UNIVERSITY OF MACEDONIA

DEPARTMENT OF ECONOMICS

MASTER IN ECONOMICS

ΜΙΣΘΟΛΟΓΙΚΕΣ ΔΙΑΠΡΑΓΜΑΤΕΥΣΕΙΣ ΚΑΙ ΑΣΥΜΜΕΤΡΗ ΠΛΗΡΟΦΟΡΗΣΗ

BY ALEXANDROS LATSIDIS

SUPERVISOR: ASSISTANT PROFESSOR ELEFTHERIOS FILIPPIADIS

Master Thesis submitted to the Department of Economics of the University of Macedonia in fulfillment of the requirements for the degree of Master in Economics.

THESSALONIKI, OCTOBER 2021

Contents

Abstract

Current developments in the theory of strategic bargaining exhibit how informational asymmetries can lead to extended and costly bargaining. These models can be applied to contract negotiations, yielding an economic theory of strike activities. In this paper, so as to determine the decision or not for strike likelihood, five scenarios of negotiations are carried out between the union and the firm under an asymmetric information regime, in which the union is unsure about the firm's future profitability and the firm does not know some union's private information.

Keywords: Strike activity, asymmetry information, Bayesian Nash Equilibrium

1. Introduction

It has long been recognized that any consistent economic model of strike activities must be appealed to some form of incomplete information. The reason is that the assumption of perfect information implies that both the union and the firm will know the outcome before embarking on the strike. If both parties are rational, they should therefore agree to the outcome ex ante, thereby avoiding the strike and the associated costs. Recently, a considerable deal of progress in the theoretical analysis of disputes has been made by focusing on a peculiarly single case: that of one-sided asymmetric information over the size of bargaining surplus. In the context of application of this framework to strikes and lockouts, it is generally assumed that the firm's profitability is unknown to union members. Strike likelihood is then viewed as a screening device that permits employees to gain higher wages from more profitable employers. In addition to offering a simple explanation for the existence of disputes, this class of models yields a rich set of empirical implications for observed wage settlements and the probability and duration of strike activities.

This paper is an attempt to examine when and if a decision for a strike chance takes place during negotiations between trade unions and firms under an asymmetric information case, where the firm possesses information about the situation (e.g. profitability) that the union disregards or where the union makes an effort to keep private information that is unknown to the firm. In particular, in this paper, using game theory, I invent and study five different scenarios with the union having two stances (soft and tough), which are decided by nature in the negotiation process, while the firm appearing one type. The purpose of creating these stories, that with the assist of game theory are represented with tables the payoffs of the two players, is the construction of a third table, which using probabilities **p** includes the payoffs of both attitudes of the union and the firm, exploring the existence of Bayesian Nash Equilibria, which consequently suggest the emergence of strike activities.

The paper is organized as follows. Section 2 presents the literature review. Section 3 describes the model and narrates five stories. Finally, Section 4 concludes.

2. Literature review

There has been an appreciable debate about a strike decision, as evidenced by trade union and firm negotiations under an **asymmetric information** regime where the firm has information about the state (e.g. profitability) that the union does not know. The literature generally argues that any consistent economic model of strikes must be based on some **incomplete information** about the payoff functions of the two negotiating parties. **David Card (1990)**[1] presents and studies a simple strike model, which is based on the assumption that costly disputes are the result of one-sided asymmetric information about the firm's profitability. In particular, the model shows that the frequency and duration of strikes will decrease when the expected surplus from an agreement increases. Therefore, increases in the expected profitability of the company, in turn, will reduce the likelihood and duration of strikes. Furthermore, the increase of the expected profitability and the increase of the external opportunities of the employees will increase the wages under negotiation. **Karen Mumford (1995)**[2] deals with the strike model formulated by Hayes (1984). More specifically, in the context of the empirical analysis of the model, she uses annual data from the coal industry of New South Wales (Australia) for the period 1952-1987. According to the results of her research the model comes to two different conclusions: a) there is a negative relationship between real corporate profits and strike frequency

1 Strikes and wages: A test of an asymmetric information model (Aug.1990)
2 Strikes and profits: considering an asymmetric information model (Dec.1995)

and b) there is a positive relationship between the union's expectations for corporate profitability and the duration of strikes.

