correlation between the firms' profits. By definition, the two firms' profits are positively correlated if and only if

(5) $$P(jG|iG) > g_j \text{ , and } P(jB|iB) > b_j \text{ for } i \neq j = 1, 2.$$

This simply means that after observing the other firm i to be in the good (bad) state, union j becomes more optimistic (pessimistic) about its firm's profit and hence updates its prior upwards (downwards).

After the states of the two firms are determined, at each instant each union decides whether to make a wage demand, conditional on its having not made a demand before that instant. If a union decides to make a wage demand at time t ($0 \leq t \leq T$), it then chooses the magnitude of the wage demand d $\in$

$[0,\infty)$, to which the firm responds immediately by accepting or rejecting that wage demand. Acceptance means exchange takes place at the wage demanded by the union, with the union receiving the wage demand d and the firm receiving its profit net of the wage demand for the remaining period $[t, T]$; rejection means both parties get their alternative utility level for the remaining period $[t,T]$, which are normalized to zero. During the course of contract negotiations, each union observes what is going on in the contract negotiations of the other bargaining pair: specifically, it observes whether the other union has already made a demand, whether the firm has accepted, and the magnitude of the wage settlement if the firm has accepted.

To conclude the specification of the game, we need to specify the payoffs of both parties for the period from the expiration of the previous contracts to the time when unions make a wage demand. That period is defined as a holdout in Cramton and Tracy (1992). In the U.S. according to the National Labor Relations Act, the terms and conditions of employment during holdouts are governed by the previous contract. In Canada, similar laws apply. Therefore, during a holdout, a union is paid the wage rate in the previous contract and a firm receives its profit net of the wage cost, specifically, union 1 is paid w_1 and union 2 is paid w_2.

The payoff flows of both parties in bargaining pair i (i =1,2) are summarized in Figure 1. Note that during the period of a holdout, a firm's profit π_i' might be lower than its profit π_i in the normal production period after the conclusion of contract negotiations. Cramton and Tracy (1992) give a number of potential reasons for such inefficiencies; for example workers may be more likely to work to rule during a holdout; potential customers and suppliers may be reluctant to deal with firms if a holdout signals a greater likelihood of an impending strike; a holdout may delay changes in work rules which might increase productivity. It is worth noting, however, that unlike earlier models, these inefficiencies are not required to generate holdouts in the current model: positive holdouts will occur here even when $\pi_i = \pi_i'$.

For the remainder of the paper we shall assume that wage settlements in the previous contracts are lower than the firms' profit in the bad state π_b, i.e. $w_i < \pi_b$ for i = 1, 2. Otherwise, if the existing wage settlements are greater than the firms' profits in the bad state ($w_i > \pi_b$ for i =1,2), unions have no incentive to make a wage demand and conclude contract negotiations when they are sufficiently pessimistic about the firms' ability to pay.

An equilibrium of the above game consists of unions' strategies, firms' strategies and unions' beliefs. A union's strategy consists of the timing and magnitude of its wage demand. Specifically, at each instant a union decides whether to make a wage demand and the magnitude of its wage demand, conditional on its having not done so before that instant. A firm's strategy is simply its acceptance decision. In a perfect Bayesian equilibrium, we must have: 1). the strategies of all players are optimal; and 2). the unions's belief is consistent with Bayes law for any possible history of the game whenever it is applicable.

We now proceed to characterize the perfect Bayesian equilibrium of the game. We shall do so via two steps. First, taking as given the timing of both unions' wage demands, we derive the unions' optimal wage demands and the firms' responses (lemma 1); we then note that the game between the two unions in choosing the time of their wage demands is a war of attrition game. We use this fact to determine the timing of the unions' wage demands (Propositions 1, 2 and 3).

Lemma 1. 1. Each firm accepts a wage demand if and only if it is less than or equal to its profit;

2. If the two unions decide to make wage demands at the same time t, union i (i=1,2) demands π_g if $g_i > \pi_b / \pi_g$ ($\equiv$ b), and demands π_b if $g_i < b$[4];

3. If union i makes a wage demand before union j, then union i demands π_g if $g_i > b$ and π_b if $g_i < b$; union j demands π_g if $p_j > b$ and π_b if $p_j < b$, where p_j is the posterior belief of union j after observing the outcomes in union i. It is calculated as follows: $p_j = g_j$ if the wage settlement in union i is π_b; $p_j = P(jG|iG)$ if the high wage settlement π_g is reached without a strike in union i; $p_j = P(jG|iB)$ if a strike occurs in union i.

Proof. See Appendix.

When unions make wage demands at different times, unions who make demands later have an opportunity to learn from the outcomes in previous negotiations. As demonstrated and empirically confirmed in Kuhn and Gu (1994a), the opportunity to learn from others raises unions' utilities and reduces strikes. Intuitively, this follows from the fact that unions' learning improves their information about firms' ability to pay. Therefore, when two contract negotiations proceed simultaneously in an industry, each union has an incentive to hold out and let the other union conclude negotiations first, thus learning from the outcomes in the other union. However, by so doing, the union is paid the existing lower wage during the period of holdout and has to delay a possible higher wage settlement. Unions trade off the benefit of the opportunity to learn from others against the cost associated with delayed higher wage settlements to decide the timing of their wage demands.

Propositions 1, 2 and 3 characterize the optimal timing and magnitude of the unions' wage demands in the perfect Bayesian equilibrium for various values of the two unions' priors g_1 and g_2.

Proposition 1. If $g_1 < b$ and $g_2 < b$, both unions demand π_b immediately at time 0.

Proof. See Appendix.

In this case where both unions are sufficiently pessimistic about firms' ability to pay, they make low wage demands of π_b immediately after the expiration of the previous contracts. Both firms will always accept. Neither holdouts nor strikes occur.

Proposition 2. If $g_1 > b$ and $g_2 < b$, in the unique perfect Bayesian equilibrium the two unions' optimal strategies must have the following features:

1. union 1 makes a high wage demand of π_g at time 0;

2. when $P(2G|1G) < b$, union 2 makes a low wage demand of π_b at time 0; when $P(2G|1G) > b$, it makes a wage demand immediately after union 1, with the magnitude of the demand depending on the outcome in union 1: it demands π_g if union 1 doesn't strike and demands π_b if union 1 strikes.

Proof. See Appendix.

The most interesting case is in Proposition 3, when $g_1 > b$ and $g_2 > b$. In that case if the two firms' abilities to pay are highly correlated such that $P(1B|2B) > 1-b$ and $P(2B|1B) > 1-b$, there exist many Perfect Bayesian equilibria. However, the one equilibrium involving randomization by both unions seems to be the natural candidate in the present context where unions have strategic uncertainty about the timing of the other unions' wage demands (see also Chamley and Gale 1994). Furthermore, as Osborne (1985) has shown, that is the only equilibrium that satisfies a particular version of trembling-hand perfection.[5] In what follows, we shall focus on this particular equilibrium only. In this equilibrium, both unions adopt mixed strategies in choosing the time of their wage demands, and union i makes a wage demand between time t and t +dt with probability $h_i(t)dt$, conditional on neither union having made an offer at time t. Thus $h_1(t)$ and $h_2(t)$ are hazard rates for making the first offer in the industry.

Proposition 3. When $g_1 > b$ and $g_2 > b$, the equilibrium strategies of the two unions must have the following features:

1. If the firms' profits are highly correlated such that $P(2B|1B) > 1-b$ and $P(1B|2B) > 1-b$, union i makes a wage demand with probability $h_i(t)dt$ between time t and t+dt, conditional on neither having made a demand at t, where

(6) $$h_1(t) = \frac{r(g_2\pi_g - w_2)}{(1-g_1)\pi_g[(b - P(2G|1B)]} \frac{1}{1-e^{-r(T-t)}}, \text{ and}$$

(7) $$h_2(t) = \frac{r(g_1\pi_g - w_1)}{(1-g_2)\pi_g[(b - P(1G|2B)]} \frac{1}{1-e^{-r(T-t)}}.$$

The union which makes a demand first demands π_g; immediately after that union has made a wage demand, the other union demands π_b if a strike occurs in the preceding negotiation, and demands π_g if no strike occurs in the preceding negotiation[6].

2. If the firms' profits are highly uncorrelated such that $P(1B|2B) < 1-b$ and $P(2B|1B) < 1-b$, both unions demand π_g immediately at time 0.

3. If the degree of correlation between the firms' profits is in an intermediate range such that $P(1B|2B) < 1-b$ and $P(2B|1B) > 1-b$, union 1 demands π_g at time 0 and union 2 makes a wage demand immediately afterwards. It demands π_g if union 1 doesn't strike and demands π_b if union 1 strikes.

Note by the assumption $g_1 > g_2$, we have $P(2B|1B) > P(1B|2B)$.

Proof. See Appendix.

One simple prediction of our model follows directly from (6) and (7). Note that whenever unions adopt mixed strategies (i.e. whenever there are positive holdouts in the current model), the hazard rates $h_1(t)$ and $h_2(t)$ are increasing functions of time: as time proceeds, the (discounted) benefits of learning from others to obtain high wage settlements decrease and thus unions are more likely to make wage demands. It is also interesting to note that, in all cases where the equilibrium does *not* involve randomization, the unions either move simultaneously or union 1 (which has the higher *ex ante* prior of its firm being in the good state) moves first. This accords with the notion in the industrial relations literature that unions may "target" high-profitability firms in an industry first.