Archontis L. Pantsios and Solomon W. Polachek (2017)[3] review the **model of common costs of strike activities**. In particular, they investigate the bargaining behavior of a union and a firm with the help of the Hicksian concession curves. These are curves, which describe the indifference of the players between two options. In particular, **the firm's concession curve** is determined by its indifference between a set of maximum wage offers and expected strike duration. On the other hand, **the union's resistance curve** is related to its indifference between a minimum wage and the expected duration of a strike. Moreover, they observe that both players fare best when they concede at the same time and fare worst when both hold-out. On the contrary, when they choose different strategies, the union works best when it holds-out while the firm concedes. Respectively, firms do better when they hold-out while the union concedes. In summary, they conclude that the asymmetric increase in strike costs can have ambiguous effects on the likelihood of strike activity. **Syed M. Ahmed (1989)**[4] examines the strike theory of the Reder-Neumann-Kennan (RNK) using the method of Maki (1986). More specifically, he uses a **transfer function model**[5] to estimate the effect of strikes on output of the Canadian manufacturing industries. Moreover, the hypothesis of an inverse relation between the frequency of strikes and the output loss could not be statistically confirmed.

Dennis R.Maki (1986)[6] describes a method that investigates whether the cost of a strike activity affects the frequency of strikes taking place in Canadian unionized companies and industries, and which is measured by output lost. The results of this study suggest that a strike activity is inversely related to the costs incurred by the parties involved. However, the results do not confirm whether the cost of strikes is the main or simply an additional explanatory factor of their frequency, which indicates that the data are not strong, probably due to the small sample size used in the cross-

3 How asymmetrically increasing joint strike costs need not lead to fewer strikes (2017)
4 The effects of the joint cost of strikes on strikes in Canadian manufacturing industries – a test of the Reder–;Neumann–;Kennan theory (1989)
5 Transfer function models describe the relationship between the inputs and outputs of a system using a ratio of polynomials.
6 The effect of the cost of strikes on the volume of strike activity (Jul.1986)

sectional analysis. **Martin J. Mauro (1982)**[7] studies a negotiation model in which negotiators have asymmetric information because each party to the negotiations uses different variables in estimating the outcome of bargaining and due to each is not fully aware of the opponent's position.[8] More specifically, he applies it to a sample of fourteen negotiating relationships between specific companies and unions over a period of about thirty years. A notable conclusion is that a strike is less likely to have occurred if it had taken place during the previous trading period, indicating that the strike is a learning process for players.

W. Stanley Siebert, Philip V. Bertrand and John T. Addison (1985)[9] discuss about **the political strike model** of **Ashenfelter and Johnson (AJ) (1969)**[10]. Drawing on **Ross's (1948)**[11] insight that the union was essentially a political institution operating in an economic environment, Ashenfelter and Johnson try to study the implications for strikes of the divergent goals of the union leadership and the rank and file membership. The main idea is that strikes are caused by the unrealistically high wage desires of the latter, which are nevertheless processed by the better informed union leadership in order to deflect any incipient challenge to its authority and continued tenure in office. The function of a strike is an equilibrating mechanism to square up the membership's wage expectations with what a firm may be prepared to pay. Strikes are attributed exclusively to the union side. However, the authors innovation lies in the fact that by applying a set of data from eighty negotiating contracts of ten major manufacturing industries, they re-evaluate the AJ model and point out that this model is not political[12] because it is based on asymmetric information, while claiming that can be a useful guide in the future analysis of strikes. **Barry Sopher (1990)**[13] investigates the frequency of strike activities in complete information games. In particular, he applies **the joint-cost theory**, which correlates the strike likelihood negatively with its marginal cost and positively with the size of the surplus that is expected to be divided. Thus, he uses a

7 Strikes as a result of imperfect information (Jul.1982)
8 If employees are concerned with real spendable profits (real profits after taxes), for example, then a change in tax liabilities will affect their wage demands.
9 The political model of strikes: A new twist (Jul.1985)
10 Bargaining Theory, Trade Unions and Industrial Strike Activity (1969)
11 Trade Union Wage Policy (1948)
12 The essence of the political model is that the employer chooses a wage and duration of strike that will maximize profits subject to a workers "resistance curve", which is set mechanically and cannot be revised when a strike looks likely.
13 Bargaining and the joint-cost theory of strikes: An experimental study (Jan.1990)

set of **"shrink pie" games**, in which players trade in successive periods on how to split a sum of money. In conclusion, he notes that strikes are a common occurrence in these games and furthermore do not disappear over time.

Moreover, much of the literature focuses on strike as a behaviour. **Beth Hayes (1984)**[14] argues that the strikes are an inefficient Pareto result of negotiations between a union and a firm. Nevertheless, the strikes are a consequence of rational behavior on the part of both sides. More specifically, time, which is expressed through strike duration, is a variable used by the union to obtain information available to the firm. In conclusion, the author believes that strikes take place when a company is in a state of low and not high profit. **John Kennan (1980)**[15] presents a new and quite different approach to the economic theory of strikes, which is based on **the hypothesis of the collective behavior of employees and companies**. In particular, regardless of whether a player follows an optimal strategy in advance, it is clear that a strike is not optimal against Pareto in retrospect because it reduces the overall amount of surplus that will be distributed to both players.