If the firms' profits are perfectly correlated, i.e. $p_{12} = p_{21} = 0$ in Figure 1, we have the following corollary. (denote p_{11} by p : the probability that both firms are in the good state)

Corollary 1. If the firms' profits are perfectly correlated, the unions' strategies must have the following features:

1. if $p < b$, both unions make a low wage demand of π_b immediately at time 0;

2. if $p > b$, conditional on neither union having made a wage demand at t, union i (i=1,2) makes a wage demand between t and t + dt with probability $h_i(t)dt$, where

(8) $$h_1(t) = \frac{r(p\pi_g - w_2)}{(1 - p)\pi_b} \cdot \frac{1}{1 - e^{-r(T-t)}};$$

(9) $$h_2(t) = \frac{r(p\pi_g - w_1)}{(1 - p)\pi_b} \cdot \frac{1}{1 - e^{-r(T-t)}}.$$

The union which moves first demands π_g. After a union makes a demand, the other union makes a demand immediately afterwards: it makes a high wage demand of π_g if there was no strike in the preceding negotiation and makes a low wage demand of π_b if there was a strike.

4.3 Comparative Studies

In this section we investigate how holdout durations vary with the parameters of the model, in particular the wage settlements in the previous contracts and the probability that firms are in the good state. For simplicity, we restrict our attention to the case where the firms' profits are perfectly correlated.

Proposition 4. 1. The higher are the existing wage settlements, the longer are holdout durations;

2. The lower is the probability that firms are in the good state, the longer are holdout durations;

3. The longer is the contract duration, the longer are holdout durations.

Proof. See Appendix.

When the wage settlements in the previous contracts increase, the cost of delaying wage settlements decreases, which leads to longer holdouts. Similarly, when unions believe it is less likely that firms are in the good state, they expect lower wage settlements, and the cost of delaying is then lower. This causes longer holdout durations. Finally, when contract durations increase, the discounted benefit of learning from others to obtain higher wage settlements increases. Unions then have a greater incentive to delay wage settlements. In Sections 4.5 and 4.6, we test these implications of our model.

4.4 N (N>2) Bagaining Pairs

In this section we extend the model in Section 4.2 to the case of n (n > 2) bargaining pairs and see how expected holdout curations vary with the number of bargaining pairs in an industry. For simplicity, we assume that the firms' profits in the n bargaining pairs are perfectly correlated. With probability p all n firms are in the good state; and with probability 1-p all n firms are in the bad state. As before, the firms' profits gross of labor cost are π_g and π_b in those two states respectively. Finally, we assume that wages in all previous contracts are w. Proposition 5 identifies the unique symmetric equilibrium of the game.[7]

Proposition 5. In the unique symmetric perfect Bayesian equilibrium, the unions' strategies must have the following features:

1. if $p < b$, all n unions make the low wage demand of π_b immediately at time 0;

2. if $p > b$, conditional on none of the unions having made a demand at t, each union makes a wage demand between time t and t+dt with probability h(t)dt, where

$$h(t) = \frac{r(p\pi_g - w)}{(n-1)\ (1 - p)\pi_b} \cdot \frac{1}{1 - e^{-r(T-t)}} \equiv \frac{1}{(n-1)} A(t). \tag{10}$$

The union which makes a wage demand first demands π_g. Immediately after a union has made a wage demand, all other unions make wage demands: they make the high wage demand π_g if there was no strike in the preceding negotiation and make the low wage demand π_b if there was a strike.

Proof. See Appendix.

In equation (10), a higher number of negotiations, n, leads to a lower hazard h(t) at every instant $t \in [0,T]$. As the number of negotiations in an industry increases, each union thus has a greater incentive to delay making the first wage demand. Intuitively, as the number of negotiations in the model expands, a union's expected benefit of delaying its wage demand rises because it expects a higher probability that at least one of the other unions will make a demand during that period of delay, thus learning about its firm's ability to pay.

Given n unions all making the first wage demand with probability h(t)dt, and given the result that all other unions make a demand immediately after the first one, the overall hazard rate for holdouts ending in each of the n firms is just given by:

$$(11) \quad H(t) = \frac{n}{(n-1)} A(t),$$

which is also decreasing with n, but at a diminishing rate. Intuitively, as the number of unions expands, the probability of each union making the first offer falls at a rate proportional to 1/(n-1), which depends on the number of *other* unions (n-1) from whom useful information might be gathered by waiting. At the same time, the total number of unions making offers with probability h(t)dt expands at a rate proportional to n. Since the former effect dominates the latter (n/(n-1) falls with n), we expect average holdout duration (which is inversely related to the hazard) to increase with n, but at a decreasing rate. In Sections 4.5 and 4.6, we test this implication using a large sample of contract negotiations in Canadian manufacturing industries.

4.5 Data

In our empirical investigation, we shall focus on three of the more novel implications of the current model, on which existing models of holdouts appear to be silent. Specifically, we consider the effects of increasing the number of negotiations taking place simultaneously in an industry on holdout durations, the effect of contract duration on holdout durations, and the structure of the hazard rate for holdouts over time.

Our data come from two sources: Labor Canada's Wages File, and their Work Stoppages File. Labor Canada's Wages File provides information on the settlement, effective, expiry date and other characteristics of all Canadian collective bargaining contracts involving 500 or more workers from 1965 to 1988[8]. The Wages File supplies data on start and end dates of strikes for a broader sample of negotiations. Combining information from these two sources, we define holdouts as the period between the expiry date of old contracts and settlement date of new contracts if no strike occurs, or the period between the expiry date of old contracts and the time a strike begins if a strike occurs. Details of the merging process, as well as the criteria used to remove duplicate negotiations from the data are provided in Harrison (1994).

In this paper, we focus on holdouts in manufacturing industries, within which it is possible to generate particularly long series of negotiations within fairly detailed, consistently defined industry groups. In total, the Wages File contains data on 2,888 wage negotiations, which comprise 20 two-digit manufacturing industries, or 82 three-digit industries over this period. After excluding industries with fewer than 10 contract negotiations over the entire period, plus the "miscellaneous manufacturing" category, we are left with 2826 negotiations in 17 two-digit industries, or 2747 negotiations in 55 three-digit industries, as our basic sample for analysis[9].

Some basic descriptive statistics on our sample of negotiations are provided in Table 2, which focuses on the two-digit sample. More detailed statistics, broken down by 2- and 3-digit industries, are provided in Appendix Tables A1 and A2. Together, these Tables indicate the following. First, for the period 1965-1988 the average dispute (strike and/or holdout) incidence is 84.9 percent and the median (mean) dispute duration (conditional on a dispute occurring) is 61 (83.5) days. These are considerably higher than those in the U.S. reported by Cramton and Tracy (1992), which are 57 percent and 37 (65) days respectively for the period 1970-1989. Secondly, holdouts are common, and considerably more common than strikes. For the period between 1965 to 1988, the incidence of holdouts only is 64.2 percent, while the incidence of holdouts followed by strikes are 20.2 percent, yielding a total holdout incidence of 84.4 percent, compared to 20.7 percent for strikes. Third, almost all strikes take place only *after* a holdout has occurred.[10]

Fourth, there is considerable variation in holdout duration across industries. Across two-digit industries the incidence of holdouts ranges from a high of 97.1 percent in leather to a low of 66.4 percent in chemical products. The average duration of holdouts ranges from 120.1 in paper to 41.1 in furniture; similar, but somewhat greater ranges for both incidence and duration are found across three-digit industries.[11] Fifth, the average contract negotiation in both our samples covered a little over 1300 workers, and the mean duration of negotiated contracts was about 27 1/2 months, with quite a narrow range across industries: from 21.8 to 34.7 across two-digit industries, and from 20.3 to 34.7 across three-digit industries.

Finally, consider the number of concurrent negotiations for each negotiation in our sample. Concurrent negotiations are defined as those with the same (calendar) expiry date for the *previous* contract within each negotiation's (2- or 3-digit) industry.[12] Table 2 indicates that the average negotiation in the two digit industry sample had 3.4 concurrent negotiations; this however varies considerably, with 10% having 7 or more concurrent negotiations. Across industries, there is also considerable variation in this number. For example, across 2-digit industries, it ranges from 1.0 in furniture and leather to a high of 13.8 in the paper industry, which is much higher than any other industry.[13] Very suggestively, the pulp and paper industry also has the longest mean holdout duration as well. While this is encouraging for our model, more detailed analysis of the data, both within industries and across industries, with allowance for the fact that the very distinct paper industry might be a special case, and with statistical controls for other possible determinants of holdout duration, is clearly required.

To illustrate trends in the level and type of disputes over time, Figures 2 and 3 plot the incidence and mean duration of strikes and holdouts over the period of the data. These Figures show that holdout incidence and duration are higher, respectively, than strike incidence and duration across all years in the sample. Interestingly, while strike incidence exhibits a well-known decline in the 1980's, little or no trend is evident in holdout incidence over the entire period. Time series of both strike and holdout durations appear to be significantly noisier after 1975 than before, but with no clear trend in their levels either. To illustrate how rapidly holdouts are settled over time, the Kaplan-Meier empirical hazard is shown in Figure 4. The hazard in Figure 4 is the fraction of holdouts ongoing at the start of a week which end during the week. The hazard is roughly constant for the first 15 weeks at 9 percent, is then increasing between 16 to 22 weeks, and displays no trend afterwards.

Finally, the raw empirical correlation between the number of concurrent negotiations and holdouts is presented in Table 3. Strikingly, in both the two- and three-digit industry data, both holdout incidence and duration are monotonically increasing with the number of concurrent negotiations, with mean holdout duration ranging from 45 days when there is only one negotiation expiring at a time, to 120 days when there are 11 or more. Again, this is suggestive, but more in-depth analysis is clearly required.

4.6 Empirical Analysis

1. Holdout Durations.

Given the fact that a holdout occurs in 84.9 percent of all negotiations in our sample, our main focus in this paper is on holdout durations, rather than incidence.[14] The main purpose of the empirical analysis is to assess the effect of the number of concurrent negotiations and contract duration on holdout duration while controlling for other factors which might influence holdout duration, and to estimate the shape of the hazard rate for holdouts, controlling for observable characteristics of the negotiations.

Aside from the number of concurrent negotiations in each negotiation's industry and the length of the contract being negotiated, observed covariates for which we are able to control include the monthly index of industrial production, the logarithm of the number of workers in the bargaining unit, a cubic in time, 11 dummies for months during which previous contracts expired, and dummies for regions and industries. The monthly index of industrial production (deseasonalized and detrended) is designed to capture any cyclical factors affecting holdout durations. This variable is constructed as the residuals from a regression of a 12-month moving average of the logarithm of the index of industrial production on a cubic spline in time (see Harrison and Stewart (1989) for details). The size of a bargaining unit is included because of its documented impact on strikes (Harrison and Stewart 1993) and the possibility of a similar effect on holdout duration as well. The cubic in time is included to allow for the possibility of a trend in holdout durations; 11 month dummies and 4 region dummies will capture any seasonal or regional fixed effects in contract negotiations. Finally, although we can think of no obvious objection to using the cross-industry variation in the number of concurrent negotiations to identify the effects of that variable, we report some specifications which use industry dummies to focus on within-industry variation alone.

Parameter estimates from an OLS model of log durations are on the two- and three-digit samples are presented in Tables 4 and 5 respectively.[15] In view of the very distinctive nature of the Canadian pulp and paper industry in this regard, estimates are presented both with and without that industry included. In both tables, standard errors are adjusted for the fact that error terms may be correlated within concurrent negotiations using Huber's (1967) formula.

Focusing first on the two-digit results in Table 4, we first note that the number of concurrent negotiations has positive, but diminishing marginal effects on expected holdout durations in all four specifications shown.

Holdout durations are maximized at 20, 21, 6 and 5 concurrent negotiations in columns 1-4 respectively, which implies an increasing effect over almost all observed X's in each case. Perhaps not surprisingly, the effect is most significant when when the pulp and paper industry is included without allowing for industry fixed effects, but the specifications with fixed effects and excluding pulp and paper indicate that the effect is not due only to differences between the paper industry and other industries. Since we can think of no obvious reason why our results without the industry dummies might be spurious however, we shall focus on these, more precise, estimates in most of the following discussion. In essence, we shall proceed on the assumption that industries, including paper, with long holdout durations, have such long durations in part *because* of the synchronized, but decentralized bargaining structures in those industries.[16]

To get an idea of the magnitude of the effects identified in column 1 of Table 4, we note that raising the number of negotiations taking place simultaneously from 1 to 2 increases the predicted holdout length for the entire sample from 39 to 44 days; raising it further to five, then to ten increases the holdout length to 58 and 84 days respectively. Relative to the median holdout duration of 55 days in our 2-digit industry sample, these seem to be quite large effects.

The coefficient on the duration of contracts in all columns of Table 4 is positive and, for the most part, statistically significant, indicating that longer contracts give rise to longer holdouts, as is predicted by Proposition 4. The negative and statistically significant coefficient on the size of a bargaining unit suggests that holdouts are shorter in larger bargaining units. In none of the specifications were any of the coefficients of a cubic in time (not reported) significant, indicating no presence of any trend in holdout durations. Finally the coefficient on the index of industrial production in all columns are statistically insignificant. This suggests that, unlike strike durations, holdout durations exhibit no cyclical pattern (Harrison and Stewart 1989).

Table 5 reports estimates of holdout durations when the relevant negotiations are assumed to be those in the same three-digit industry. Overall the results are very similar to those in Table 4, with a positive but diminishing marginal effect of concurrent negotiations on holdout durations, and a positive effect of contract duration. Conditional on negotiations being synchronized, this suggests that the informational value of observing other settlements within narrower, three-digit industries is not significantly greater than that of settlements within the broader, two-digit context.

Both to assess the robustness of the above results to functional form assumptions, and to generate estimates of the dependence of the holdout hazard on elapsed time, we also estimated a variety of proportional hazards models for holdouts. In all these models, the hazard for ending the holdout in contract negotiation i at time t is given by

$$H_i(t) = e^{-\beta' X_i} H_0(t). \tag{12}$$

In (12), $H_0(t)$ is the baseline hazard at time t, X_i is a vector of explanatory variables for contract negotiation i, and β is a vector of parameters to be estimated. As is well known, this specification implies that the explanatory variables influence the scale of the hazard rate, but not the form of its dependence on time.

To estimate the baseline hazard, a number of parametric and semiparametric approaches are used. Among parametric approaches, we consider both exponential and Weibull models; these models impose a constant baseline hazard and a monotonic baseline hazard respectively. Among semiparametric approaches we implement both Cox's partial likelihood technique, which allows for an arbitrary baseline hazard but does not estimate it, and the discrete hazard approach used by Meyer (1988), which estimates a piecewise-constant baseline hazard.[17]

Results from all four proportional hazard models are reported in Tables 6 and 7 for two- and three-digit industries respectively. Overall, the results in Tables 6 and 7 are similar to those in Tables 4 and 5, indicating that the effect of the number of concurrent negotiations is quite robust to functional form assumptions. Further, there is evidence of an increasing baseline hazard rate over time, consistent with the model, and with the raw hazards shown in Figure 4. For example, the estimates of σ from the Weibull model are .883 and .877 when the relevant negotiations are assumed to be those in the same 2-digit industry and 3-digit industry respectively (Tables 6 and 7). Both estimates are (very significantly) less than 1, indicating an increasing hazard. Figures 5 and 6 plot the estimates of the piecewise-constant baseline hazard from the discrete hazard analysis, which also clearly show an increasing hazard.

2. Holdout Incidence.

Table 8 reports estimates of a simple probit model for holdout incidence, using the same covariates as our analysis of durations. Aside from the technical difficulties of incorporating zero durations into certain duration models[18], a main reason estimating a separate model for incidence is that our model predicts a mass point in the density of completed holdout durations at zero: For all the combinations of parameter values for which unions do *not* use randomized strategies, holdouts are predicted to be exactly zero. Overall the results are very similar to those for holdout durations: The number of negotiations taking place simultaneously in a two- or three-digit industry is found to have a negative effect on the probability of a holdout occurring.[19] Unions are more likely to hold out when they negotiate contracts of longer duration.. Like holdout durations, holdout incidence displays no cyclical behavior.

4.7 Conclusion

In this paper we propose a new explanation of the most common form of labor contract disputes: holdouts. Unlike previous models, our model focuses on the information externality which arises among unions and firms in the same industry. Holdouts are modeled as a delaying tactic, employed by unions to obtain information from bargaining outcomes of other unions in their industry. A main implication of the model, on which previous models of holdouts are silent, is the following: as the number of negotiations in the model expands, unions have a greater incentive to delay their wage settlements in order to learn from the outcomes of other negotiations, generating longer holdouts. We test this implication using a large sample of contract negotiations in Canadian manufacturing industries from 1965-1988, with generally positive results. Other predictions of the model which are confirmed by the data are (i) an increasing hazard rate for holdout settlement over time; and (ii) a positive effect of contract duration on holdout duration.

While we view our empirical results in this paper more as suggestive than as conclusive evidence in favor of the model presented here, and while we see the model developed here as complementary rather than competing with existing models of holdouts (e.g. Cramton and Tracy 1992), we do see an important lesson emerging from the current model's apparent success. In particular, especially when seen in conjunction with our related work on strikes (Kuhn and Gu 1994a; 1994b) these results strongly suggest that future work on wage negotiations and strikes can gain significantly by paying closer attention to the *context of other negotiations in the industry*. Unfortunately, despite its key role in the industrial relations literature, and despite its potential importance in explaining both intranational and cross-national differences in the performance of industrial relations systems, this context has been largely neglected by both economists, both theoretical and empirical, to date.

APPENDIX

I. Proof of Lemma 1

1. This results immediately from the fact that each union's offer, once made, is a take-it-or-leave-it offer.

2. If the two unions make wage demands simultaneously, neither union has a previous negotiation from which to acquire any information. The optimal wage demand depends on the value of each union's prior about its firm's state. Specifically, union i makes a "high" wage demand of π_g if $g_i > b$, and makes a low wage demand π_b if $g_i < b$.

3. If union i makes a wage demand before union j, union i's optimal wage demand will be exactly the same as in point 2 above: it has no previous negotiation from which to acquire any information. Union j's optimal wage demand however now depends on what it observes from the preceding negotiations, since this affects its optimally updated prior, p_j, that firm j is in the good state. Specifically, union j demands π_g if $p_j > b$ and π_b if $p_j < b$. Union j's posterior in each of the three possible outcomes of the preceding negotiations are calculated as follows:

(i) *Low wage settlement* π_b *in union i.* When $g_i < b$, union i makes a low wage demand of π_b, which firm i will always accept. Union j clearly learns nothing from the outcome of the previous negotiations. Its posterior is the same as its prior $p_j = g_j$.

(ii) *High wage settlement* π_g *without a strike in union i.* When $g_i > b$, union i makes a high wage demand of π_g. If firm i accepts this demand, it must be in the good state. Union j's updated prior that firm j is in the good state is then $p_j = P(jG|iG)$.

(iii) *Strike in union i.* When $g_i > b$, union i makes a high wage demand of π_g. If firm i rejects this wage demand and a strike ensues, it must be in the bad state. Union j's updated prior that firm j is in the good state is then $p_j = P(jG|iB)$. ∎

II. Proof of Proposition 1

Suppose that union i (i=1,2) makes a wage demand at time $t \in [0,T]$. If union i makes a wage demand before or at the same time as the other union j, it makes a low wage demand of π_b, since its prior is $p < b$; if union i makes a wage demand after the other union j, it observes a low wage settlement of π_b in union j. It clearly learns nothing from the outcomes of previous negotiations. Its updated prior is $p < b$ and its optimal wage demand is then π_b. Therefore union i will always make a low wage demand of π_b, no matter when the other union makes a wage demand. Union i's expected payoff is:

$$\text{(A1)} \qquad \int_0^t w_i \, e^{-rt} \, dt + \int_t^T \pi_b \, e^{-rt} \, dt.$$

It is a dominant strategy for union i to make a low wage demand of π_b at time 0, since $w_i < \pi_b$ by assumption.