Alison Booth and Robert Cressy (1990)[16] develop a model of asymmetric information, in which the firm holds private information on its own profitability. Furthermore, in this model some comparative static predictions about strike behavior are made. More specifically, the model concerns a two-period framework, where the union and the company negotiate wages for the current and next period. Thus, a strike takes place if and only if the union's wage demand is rejected and the union is "strict". For this purpose, the optimal reservation values are created for the firm and the union. In particular, these prices indicate when the firm should reject a wage claim and when the union should respond to this rejection through the strike. **Joseph S.Tracy (1987)**[17] points out that from an economic point of view; a critical determinant of strike activity is uncertainty. More specifically, the negotiation between the union and the firm is related to the division of rents. Uncertainty may relate to the size of the rents to be divided or the bargaining costs of each party. In case of uncertainty, negotiations serve as a learning process in which one party can infer the other party's private

14 Unions and strikes with asymmetric information (Jan.1984)
15 Pareto optimality and the economics of strike duration (Mar.1980)
16 Strikes with asymmetric information: Theory and evidence (1990)
17 An empirical test of an asymmetric information model of strikes (Apr.1987)

information by observing his or her actions during the negotiations. A strike occurs whenever this process continues after the expiration of the current contract. Moreover, the effects of cyclic shocks to the industry as well as to the local labor market are tested. Thus, many industries tend to increase rents in order to reduce strike activities. On the other hand, the local labor market lower both the level of the rents and the relative bargaining costs to the union by providing part-time job opportunity. Both effects should incline increase strike activity. In summary, the results confirm that the strikes are countercyclical in relation to industrial shocks and pro-cyclical in relation to local shocks.

Ramon Rabinovitch and Itzhak Swary (1976)[18] assess a model that describes the negotiation process between employers and unions under uncertainty. More specifically, they identify the final settlement as the result of a set of meetings and introduce uncertainty about the other's side intentions and the incident of the strike frequency. Thus, the central feature of the trading process is the search for more information. Therefore, they conclude that the strike is not as absurd as it seems according to Hicks. In a world of uncertainty, a strike activity follows rational behavior based on assumptions about uncertain information. **Sheena McConnell (1989)**[19] examines the relationship between wages and strikes. In particular, she uses a set of USA employment contract data, which contains information about wages being traded as well as possible vacation pay. The results suggest that both the likelihood and duration of a strike are negatively correlated with real wages. This finding therefore reinforces the theory that strikes are used as tools to find information and not as accidents or mistakes that occur during negotiations.

Peter C. Cramton and Joseph S.Tracy (1992)[20] develop a negotiation model that includes the decision to strike, in the context of collective bargaining in the USA. At the same time, the model suggests that the disputes will turn from holdouts to strikes in three cases. First, when during the previous contract there is a significant rate of uncompensated inflation, which reduces the employee's wage in the holdout regime. Second, when there is a significant reduction in the local unemployment rate which increases the employee's reservation wage in the strike threat. Third, when

18 On the theory of bargaining, strikes, and wage determination under uncertainty (Nov.1976)
19 Strikes, wages, and private information (Sep.1989)
20 Strikes and holdouts in wage bargaining: Theory and data (Mar.1992)

there is an increase in demand for the company, which will improve profitability and widen the gap between the current and the new negotiated wage. **Anthony Barlow and Aongus Buckley (1998)**[21] study a wage bargaining model according to which strikes take place due to incomplete information. More specifically, they use for their research purposes, a set of data on wage negotiations in Irish companies, in order to examine the trend of strike activity at company level. Thus, they find that strike activity in Ireland is positively related to the size of the company. Equally important is the fact that the probability of a strike is inversely related to the cost of the strike.

Jean-Michel Cousineau and Robert Lacroix (1986)[22] argue that the relevant bargaining power and changes in it should not have an impact on the strike mobilization, when the two sides involved in the negotiations are well informed. Thus, they investigate why strike activity varies between industries as well as over time. For this purpose, they use as data 1871 collective agreements of the Canadian Ministry of Labor. The results of their research showed that openness to foreign competition, the size of the negotiating unit, the duration of the previous employment contract and the existence of extensive wage controls better explain the variability of the strike between industries, in relation to its differences in their bargaining power. At the same time, the productive capacity utilization rate, the inflation rate, the selling price index, the extent of wage controls and the job vacancy rate describe the differences of the strike activity trend over time. **Henry S. Farber (1978)**[23] denotes that changes in wages as well as the frequency of strikes are influenced by changes in the economic environment and by the better understanding of the behavioral processes of collective negotiations.

Thomas M. Geraghty and Thomas Wiseman (2007)[24] investigate whether the predictions of **the war of attrition model** are in line with the characteristics of the wage strikes that took place in the United States in the 1880s. Furthermore, the war of attrition is a very costly way of resolving labor disputes and is confirmed by three factors, which were present in the strikes in question. More specifically, the lack of

---

21 A firm-level study of strike propensity in Ireland (1998)
22 Imperfect information and strikes: An analysis of Canadian experience (Apr.1986)
23 Bargaining theory, wage outcomes, and the occurrence of strikes: An econometric analysis (Jun.1978)
24 Wage strikes in 1880s America: A test of the war of attrition model (Dec.2007)

mutual trust of the two sides with respect to the compliance with the agreements, the lack of impartial arbitration and the small divisible surplus. In conclusion, the authors point out that increasing global competition is squeezing producers' profit margins and therefore, 21st century strikes may again fit the model of the attrition war. **Peter Ingram, David Metcalf and Jonathan Wadsworth (1993)**[25] study British strike data and look for consistency in various strike models. Moreover, they are investigating the impact of the size of the two trading players (firm, union) and the size of the workplace in the strike mobilization. In terms of conclusions, the strike occurrence is higher in bargaining groups with more than fifty employees than in those with fifty or fewer employees. In addition the strike incidence in British manufacturing appears counter-cyclical and is positively linked to unemployment.

Daphne Nicolitsas (2000)[26] explores the reasons why the frequency of strikes in the United Kingdom declined in the 1980s. Thus, she used a panel data set containing product market, industry structure and labor market data for 90 UK manufacturing industries from 1983-1988. The results show that strike activities were reduced because they became more expensive. In particular, the author identifies the factors that affect both employers and employees (e.g. revenues, inventories) and their impact on the fluctuations in the frequency of strikes. She reached the conclusion that factors which affect only workers, such as the unemployment rate, fail to explain the fluctuations observed in the strike frequency. **Melvin W. Reder and George R. Neumann (1980)**[27] argue that the strikes are accidents and are influenced by the institutional arrangements and the trading style adopted by the players. Moreover, they point to the inverse relationship between strike activity and the costs it incurs in manufacturing, signaling a possible increase in strike costs leading to a reduction in their occurrence.

David Card (1987)[28] studies two aspects of strike activity related to renegotiation of union contracts. In particular, he studies the effects of endogenously-determined contract characteristics[29] on dispute probabilities and the effects of lagged

25 Strike incidence in British manufacturing in the 1980s (Jul.1993)
26 Accounting for strikes: Evidence from UK manufacturing in the 1980s (2000)
27 Conflict and contract: The case of strikes (Oct.1980)
28 Longitudinal analysis of strike activity (May 1987)
29 These are characteristics of the collective bargaining agreement that affect subsequent strike outcomes

strike outcomes on future strike likelihood and duration. Furthermore, he argues that strike frequency is significantly affected by contract characteristics determined in earlier settlements. Moreover, strike activities are more in summer and autumn than in winter and spring. An equally interesting conclusion is that strike likelihoods are notably affected by preceding strike outcomes. For example after a peaceful settlement of the most recent contract negotiation, strike likelihood is 10 percentage points higher if the contract was settled after a l to l4 day strike, and 5-7 percentage points lower if the contract was settled after a longer work stoppage. **Oliver Hart (1989)**[30] examines the effect of asymmetric information on a company's profitability and concludes that it fails to explain long strikes if the company and employees can negotiate too often without commitment. Thus, the author points out that it is possible for significant strike activities to occur if there is a small (but not insignificant) delay between offers, which may be due to the transaction cost of making offers or because of technological reasons, as well as if a strike-bound company experiences a reduction in profitability after a certain point.

Yanis Varoufakis (1996)[31] states conventional strike models begin with the assumption that negotiators' rational beliefs can be resolved in advance. Strikes are also explained as either a result of institutional constraints or a possibility of irrationality. Thus, he explores the alternative interpretation of strikes. In particular, he argues that the strikes help to shape the mood of the negotiators. In addition, the stability of bargaining protocols bases not only on the conventions governing the relations between firms and unions but also on those that describe the relationship between employers and union leaders as well as on technological innovations. **W. Stanley Siebert and John T. Addison (1981)**[32] investigate the strikes in terms of frequency and claim that they are accidents. For the sake of convenience, their analysis focuses on predicting the frequency of a strike activity and does not extend to what happens either during or after the end of the strike. Then, they compare **the accident model of strikes** with the road accidents model, describing its basic predictions. More specifically, strikes can be compared with road accidents in the sense that, whereas any accident is unforeseen, the probability of having an accident is foreseen and is a consequence of rational choice. At the end of their analysis, they

30 Bargaining and strikes (Feb.1989)
31 Bargaining and strikes" Towards an evolutionary framework'' (Jan.1996)
32 Are strikes accidental? (Jun.1981)

make a series of proposals to reduce strikes in the light of accident theory, such as arbitration, conciliation, mediation procedures, fact-finding commissions and cooling off periods.