III. Proof of Proposition 2

Suppose union 1 makes a wage demand at time $t \in [0,T]$. By lemma 1, union 1 makes a high wage demand of π_g no matter when union 2 makes a demand. Union 1's expected payoff is:

$$\text{(A2)} \qquad \int_0^t w_1 e^{-rt} dt + \int_t^T g_1 \pi_g e^{-rt} dt.$$

Union 1 maximizes its expected payoff by making a high wage demand of π_g at time 0, since $g_1 \pi_g > w_1$.

Given union 1 makes a high demand of π_g at time 0, union 2 chooses a time to make a demand in order to maximize its expected payoff. If union 2 chooses time 0 to make a wage demand, it demands π_b and gets the expected payoff

$$\text{(A3)} \qquad \int_0^T \pi_b e^{-rt} dt;$$

If union 2 chooses time $t > 0$ to make a demand, i.e. makes a demand after union 1, union 2's optimal wage demand depends upon what it observes in the preceding negotiations. If union 1 strikes, firm 1 must be in the bad state, union 2's updated prior that firm 2 is in the good state is then $p_2 = P(2G|1B) < g_2 < b$. Its optimal strategy is of course simply to demand π_b; if union 1 does not strike, firm 1 must be in the good state, union 2's updated prior is then $p_2 = P(2G|1G)$. Union 2 makes a high wage demand of π_g if and only if $P(2G|1G) > b$.

To summarize, when union 2 chooses $t > 0$ to make a wage demand, its expected payoff is

$$\text{(A4)} \qquad \int_0^t w_2 e^{-rt} dt + \int_t^T \pi_b e^{-rt} dt$$

if $P(2G|1G) < b$, and it is

(A5) $$\int_0^t w_2 e^{-rt}\, dt + \int_t^T \left\{g_1 P(2G|1G)\, \pi_g + (1-g_1)\pi_b\right\} e^{-rt}\, dt$$

if $P(2G|1G) > b$.

Comparing union 2's expected payoffs A3, A4 and A5, we have the proof. ■

IV. Proof of Proposition 3

1. If union i is the first to make a wage demand, it makes a high wage demand of π_g; if union i is the second to make a demand, it makes a high wage demand of π_g if there was no strike in the preceding negotiation between union j and firm j, and makes a low wage demand of π_b if there was a strike. This follows directly from union i's updated prior p_i: if there was a strike in the preceding negotiation, its updated prior that firm i is in the good state is $p_i = P(iG|jG) > g_i > b$; otherwise if there was no strike, its updated prior is $p_i = P(iG|jB) = 1 - P(iB|jB) < b$.

Now consider the mixed strategy equilibrium. Suppose that union i makes a wage demand with probability $h_i(t)dt$ between t and t+dt, conditional on neither having made an demand. In equilibrium, each union must be indifferent between making a demand and not making a demand at time t. Conditional on neither union having made a wage demand at time t, if union i makes the optimal high wage demand of π_g at t, its expected payoff is

(A6) $$\int_t^T g_i \pi_g e^{-rt}\, dt = g_i \pi_g \frac{e^{-rt} - e^{-rT}}{r} .$$

If union i waits until time t+dt, it is paid the wage w_i. However, with probability $h_j(t)dt$, the other union j makes a wage demand during this short interval of time. Then, union i makes an optimal demand right after union j and from t + dt to T, it gets

$$\text{(A7)} \qquad \int_{t+dt}^{T} [g_j P(iG|jG)\pi_g + (1-g_j)\pi_b] e^{-rt} dt$$

$$= [g_j P(iG|jG)\pi_g + (1-g_j)\pi_b] \frac{e^{-r(t+dt)} - e^{-rT}}{r};$$

If union j doesn't make a demand between t and t+dt, union i (by indifference) should be willing to make an optimal wage demand π_g and from time t+dt on it now gets

$$\text{(A8)} \qquad \int_{t+dt}^{T} g_i \pi_g e^{-rt}\, dt = g_i \pi_g \frac{e^{-r(t+dt)} - e^{-rT}}{r}.$$

Uni n i is indifferent between making a wage demand and waiting until t+dt if and only if

$$\text{(A9)} \qquad g_i \pi_g \frac{e^{-rt} - e^{-rT}}{r} =$$

$$e^{-rt} w_i dt + h_j(t)dt[g_j P(iG|jG)\pi_g + (1-g_j)\pi_b] \frac{e^{-r(t+dt)} - e^{-rT}}{r}$$

$$+ (1-h_j(t)dt) g_i \pi_g \frac{e^{-r(t+dt)} - e^{-rT}}{r}.$$

Rearranging the above the equation,

$$\text{(A10)} \qquad (g_i \pi_g - w_i)\, e^{-rt}\, dt =$$

$$h_j(t)dt\{g_j P(iG|jG)\pi_g + (1-g_j)\pi_b - g_i \pi_g\} \frac{e^{-r(t+dt)} - e^{-rT}}{r}.$$

The right hand side of the equation is the benefit from the opportunity to learn from others, and the left hand side is the cost associated with the delayed higher wage settlement. A union trades off the benefit against the cost to determine when to make a wage demand.

Solving (A10) as $dt \to 0$, we have

$$\text{(A11)} \qquad h_j(t) = \frac{r[g_i\pi_g - w_i]}{(1-g_j)\pi_g[b-P(iG|jB)]} \cdot \frac{1}{1 - e^{-r(T-t)}}, \text{ for } j = 1, 2.$$

2. Suppose union i (i = 1,2) makes a wage demand at time t. When the firms' profits are highly uncorrelated such that $P(1B|2B) < 1-b$ and $P(2B|1B) < 1-b$, union i makes a high wage demand of π_g no matter when the other union j makes a demand and what the outcomes in the preceding negotiations are. To see this, note that when union i makes a wage demand before or at the same time as union j, it makes a high wage demand of π_g since its prior $g_i > b$. When union i makes a demand after union j made the optimal wage demand π_g, its updated prior is $p_i = P(iG|jG) > g_i > b$ if firm j accepts and it is $p_i = P(iG|jB) = 1-P(iB|jB) > b$ if firm j rejects. Thus union i's updated prior is greater than b no matter what the outcomes in the preceding negotiation are and its optimal strategy is of course simply to make a high wage demand of π_g.

When union i chooses time t to make a wage demand, it will always demand π_g from the above argument and thus gets

$$\text{(A12)} \qquad \int_0^t w_i\, e^{-rt}\, dt + \int_t^T g_i\pi_g\, e^{-rt}\, dt.$$

It chooses time 0 to make the high wage demand of π_g to maximize its expected payoff. Similarly we can show that union j will also make a high wage demand of π_g immediately at time 0.

3. By a similar argument as in point 2 above, in equilibrium union 1 will always make a high wage demand of π_g at time 0. Given union 1's

strategy, if union 2 chooses time 0 to make a demand, it will demand π_g and get

(A13) $$\int_0^T g_2 \pi_g \, e^{-rt} \, dt;$$

If union 2 chooses time $t > 0$ to make a demand and union 1 doesn't strike, its updated prior is $p_2 = P(2G|1G) > b$ and its optimal strategy is to demand π_g. If union 2 moves at $t > 0$ and union 1 strikes, and its updated prior is $p_2 = P(2G|1B) < b$ and its optimal strategy is to demand π_b if union 1 strikes. Union 2 thus expects to get

(A14) $$\int_0^t w_2 \, e^{-rt} \, dt + \int_t^T [g_1 P(2G|1G)\pi_g + (1-g_1)\pi_b] \, e^{-rt} \, dt.$$

From (A13) and (A14), we can see that union 2 will choose to make a wage demand right after union 1 to maximize its payoff. ∎

V. Proof of Proposition 4

1. At time t, the hazard that holdouts end is $h_1(t)+h_2(t)$. From Corollary 1, we have

(A15) $$\partial[h_1(t)+h_2(t)] \, / \, \partial w_1 = \partial[h_1(t)+h_2(t)]/\partial w_2$$

$$= - \frac{r}{(1-p)\pi_b} \frac{1}{1 - e^{-r(T-t)}} < 0.$$

Therefore, higher wage settlements lead to lower hazards and longer holdouts.

2. It is easy to verify that

(A16) $\partial[h_1(t)+h_2(t)] \,/\, \partial p$

$$= \frac{r(2p\pi_g - w_1 - w_2)}{(1-p)^2 \;\pi_b} \;\frac{1}{1 - e^{-r(T-t)}} > 0$$

A higher p leads to a higher hazard rate and thus a shorter holdout.

3. Differentiating with respect to T yields:

(A17) $\partial[h_1(t)+h_2(t)] \,/\, \partial T$

$$= \frac{r(2p\pi_g - w_1 - w_2)}{(1-p) \;\pi_b} \;\frac{(-r)e^{-r(T-t)}}{[1 - e^{-r(T-t)}]^2} < 0$$

A longer contract duration thus leads to a longer holdout. ∎

VI. Proof of Proposition 5

1. This follows immediately from a similar argument to that in the proof of Proposition 1.

2. For h(t) to form a part of the equilibrium, a firm must be indifferent between making a wage demand at time t and waiting until t+dt. Suppose that at time t none of the unions has made a wage demand. If a union chooses to make a wage demand, it will make a high wage demand of π_g and expects to get from time t on

(A18) $$\int_t^T p\pi_g e^{-rt} = p\pi_g \;\frac{e^{-rt} - e^{-rT}}{r}$$

If the union waits until t+dt, it is paid the wage w during that time interval. However, during that interval, with probability (n-1)h(t)dt, at least one of the other n-1 unions makes a wage demand. The union then makes a wage demand immediately afterwards: it demands π_g if there was no strike in the preceding negotiation and demands π_b if there was a strike. From time t+dt on, the union expects to get

(A19) $$\int_{t+dt}^{T}[p\pi_g+(1-p)\pi_b]e^{-rt}dt = [p\pi_g+(1-p)\pi_b]\frac{e^{-r(t+dt)}-e^{-rT}}{r}.$$

If none of the other unions makes a wage demand between t and t+dt, the (by indifference) the union should again be willing to make a high wage demand of π_g and from then on it gets

(A20) $$\int_{t+dt}^{T}p\pi_g e^{-rt}dt = p\pi_g\frac{e^{-r(t+dt)}-e^{-rT}}{r}.$$

The union is indifferent between making a wage demand at time t and waiting until time t+dt, if and only if

(A21) $$p\pi_g\frac{e^{-rt}-e^{-rT}}{r} = (n-1)h(t)dt\,[p\pi_g+(1-p)\pi_b]\frac{e^{-r(t+dt)}-e^{-rT}}{r}$$

$$+\,[1-(n-1)h(t)dt]p\pi_g\frac{e^{-r(t+dt)}-e^{-rT}}{r} + e^{-rt}\,wdt.$$

Solving the above equation, we have

(A22) $$h(t) = \frac{r(p\pi_g-w)}{(n-1)(1-p)\pi_b}\cdot\frac{1}{1-e^{-r(T-t)}}.\quad\blacksquare$$

NOTES

[1]In a recent paper, Chamley and Gale (1994) investigate strategic delay and informational externalities in a model of investment. The pure informational externality in their model is similar to the one in our model.

[2]For example, almost all formal economic models of strikes (e.g. Hayes 1984; Card 1990) consider only a single bargaining pair in isolation. While empirical analyses of strikes have occasionally tried to control for past bargaining outcomes in each bargaining pair (e.g. Card 1988), to our knowledge no such studies have considered the effects of concurrent or past behavior of other bargaining pairs within the industry.

[3]For example, the "waiting game" aspect of holdouts identified here illustrates a potential efficiency cost of decentralized bargaining structures which has not received much attention to date. For a more detailed analysis of the effects of bargaining structures on bargaining outcomes in sequential learning models of negotiations, see Kuhn and Gu (1994b).

[4]If $g_i = b$, union i is indifferent between π_g and π_b. Throughout the paper we will ignore this borderline case.

[5]In Osborne (1985), an equilibrium is trembling hand perfect if the equilibrium strategies are robust with respect to a perturbation of these strategies that incorporates the probability of small mistakes that players concede at time 0.

[6]As mentioned, in this case, there exist many perfect Bayesian equilibria. One such equilibrium is as follows: union 1 makes a wage demand at time 0; at each instant, union 2 makes a wage demand if and only if the other union has made a demand. By the same argument as in Osborne (1985), we can show that none of these equilibria are trembling hand perfect because the equilibrium strategies are not robust with respect to a perturbation of these strategies that incorporates the probability of small mistakes that unions may make wage demands at time 0.

[7]As in the case of Proposition 3, there also exist asymmetric equilibria, but these do not satisfy a version of trembling-hand perfection which is natural for this context (Osborne, 1985).

[8]Some data are actually available for 1964, but coverage is incomplete. Thus we started our analysis in 1965.

[9]The analysis was also performed for *all* industries, and for industries with 20 or more negotiations only, with almost identical results.

[10]Of all strikes over that period, 97 percent of them occur after holdouts, which clearly renders the model in Cramton and Tracy (1992) inappropriate. They assume that disputes are either strikes or holdouts and strikes always take place without holdouts at the contract expiration.

[11]Specifically, holdout incidence ranges from 100 percent in dairy products, paper box, platemaking, publishing and printing, aluminum rolling, and miscellaneous nonmetallic to a low of 41.7 percent in chemical printing. The average duration of holdouts ranges from 126.3 days in the paper box industry to 22.9 days in automobile fabric accessories.

[12]Much of the analysis was replicated defining all previous contracts ending in the same *month* in the industry as concurrent. The results were very similar.

[13]The Canadian pulp and paper industry has been noted as one in which informal coordination among union locals via sequential negotiations of contracts which expire simultaneously is very common (see, e.g., Anderson, 1989, p. 212).

[14]This implicitly treats the fact that a holdout has occurred as exogenous to the process generating holdout durations. A similar, but clearly much less appropriate, assumption is made in most analyses of strike durations (e.g. Kennan 1985, Harrison and Stewart 1989), given that strikes only occur in about 15 percent of negotiations.

[15]Duration models of this form, in which log durations are specified directly as a function of parameters, data and an error term, are sometimes referred to as "accelerated failure time" models (e.g. Ruhm, 1992).

[16]In some other specifications (not reported) we disaggregated the number of concurrent negotiations into those involving the same union, and those involving another union. This was done to take into account the possibility that cooperating locals of the same union might develop their own mechanisms to solve the information externality problem (such as a rotating arrangement, or a common strike fund). The coefficients of negotiations by the same and other unions were however remarkably similar, providing no evidence that this kind of intra-union cooperation occurs.

[17]Although none of the results reported here allow for unobserved heterogeneity in hazard rates, we did attempt to estimate Meyer's discrete hazard model with gamma heterogeneity, finding that in all cases the estimates for the variance of the unobserved component converged toward zero. If such heterogeneity is nonetheless important, this will bias the results toward a finding a *declining* hazard function.

[18]For example, the log duration models reported in Tables 4 and 5 cannot be estimated with any durations exactly equal to zero.

[19]To allow for nonlinear effects of the number of concurrent negotiations on holdout incidence, we also estimated the holdout incidence model including the square of the number of concurrent negotiations. Unlike holdout durations, no evidence of a declining marginal effect was found.

Figure 1: Union and Firm Payoffs in Bargaining Pair i

(a) Payoff if a Strike Occurs

	Holdout	Strike
	0 — t (Time of Strike)	t — T
Union Payoff	w_i	0
Firm Payoff	$\pi_i' - w_i$	0

(b) Payoff if No Strike Occurs

	Holdout	Settlement
	0 — t (Time of Settlement)	t — T
Union Payoff	w_i	d_i
Firm Payoff	$\pi_i' - w_i$	$\pi_i - d_i$

Note

d_i: wage demand by union i;

π_i: firm i's profit after a settlement;

π_i': firm i's profit during a holdout.