William B. Nelson, Gerald W. Stone, JR and J Michael Swint (1981)[33] study the collective bargaining of civil servants and through them look for the key economic factors responsible for strike activities in the public sector. More specifically, they examine union leaders, union members, bureaucrats, politicians and voters in order to clarify both the constraints imposed on the negotiating parties by their constituents and the differences between the collective bargaining of the public and of the private sector. According to the results of their research, frequent and long-lasting strikes take place only when both negotiating players are motivated by self-interest. In the cases where motivation is at least partially constituency interested, strikes will be infrequent, and when they happen, of shorter duration. An equally important conclusion is that the public sector strikes are counter-cyclical and are mainly affected by the business cycle and its impact on state and local revenues.

An equally important topic that the literature explores is whether it is possible in the context of negotiations between a union and a firm for the union to hold private information that is unknown to the firm. **Jean Paul Azam and Claire Salmon (2003)[34]** argue that the level of strike activity in Bangladesh can be explained to some extent by political cycle. In the months leading up to the elections, the government loses credibility in its commitment to expand job creation, through increased public spending, in order to increase its chances of staying in power. This causes a rise in strikes; at least in the industrial sector, as unions try to achieve the best of the expected boost in labor demand. These results suggest that the political dimension of trade union activity is likely an important variable to consider for understanding its behavior in developing countries, at least in the industrial sector. **Kyung Nok Chun, Zachary Schaller and Stergios Skaperdas (2020)[35]** denote that the strikes are not the result of asymmetric information or errors. They may be due to long-term,

33 An economic analysis of public sector collective bargaining and strike activity (Mar.1981)
34 Strikes and political activism of trade unions: Theory and application to Bangladesh (Mar.2003)
35 Why are there strikes? (May 2020)

strategic reasons such as power asymmetries and trade union solidarity, which can be expressed through material support.

3. Model outline

In this paper, in the context of finding or non-strike activity, I create and study five games in which each player (which are the union and the firm) has incomplete information about the other player. In particular, union may not know the exact payoff functions of the firm, but instead have beliefs about these payoff functions. The reason I look at this model is to find Bayesian Nash Equilibria. Bayesian Nash Equilibrium is defined as a strategy profile that maximizes the expected payoff for each player given their beliefs and given the strategies played by the other players. At this point, it is necessary to point out that when conducting games the potential gains or losses of the union are not monetary but are the result of a utility function. According to the literature, the utility of the union depends on many factors, such as wage, employment rate and possibly in some cases the satisfaction received by the union leadership which is expressed by having a good name or ability her re-election.

3.1 Case 1

As part of the first case, I study a game between the union and the firm. More specifically, I will consider two cases where the union can be soft or hard in the negotiations, while the firm is always of one type. In general, there is a probability **p** that the union is tough and a probability **1-p** that the union is soft. Both players are aware of these probabilities.

I start with the case that the union has a tough attitude. Thus, I investigate the case where the union has a tough stance in negotiations with the firm. Assume the following payoffs table between the two players:

TYPE: TOUGH UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w}^*, \boldsymbol{\pi}^*$	$\mathbf{w}_0 , \boldsymbol{\pi}_0$
	HOLD OUT	$\mathbf{w}_r , \boldsymbol{\pi}_r$	**0,0**

Table 1: Payoff matrix with tough attitude of union

To strike, both players must select hold out (H-H). If even one does not play hold out then there is no strike. After observing the possible strategies of both players in the table 1, I argue that there is no dominant strategy. On the union side, in case the firm plays concede, the best option is to hold out, because $\mathbf{w}_r > \mathbf{w}^*$. Conversely, if the firm plays hold out, then the union has the benefit of choosing concede, because $\mathbf{w}_0 > 0$. It generally applies that: $\mathbf{w}_r > \mathbf{w}^* > \mathbf{w}_0 > \mathbf{0}$. On the part of the firm, in case the union plays concede, the preferred option is to choose hold out, as $\boldsymbol{\pi}_0 > \boldsymbol{\pi}^*$. On the contrary, if the union plays hold out, then the firm has an interest in choosing concede, because $\boldsymbol{\pi}_r > 0$. Generally valid: $\boldsymbol{\pi}_0 > \boldsymbol{\pi}^* > \boldsymbol{\pi}_r > \mathbf{0}$. At the same time it is understood that there are two Nash equilibriums, which are concede-hold out ($\mathbf{w}_0$,$\boldsymbol{\pi}_0$) and hold out-concede ($\mathbf{w}_r$,$\boldsymbol{\pi}_r$), due to the fact that no player has a benefit to change his strategy while the other player keeps his own strategy constant. Moreover, it is worth noting that there is also a Nash Equilibrium in mixed strategies and therefore the total number of equilbria is three.

All options are Pareto superior to the combination hold-out hold-out, but because the combination concede-hold out dominates concede-concede for the firm and the combination hold out-concede dominates concede-concede for the union, it is in the interest of each player to threaten to implement a hold out strategy, in the hope that the opponent will be afraid to play hold out. So every player has the inclination to show toughness even if he has no intention of playing hold out throughout the game. In order to show this toughness, each player adopts a mixed strategy by choosing hold out with a probability determined by each side maximizing the expected return.

Furthermore, I investigate the case where the union is of a soft nature in the negotiations with the firm, because the nature decided so. Being of a soft nature, the union has different payoffs in the various strategy combinations, compared to the hard union, as shown in the following table.

TYPE: SOFT UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w^* + A_1 , \pi^*}$	$\mathbf{w_0 - A_2 , \pi_0}$
	HOLD OUT	$\mathbf{w_r , \pi_r}$	**0,0**

Table 2: Payoff matrix with soft attitude of union

Based on the table 2, I notice that compared to the tough union there are differences in the wages of the soft union $(\mathbf{A_1}\ , \mathbf{A_2})$ when it plays concede. In particular, when both players choose concede, then the soft union gains an increase in its wage $(\mathbf{A_1})$, which is due to the firm's desire to reward the soft union that shows a condescending behavior in negotiations with it. On the other side, when the firm plays hold-out, then the soft union records a loss in its wage $(\mathbf{A_2})$. This reduction of the soft union's wage signals the firm's willingness to appear a toughness, which is not in its interest, in order to push the soft union to play concede. Therefore, when the firm chooses concede, the best choice for the union is also concede, since $\mathbf{w^* + A_1 > w_r}$. On the contrary, if the firm plays hold out then the union has the benefit to choose concede again, due to the fact that $\mathbf{w_0 - A_2 > 0}$. To sum up, I conclude that the union, when is soft, has an interest in playing concede regardless of the choice of firm.

At this point, having constructed the two tables depicting the payoffs of union and firm, for probability **p** when union is tough and for probability **1-p** when union is soft, I will create a third table, which will be a combination of the previous two, in order to extract the optimal strategies of the two players. More specifically, there are eight cases that illustrate player payoffs (see Appendix page 39).

3.1.1 Outcome of Case 1

		FIRM	
UNION		CONCEDE	HOLD OUT
	$C_T\,C_S$	$\mathbf{w^* + (1-P)A_1\,,\ \pi^*}$	$\mathbf{w_0 - (1-P)A_2\,,\ \pi_0}$
	$C_T\,H_S$	$\mathbf{Pw^* + (1-P)w_r\,,\ P\pi^* + (1-P)\pi_r}$	$\mathbf{Pw_0\,,\ P\pi_0}$
	$H_T\,C_S$	$\mathbf{Pw_r + (1-P)(w^* + A1\,,\ P\pi_r + (1-P)\pi^*}$	$\mathbf{(1-P)(w_0 - A_2)\,,\ (1-P)\pi_0}$
	$H_T\,H_S$	$\mathbf{w_r\,,\ \pi_r}$	$\mathbf{0\,,0}$

Table 3: Payoff matrix with a combination of the two types of union

In the table 3 I want to check if there is Bayesian Nash equilibrium in case the tough union and firm play hold-out, with the soft union choosing concede. In order for this to happen, it is necessary for the union's payoff to the corresponding cell to be greater than its other payoffs on the vertical axis (where the firm holds-out), while at the same time the firm's profits need to be greater than the profits for the same nature of the union combination (where tough union plays hold-out and soft union concede). In general, in any inequality that will be solved with respect to P, the condition must be satisfied $P \in (0,1)$.

Regarding the **union**:

- $$(1-P)(w_0 - A_2) \geq w_0 - (1-P)A_2 =>$$
$$(1-P)w_0 - (1-P)A_2 \geq w_0 - (1-P)A_2 =>$$
$$1 - P \geq 1 => \mathbf{P \leq 0}$$

To sum up, I contend that there is no Bayesian Nash equilibrium in this case because the previous inequality of the union contradicts the condition $P \in (0,1)$.

3.2 Case 2

In the cases 2-5, I examine a game between the union and the firm. In particular, I will consider two cases where the union can be soft or hard in the negotiations, while the firm is always of one type. In general, there is a probability **p** that the union is soft and a probability **1-p** that the union is tough. Both players are aware of these probabilities.