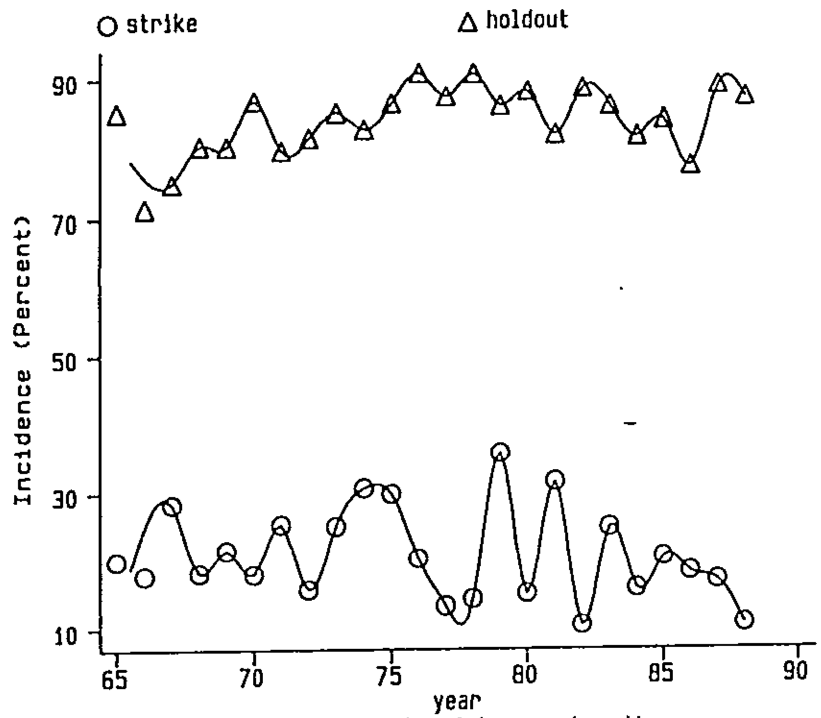

Figure 2. Dispute Incidence by Year

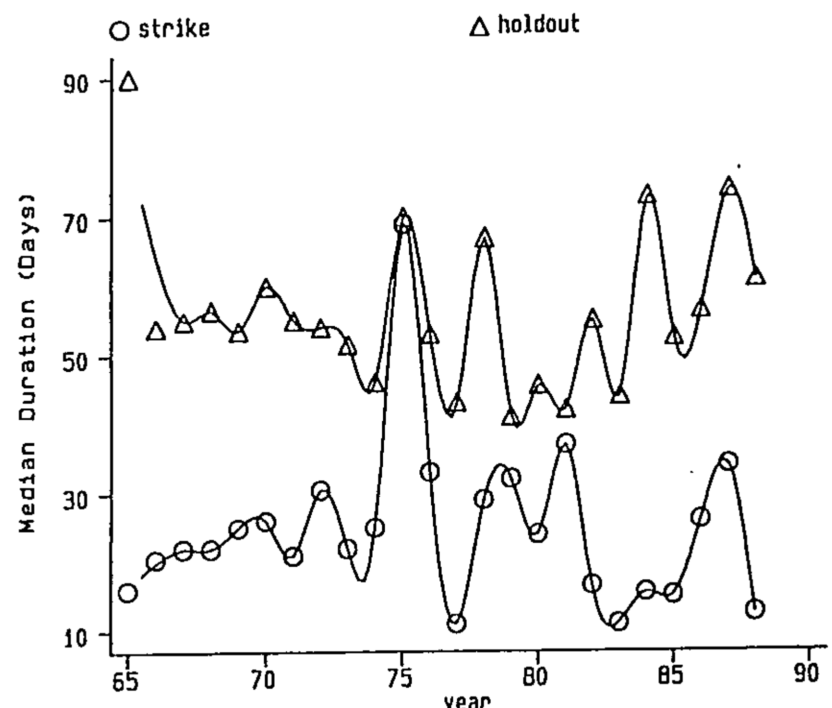

Figure 3. Median Dispute Duration by Year

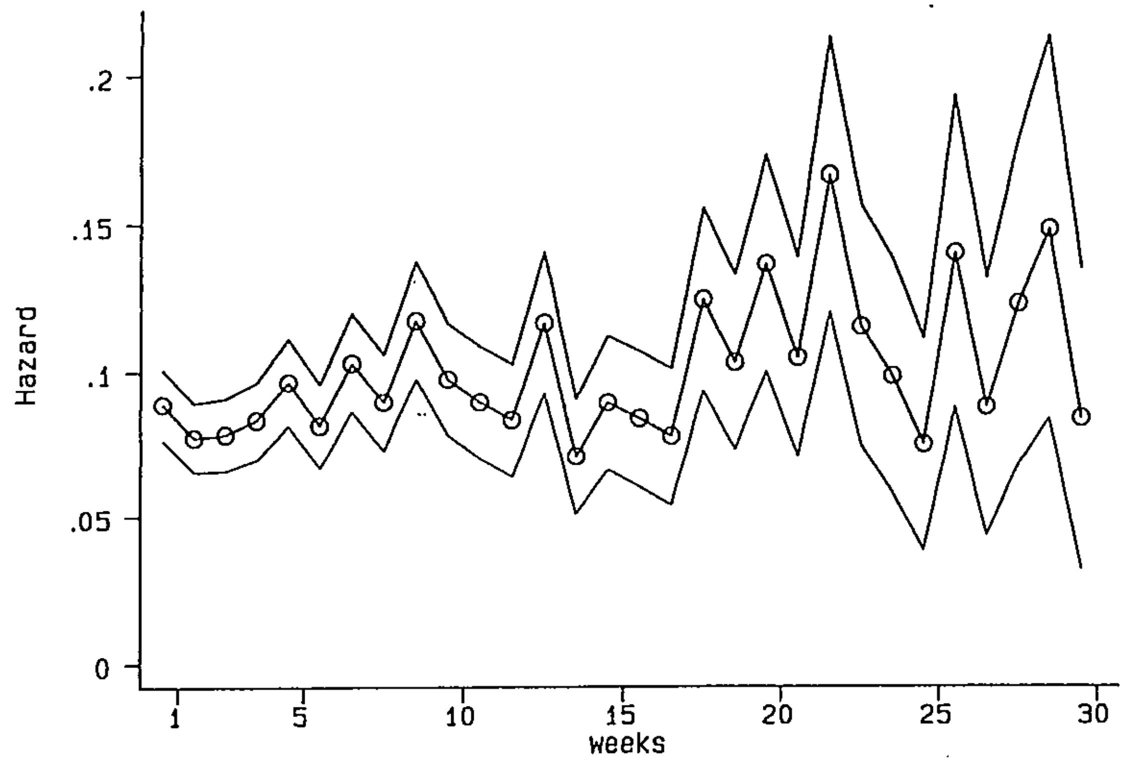

Figure 4. Kaplan-Meier Empirical Hazard

(with 95% confidence bands)

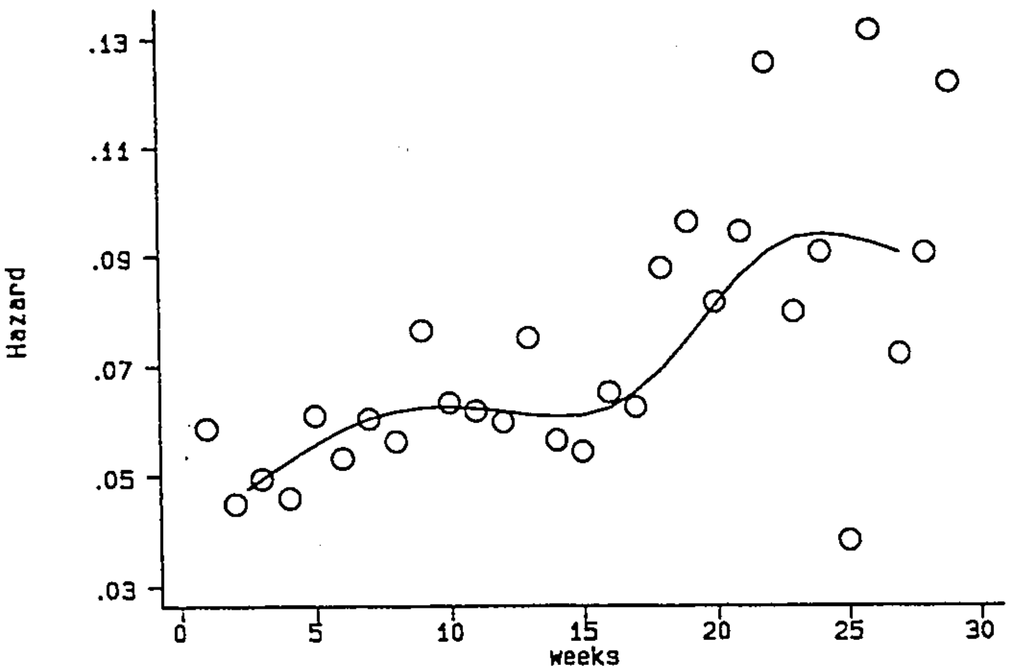

Figure 5: Piecewise Constant Baseline Hazard
(Two-digit industry sample)

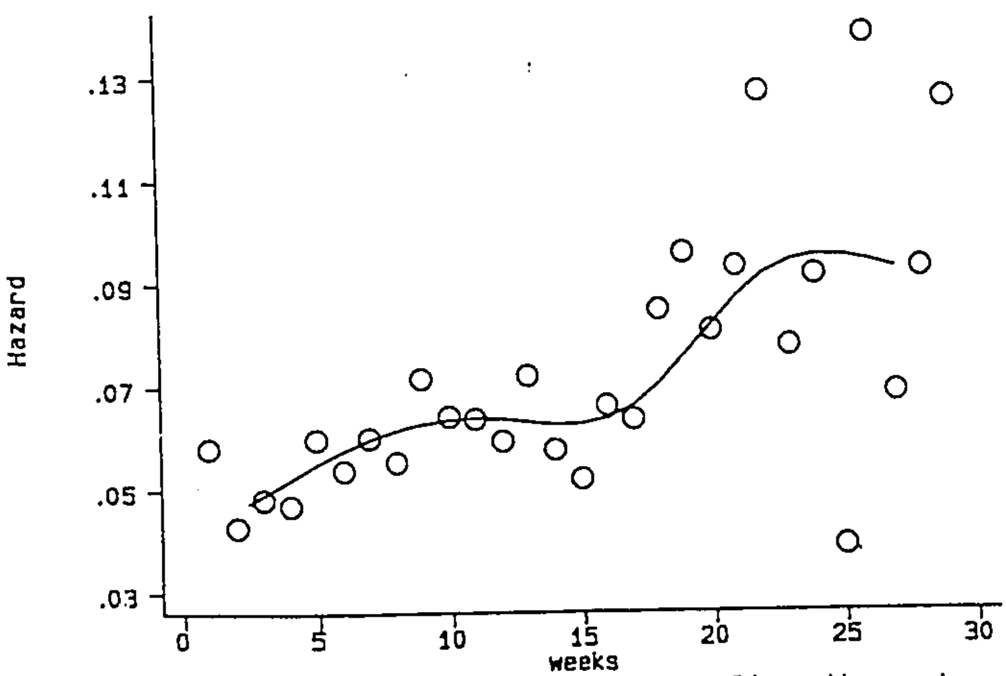

Figure 6: Piecewise Constant Baseline Hazard
(Three-digit industry sample)

Appendix Table A1 - Summary Statistics: Two Digit Manufacturing Industries

Industry	# of Obs.	Incidence (%)		Mean duration (days)		Average unit size	Average contract duration	Number of concurrent negotiations
		Strike	Holdout	Strike	Holdout			
Food/Beverages	389	14.1	87.4	30.6	85.7	1070	25.5	2.7
Tobacco	48	4.2	79.2	19.0	79.5	905	23.9	1.4
Rubber/Plastics	83	25.3	89.2	42.9	55.8	873	34.7	1.2
Leather	34	11.8	97.1	17.5	67.8	755	27.9	1.0
Textiles	145	21.4	82.1	33.2	66.0	898	27.8	1.4
Clothing	144	7.6	77.8	9.7	53.2	1819	27.9	1.6
Wood	69	33.3	85.5	36.6	88.0	5140	23.9	2.4
Furniture	22	31.8	77.3	23.0	41.1	571	21.8	1.0
Paper	400	18.8	93.5	57.9	120.9	1060	28.2	13.8
Printing/Publishing	102	7.8	86.3	38.6	93.9	967	23.5	1.6
Primary Metals	263	25.9	79.8	41.9	55.0	1682	30.0	1.8
Metal Fabricating	79	12.7	70.9	38.3	56.9	873	30.2	1.1
Machinery	122	25.4	80.3	23.6	51.7	1101	27.1	1.2
Transport. Equip.	393	32.1	83.5	36.8	63.4	1828	30.2	1.5
Electrical Products	309	22.0	86.7	30.9	57.5	1160	26.3	1.2
Nonmetallic	111	22.5	85.6	37.7	51.1	688	27.0	1.1
Chemical Products	113	18.6	66.4	39.0	77.1	753	22.7	1.2
All Manufacturing	2826	20.7	84.4	37.5	74.8	1318	27.6	3.4