Initially, I start with the case that the union has a soft attitude. Thus, I investigate the case where the union has a soft stance in negotiations with the firm. Assume the following payoffs table between the two players:

<table>
<tr><td colspan="2" rowspan="2">TYPE: SOFT UNION</td><td colspan="2">FIRM</td></tr>
<tr><td>CONCEDE</td><td>HOLD OUT</td></tr>
<tr><td rowspan="2">UNION</td><td>CONCEDE</td><td>$\mathbf{w^*, \pi^*}$</td><td>$\mathbf{w_0 , \pi_0}$</td></tr>
<tr><td>HOLD OUT</td><td>$\mathbf{w_r , \pi_r}$</td><td>**0,0**</td></tr>
</table>

Table 4: Payoff matrix with soft attitude of union

Furthermore, I investigate the case where the union is of a tough nature in the negotiations with the firm, because the nature decided so. Being of a tough nature, the union has different payoffs in the various strategy combinations, compared to the soft union, as shown in the table 5.

TYPE: TOUGH UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w^* - A_1 , \pi^*}$	$\mathbf{w_0 - A_2 , \pi_0}$
	HOLD OUT	$\mathbf{w_r , \pi_r}$	**0,0**

Table 5: Payoff matrix with tough attitude of union

According to the payoffs in table 5, I observe that compared to the soft union there are differences in the wages of the tough union ($\mathbf{A_1 , A_2}$) when it plays concede. More specifically, the tough union when playing concede, receives a reduction of its wage ($\mathbf{A_1 , A_2}$, where $\mathbf{A_2 > A_1}$) regardless of the firm's strategy. The reason why the tough union is experiencing losses in its wage ($\mathbf{A_1 , A_2}$) is due to its attempt to claim more rights, in the context of its negotiations with the firm. Therefore, when the firm chooses concede, the best choice for the union is hold-out, since $\mathbf{w_r > w^* - A_1}$. On the contrary, if the firm plays hold out then the union has the benefit to choose hold-out again, due to the fact that $\mathbf{w_0 - A_2 < 0}$. To sum up, I conclude that the union, when is tough, has an interest in playing hold-out regardless of the choice of firm. This means that when the union is tough, then hold-out is a dominant strategy for the union.

At this point, having constructed the two tables depicting the payoffs of union and firm, for probability **p** when union is soft and for probability **1-p** when union is tough, I will create a third table, which will be a combination of the previous two, in order to extract the optimal strategies of the two players. More specifically, there are eight cases that illustrate player payoffs (see Appendix page 41).

3.2.1 Outcome of Case 2

		FIRM	
		CONCEDE	HOLD OUT
UNION	$C_S C_T$	$\mathbf{w^* - (1-P)A_1, \pi^*}$	$\mathbf{w_0 - (1-P)A_2, \pi_0}$
	$C_S H_T$	$\mathbf{Pw^* + (1-P)w_r, P\pi^* + (1-P)\pi_r}$	$\mathbf{Pw_0, P\pi_0}$
	$H_S C_T$	$\mathbf{Pw_r + (1-P)(w^* - A1, P\pi_r + (1-P)\pi^*}$	$\mathbf{(1-P)(w_0 - A_2), (1-P)\pi_0}$
	$H_S H_T$	$\mathbf{w_r, \pi_r}$	$\mathbf{0, 0}$

Table 6: Payoff matrix with a combination of the two types of union

In the table 6 I want to check if there is Bayesian Nash equilibrium in case the soft union plays concede, with the tough union and the firm choosing hold-out. In order for this to happen, it is necessary for the union's payoff to the corresponding cell to be greater than its other payoffs on the vertical axis (where the firm holds-out), while at the same time the firm's profits need to be greater than the profits for the same nature of the union combination (where soft union plays concede and tough union hold-out). In general, in any inequality that will be solved with respect to P, the condition must be satisfied $P \in (0,1)$.

Regarding the **union**:

- $Pw_0 \geq w_0 - (1 - P)A_2$ =>

  $Pw_0 \geq w_0 - (A_2 - PA_2)$ =>

  $Pw_0 \geq w_0 - A_2 + PA_2$ =>

  $Pw_0 - PA_2 \geq w_0 - A_2$ =>

  $P(w_0 - A_2) \geq w_0 - A_2$ =>

$$P \geq \frac{w_0 - A_2}{w_0 - A_2} => \mathbf{P \geq 1}$$ [36]

In conclusion, I argue that there is no Bayesian Nash equilibrium in this case because the previous inequality of the union contradicts the condition $P \in (0,1)$.

3.3 Case 3

In the context of third game, I start with the case that the union has a soft nature. The payoffs of both players will be the same as the previous game:

TYPE: SOFT UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w^*, \pi^*}$	$\mathbf{w_0 , \pi_0}$
	HOLD OUT	$\mathbf{w_r , \pi_r}$	**0,0**

Table 7: Payoff matrix with soft attitude of union

Moreover, I investigate the case where the union is of a tough attitude in the negotiations with the firm, because the nature decided so. Due to its hard nature, the union has different yields in different strategy combinations, compared to the soft

36 Due to $\mathbf{w_0 - A_2 < 0}$ the result of the division will be equal to 1.

union, but also compared to the tough union of the previous research as shown in the table 8.