Notes:

1. Strike: strike occurs before contract is signed.

2. Holdout: holdout occurs before contract is signed.

3. Average unit size: = average number of workers in a bargaining unit.

4. Average duration = average duration of the contract being negotiated, months.

Appendix Table A2 - Summary Statistics: Three Digit Manufacturing Industries

SIC Code, Industry	# of Obs.	Incidence (%)		Mean duration (days)		Avearge unit size	Average contract duration	# of concurrent negotiation
		Strike	Holdout	Strike	Holdout			
101 Meat/Poultry	76	10.1	80.3	49.5	89.1	1812	25.4	3.5
102 Fish Products	47	25.5	95.7	14.6	85.9	1902	22.8	1.4
103 Fruit/Vege. Process	13	15.4	92.3	21.5	49.2	1011	25.1	1.0
104 Dairy Products	21	4.8	100.0	13.0	79.7	933	24.1	1.1
105 Flour/Cereal	21	4.8	95.2	10.0	82.9	536	23.0	1.0
107 Bakery Products	60	16.7	90.0	36.1	69.7	622	25.0	1.2
108 Miscellaneous Food	80	12.5	77.5	29.1	73.4	637	24.2	1.2
109 Beverages	71	15.5	91.6	36.0	116.9	811	30.5	3.2
153 Tobacco Products	48	4.2	79.2	19.0	79.5	905	23.9	1.4
162 Rubber Products	83	25.3	89.2	42.9	55.7	872	34.7	1.2
174 Shoe	18	11.1	94.4	16.5	58.7	693	23.6	1.0
181 Cotton Yarn	53	15.1	84.9	43.3	81.6	1005	28.2	1.4
183 Man_made Fibre	62	24.2	83.9	32.6	58.9	945	26.3	1.0
188 Auto. Fabric access.	13	23.1	53.9	24.7	22.9	710	32.4	1.0
189 Miscell. Textiles	11	45.5	81.8	24.0	64.8	523	26.2	1.0
243 Men's Clothing	87	5.8	79.3	14.2	63.2	1723	25.8	1.6
244 Women's Clothing	29	6.9	82.8	6.0	28.2	3060	32.7	1.9
246 Fur Goods	15	20.0	66.7	4.3	51.4	1003	28.7	1.5
251 Sawmills	50	38.0	84.0	38.6	89.8	6878	23.9	2.4
252 Veneer/Plywood	10	20.0	90.0	34.5	102.1	567	22.3	1.0
261 Household Furn.	13	38.5	76.9	18.0	36.9	567	21.3	1.0
271 Pulp/Paper Mills	372	19.4	94.4	58.4	121.5	1092	28.4	14.6
273 Paper Box/Bag	10	10.0	100.0	8.0	126.3	801	27.9	1.0
274 Miscell. Paper	18	11.1	72.2	66.5	101.5	523	24.1	1.1
286 Commercial Print.	24	4.2	41.7	4.0	67.2	644	20.3	1.0
287 Platemaking	49	2.0	100.0	22.0	92.7	1093	23.6	1.4
289 Publishing/Printing	29	20.7	100.0	47.2	105.1	1020	25.9	1.1
291 Iron/Steel Mills	103	27.2	78.6	28.9	53.3	2214	30.2	1.8
292 Steel Pipe/Tube	31	16.1	74.2	43.0	65.4	815	33.5	1.2

Appendix Table A2 - Summary Statistics: Three Digit Manufacturing Industries (Continued)

SIC Code, Industry	# of Obs.	Incidence (%)		Mean duration (days)		Average unit size	Average contract duration	# of concurrent negotiation
		Strike	Holdout	Strike	Holdout			
295 Smelting/Refining	93	30.1	79.6	43.2	50.1	1736	28.1	1.2
296 Aluminum Rolling	17	29.4	100.0	88.6	74.1	888	30.9	1.0
297 Copper/Alloy Roll'g	10	10.0	60.0	96.0	43.7	730	30.9	1.0
301 Boiler/Plate Works	18	16.7	83.3	39.0	67.9	670	25.8	1.0
302 Fabricated Metal	13	15.4	76.9	62.5	49.8	700	26.7	1.0
304 Metal Stamping	30	10.0	56.7	18.7	68.1	1114	34.7	1.1
311 Agri. Implement	39	43.6	84.6	15.2	29.5	1774	28.1	1.0
315 Miscell. Machinery	76	18.4	79.0	33.9	61.1	802	26.4	1.1
321 Aircraft/Parts	93	29.0	81.7	56.2	71.6	1448	28.0	1.1
323 Motor Vehicle	78	44.9	89.7	26.5	41.8	4955	31.7	1.7
324 Truck Body/Trailer	11	27.3	90.9	17.3	53.1	635	29.5	1.0
325 Motor Vehicle Parts	89	34.8	74.2	26.9	39.2	820	34.1	1.0
326 Rail Roll'g Stock	35	31.4	85.7	60.9	79.3	917	28.5	1.0
327 Shipbuild'g/ Repair	84	21.4	86.9	35.4	93.5	997	28.0	1.5
332 Major Appliances	65	23.1	92.3	32.5	50.0	836	28.7	1.2
334 Radio/TV	37	8.1	78.4	26.3	43.7	957	21.5	1.0
335 Commu. Equip.	130	19.2	83.9	25.3	69.2	1166	26.8	1.1
336 Electric. Ind. Equip	34	41.2	94.1	28.2	51.1	2680	26.2	1.0
338 Electric Wire/Cable	14	14.3	85.7	26.0	31.2	648	21.9	1.0
339 Miscell. Electrical	24	25.0	87.5	56.2	65.1	599	27.5	1.0
356 Glass/Products	80	23.8	88.8	40.9	49.8	718	28.3	1.1
359 Miscell. Nonmetallic	17	29.4	100.0	24.0	52.1	524	23.5	1.0
378 Ind. Chemicals	64	15.6	71.9	46.6	54.7	860	21.7	1.1
379 Miscell. Chemical	37	29.7	64.9	32.1	119.6	639	24.3	1.0
391 Scientific Equip.	23	21.7	87.0	27.6	40.1	823	23.7	1.0
393 Sport. Goods/Toy	19	10.5	52.6	25.5	68.0	652	26.1	1.0
All Manufacturing	2747	21.0	84.5	37.4	75.2	1339	27.5	3.2

Notes:

1. Strike: strike occurs before contract is signed.
2. Holdout: holdout occurs before contract is signed.
3. Average unit size: = average number of workers in a bargaining unit.
4. Average duration = average duration of the contract being negotiated, months.

Table 1 - Joint Probabilities of "Good" and "Bad" States at Firms 1 and 2

Firm 1's State	Firm 2's State: Good	Firm 2's State: Bad	
Good	p_{11}	p_{12}	g_1
Bad	p_{21}	p_{22}	b_1
	g_2	b_2	

Table 2 - Descriptive Statistics (2-Digit Industry Sample)

(a) Disputes	Incidence (%)	Median (mean) duration* (days)
Holdouts only[1]	64.2	60.0 (81.0)
Strikes only[2]	0.5	8.0 (37.4)
All holdouts[3]	84.4	55.0 (74.8)
All strikes[4]	20.7	26.0 (37.4)
Disputes[5]	84.9	61.0 (83.5)

(b) Contract Characteristics	Mean	10th percentile	Median	90th percentile
# of concurrent negotiations in same 2-digit industry	3.4	1	1	7
Contract duration (months)	27.6	12	24	36
Number of employees covered	1318	500	745	2100

Notes:

* conditional on a dispute occurring.
1. includes only holdouts not followed by a strike.
2. includes only strikes not preceded by a holdout.
3. includes all holdouts.
4. includes all strikes.
5. includes strikes and/or holdouts.

Table 3 - Holdouts and the Number of Concurrent Negotiations: Raw Data

# of concurrent negotiations within same 2-digit industry					
	1	2	3-10	11+	Total
# of observations	1742	478	385	221	2826
Holdout incidence	81.9	83.1	89.6	97.7	84.4
Median (mean) holdout duration (days)	45.0 (64.1)	54.0 (71.2)	79.0 (94.6)	120.0 (120.1)	55.0 (74.8)
# of concurrent negotiations within same 3-digit industry					
	1	2	3-10	11+	Total
# of observations	1923	334	270	220	2747
Holdout incidence	82.7	83.2	87.8	97.9	85.0
Median(mean) holdout duration (days)	45.5 (64.5)	60.0 (78.0)	89.0 (102.1)	120.0 (120.6)	55.0 (75.2)

Table 4 - Holdout Duration: OLS Estimates
(Negotiations within same 2-digit industry)

Dependent variable: logarithm of holdout durations

	All industries		All industries excluding paper	
Variable	(1)	(2)	(3)	(4)
1. # of concurrent negotiations	.1170 (5.252)	.0411 (1.852)	.2122 (2.644)	.1596 (2.005)
2. # of concurrent negotiations squared	-.0029 (-3.305)	-.0010 (-1.228)	-.0166 (-1.530)	-.0167 (-1.552)
3. agreement duration	.0064 (1.765)	.0137 (3.730)	.0039 (1.042)	.0114 (2.872)
4. log of number of employees	-.1691 (-4.507)	-.1387 (-3.666)	-.1570 (-3.899)	-.1460 (-3.623)
5. index of industrial production	-.1059 (-.165)	-.2111 (-.349)	-.4642 (-.614)	-.6035 (-.834)
6. industry dummies	No	Yes	No	Yes
sample size	2384	2384	2010	2010

Notes:

1. All regressions include 4 dummies for 5 regions (Ontario, Quebec, BC, Maritime and Prairies), 11 month dummies, time, $time^2$ and $time^3$, where *time* = time trend, measured in months, January 1965 = 0, divided by 100.
2. Heteroskedasticity consistent t-statistics are in parentheses.

3. Variables: *# of concurrent negotiations* = number of negotiations that take place simultaneously within the negotiation's 2-digit industry; *index of industrial production* = monthly index of industrial production, deseasonalized and detrended; *industry dummies* = dummies for SIC two digit industries.

Table 5 - Holdout Duration: OLS Estimates
(Negotiations within same 3-digit industry)

Dependent variable: logarithm of holdout durations

	All industries		All industries excluding paper	
Variable	(1)	(2)	(3)	(4)
1. # of concurrent negotiations	.1343 (4.883)	.0356 (1.248)	.3064 (2.481)	.2227 (1.764)
2. # of concurrent negotiations squared	-.0037 (-3.284)	-.0008 (-.735)	-.0294 (-1.413)	-.0327 (-1.524)
3. agreement duration	.0067 (1.864)	.0166 (4.513)	.0040 (1.057)	.0139 (3.478)
4. log of number of employees	-.1893 (-5.017)	-.1116 (-2.652)	-.1850 (-4.544)	-.1219 (-2.656)
5. index of industrial production	-.1408 (-.223)	-.2948 (-.488)	-.5232 (-.697)	-.7091 (-.990)
6. industry dummies	No	Yes	No	Yes
sample size	2320	2320	1946	1946

Notes:

1. All regressions include 4 dummies for 5 regions (Ontario, Quebec, BC, Maritime and Prairies), 11 month dummies, time, $time^2$ and $time^3$, where *time* = time trend, measured in months, January 1965 = 0, divided by 100.
2. Heteroskedasticity consistent t-statistics are in parentheses.

3. Variables: *# of concurrent negotiations* = number of negotiations that take place simultaneously within the negotiation's 3-digit industry; *index of industrial production* = monthly index of industrial production, deseasonalized and detrended; *industry dummies* = dummies for SIC 3-digit industries.

Table 6 - Proportional Hazard Models for Holdout Duration: Various Specifications
(Negotiations within same 2-digit industry)

Variable	Exponential	Weibull	Cox	Meyer
# of concurrent negotiations	.0841 (4.690)	.0812 (5.128)	.0966 (5.361)	.1207 (6.743)
# of concurrent negotiations squared	-.0022 (-2.913)	-.0021 (-3.198)	-.0025 (-3.404)	-.0035 (-4.815)
agreement duration	.0110 (4.141)	.0116 (4.994)	.0131 (4.873)	.0120 (4.319)
log of number of employees	-.1277 (-3.977)	-.1240 (-4.371)	-.1385 (-4.296)	-.1345 (-4.154)
index of industrial production	.3563 (.613)	.3850 (.746)	.4853 (.829)	.5531 (.929)
industry dummies	no	no	no	no
log-likelihood	-3497.9	-3469.7	-16017.3	-7404.9
sample size	2384	2384	2384	2384
Sigma for weibull (std. err.)	--	.883 (.013).	--	--

Notes:

1. A positive coefficient in the table represents a negative effect on log hazard.

2. All regressions include 4 dummies for 5 regions (Ontario, Quebec, BC, Maritime and Prairies), 11 month dummies, time, $time^2$ and $time^3$, where *time* = time trend, measured in months, January 1965 = 0, divided by 100.

3. t-statistics are in parentheses.

4. Variables: *# of concurrent negotiations* = number of negotiations that take placė simultaneously within the negotiation's 2-digit industry; *index of industrial production* = monthly index of industrial production, deseasonalized and detrended.

5. In the semiparametric method used by Meyer, the length of each interval is assumed to be one week and observations lasting more than 29 weeks are censored at 29.

Table 7 - Proportional Hazard Models for Holdout Durations: Various Specifications
(Negotiations within same 3-digit industry)

Variable	Exponential	Weibull	Cox	Meyer(?)
# of concurrent negotiations	.1003 (4.803)	.1004 (5.326)	.1196 (5.353)	.1446 (6.635)
# of concurrent negotiations squared	-.0030 (-3.323)	-.0029 (-3.711)	-.0035 (-3.899)	-.0046 (-5.106)
agreement duration	.0116 (4.348)	.0123 (5.293)	.0141 (5.207)	.0127 (4.497)
log of number of employees	-.1410 (-4.360)	-.1365 (-4.810)	-.1538 (-4.731)	-.1442 (-4.407)
index of industrial production	.2932 (.500)	.3195 (.618)	.4198 (.710)	.5508 (.916)
industry dummies	no	no	no	no
log-likelihood	-3391.8	-3361.2	-15511.0	-7210.7
sample size	2320	2320	2320	2320
Sigma for weibull (std. err.)	--	.877 (.013)	--	--

Notes:

1. A positive coefficient in the table represents a negative effect on log hazard.

2. All regressions include 4 dummies for 5 regions (Ontario, Quebec, BC, Maritime and Prairies), 11 month dummies, time, time^2 and time^3, where *time* = time trend, measured in months, January 1965 = 0, divided by 100.

3. Asymptotic t-statistics are in parentheses.

4. Variables: *# of concurrent negotiations* = number of negotiations that take place simultaneously within the negotiation's 3-digit industry; *index of industrial production* = monthly index of industrial production, deseasonalized and detrended.

5. In the semiparametric method used by Meyer, the length of each interval is assumed to be one week and observations lasting more than 29 weeks are censored at 29.

Table 8 - Holdout Incidence: Probit Coefficients

Dependent variable: Holdout Dummy

	Within 2-digit industries		Within 3-digit industries	
Variable	(1)	(2)	(3)	(4)
# of concurrent negotiations	.0415 (4.528)	.0284 (2.526)	.0418 (4.423)	.0292 (2.273)
agreement duration	.0234 (6.144)	.0254 (6.240)	.0218 (5.658)	.0269 (6.136)
log of number of employees	.1030 (2.209)	.1370 (2.813)	.1050 (2.228)	.1113 (2.001)
index of industrial production	- .0115 (- .013)	- .0151 (-.017)	.2783 (.324)	.1002 (.111)
industry dummies	no	yes	no	yes
Log-likelihood	-1141.1	-1112.3	-1110.2	-1019.4
sample size	2826	2826	2747	2604

Notes:

1. All regressions include 4 dummies for 5 regions (Ontario, Quebec, BC, Maritime and Prairies), 11 month dummies, time, $time^2$ and $time^3$, where *time* = time trend, measured in months, January 1965 = 0, divided by 100.

2. Asymptotic t-statistics are in parentheses.

3. Variables: *# of concurrent negotiations* = number of negotiations that take place simultaneously within the negotiation's 2-digit (columns 1 and 2) or 3-digit industry (columns 3 and 4); *index of industrial production* = monthly index of industrial production, deseasonalized and detrended; *industry dummies* = dummies for 17 SIC two digit industries (columns 1 and 2) or 55 three-digit industries (columns 3 and 4).

CHAPTER 5
CONCLUSIONS

A recent development in the analysis of strikes and contract negotiations - strategic bargaining models with asymmetric information -- allows us to study bargaining structures and outcomes via their effects on information transfer and learning among parties to bargaining. The thesis continues this new approach and attempts to add to our knowledge of bargaining structures, both theoretically and empirically.

In Chapter 2 of this thesis, we study learning and information transfer among unions when negotiations are sequential and there is no collusion among either unions or firms. That chapter attempts to further our understanding of relative rewards, imitation and learning. The model, which considers two union-firm bargaining pairs, generates an interest by workers in each other's wages which is based on learning their own firm's ability to pay by observing the preceding negotiations. But rather than being socially harmful, as it can be in the "informational cascade" literature, learning from actions of the others is, in a number of cases, socially beneficial. This is because learning reduces the costly mistakes made in bargaining due to asymmetric information. Using a large sample of Canadian contract negotiations for the period from 1965-1988, we find strong evidence that the more negotiations which have been concluded in the recent past in a union's industry, the less likely is a strike to occur. This can be seen as relatively convincing evidence that some social learning, with beneficial social consequences, does occur among unions negotiating wages within an industry.

In Chapter 3, we use a model of learning among unions to compare bargaining outcomes in various bargaining structures and examine the effects of centralization when negotiations are simultaneous. Existing formal models of bargaining structure and outcomes typically ignore one or both of two key issues: the issue of asymmetric information and the nature of bargaining process (simultaneous versus sequential negotiation). Among other things, this means that they cannot capture the implicit coordination, or social learning, in decentralized bargaining structures. Neither can they examine the wage leapfrogging phenomenon that has been suggested as a potential important disadvantage of decentralized bargaining structures. The current model allows us to examine these key issues. we found that when negotiations are simultaneous, collusion by firms or by both firms and unions reduces expected wage settlements and raises strike incidence since they greatly reduces learning and information transfer among unions in contract negotiations.

In the model of learning among unions examined in Chapter 2, there are clear first mover disadvantages for both unions and firms. Early negotiations generate valuable information about firms' ability to pay which unions in later negotiations can use to improve their wage settlements. Unions have an incentive to free ride and delay their wage settlements and let other unions conclude their negotiations first. In Chapter 4, we examine this information externality problem and interpret the delaying of wage settlements without strikes as holdouts. As in Cramton and Tracy's model of holdouts (1992), the model predicts that holdouts should be shorter and less frequent when the wage settlement in the existing contract is lower, and when the unions are more optimistic about the firm's ability to pay. But the model also has a number of predictions about the issues on which the Cramton and Tracy model is silent, one of which is the following: as the number of unions in the model expands, the above information externality is exacerbated, generating longer holdouts in equilibrium. This implication is tested using the large sample of Canadian contract negotiations used in Chapter 2, yielding strong evidence that the larger the number of negotiations taking place at the same time, the greater are both holdout incidence and duration.

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