TYPE: TOUGH UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w^* - A_1 \,,\ \pi^*}$	$\mathbf{w_0 - A_2 \,, \pi_0}$
	HOLD OUT	$\mathbf{w_r \,, \pi_r}$	$\mathbf{A_3 \,, 0}$

Table 8: Payoff matrix with tough attitude of union

Based on the table 8, I notice that compared to the soft union there are differences in the wages of the tough union ($\mathbf{A_1}$ **,** $\mathbf{A_2}$) when it plays concede. More specifically, the tough union when playing concede, receives a reduction of its wage ($\mathbf{A_1}$**,** $\mathbf{A_2}$ where $\mathbf{A_2} > \mathbf{A_1}$) regardless of the firm's strategy. As in case 2, the reason why the tough union is experiencing losses in its wage ($\mathbf{A_1}$ **,** $\mathbf{A_2}$) is due to its attempt to claim more rights, in the context of its negotiations with the firm. In addition, a difference is found in the payoff of the tough union when both choose hold-out ($\mathbf{A_3}$). In particular, parameter $\mathbf{A_3}$ may not be a wage, e.g. it may symbolize the pride and dignity of the tough union, which chose hold-out. Furthermore, at this point it should be noted that parameter $\mathbf{A_3}$ is greater than all the reductions that take place in the wages of the tough union ($\mathbf{A_3} > \mathbf{A_2} > \mathbf{A_1} > 0$), because pride and dignity are high values that are bordered higher than wages. Therefore, when the firm chooses concede, the best choice for the union is hold-out, since $\mathbf{w_r} > \mathbf{w^*} - \mathbf{A_1}$ **.** On the contrary, if the firm plays hold out then the union has the benefit to choose hold-out again, due to the fact that $\mathbf{A_3} > w_0 - \mathbf{A_2}$**.** To sum up, I conclude that the union, when is tough, has an interest in playing hold-out regardless of the choice of firm. This means that when the union is tough, then hold-out is a dominant strategy for the union.

In the literature, a case of tough union in which the dimension of pride can be seen is the white workers in **South Africa** in the 1920s. In particular, at that time white workers were treated with contempt and racism by the government in relation to their black colleagues. However, the **white miners and artisans**, displaying their dignity and pride became more militant and began to precipitate violent strike action so as to claim more professional rights. The year 1922 saw the biggest and bloodiest industrial disruption in South African labour history, which took on the features of a civil war on the Witwatersrand. In order to maintain an entrenched industrial colour bar and to avoid retrenchments, 22.000 white workers participated in this strike, which was characterized by pitched battles between the armed forces of labour and the state.[37]

At this point, having constructed the two tables depicting the payoffs of union and firm, for probability **p** when union is soft and for probability **1-p** when union is tough, I will create a third table, which will be a combination of the previous two, in order to extract the optimal strategies of the two players. More specifically, there are eight cases that illustrate player payoffs (see Appendix page 44).

3.3.1 Outcome of Case 3

		FIRM	
UNION		CONCEDE	HOLD OUT
	$C_S C_T$	$\mathbf{w^* - (1-P)A_1, \pi^*}$	$\mathbf{w_0 - (1-P)A_2, \pi_0}$
	$C_S H_T$	$\mathbf{Pw^* + (1-P)w_r, P\pi^* + (1-P)\pi_r}$	$\mathbf{Pw_0 + (1-P)A_3, P\pi_0}$
	$H_S C_T$	$\mathbf{Pw_r + (1-P)(w^* - A1, P\pi_r + (1-P)\pi^*}$	$\mathbf{(1-P)(w_0 - A_2), (1-P)\pi_0}$

37 A racially divided class. Strikes in South Africa 1973-2004 (Wessel Visser)

	$H_S H_T$	$\mathbf{w_r , \pi_r}$	$\mathbf{(1-P)A_3 , 0}$

Table 9: Payoff matrix with a combination of the two types of union

In the table 9 I want to check if there is Bayesian Nash equilibrium in case the soft union plays concede, with the tough union and the firm choosing hold-out. In order for this to happen, it is necessary for the union's payoff to the corresponding cell to be greater than its other payoffs on the vertical axis (where the firm holds-out), while at the same time the firm's profits need to be greater than the profits for the same nature of the union combination (where soft union plays concede and tough union hold-out). In general, in any inequality that will be solved with respect to P, the condition must be satisfied $P \in (0,1)$.

In particular for the **firm**:

- $P\pi_0 \geq P\pi^* + (1-P)\pi_r =>$

  $P\pi_0 \geq P\pi^* + \pi_r - P\pi_r =>$

  $P\pi_0 - P\pi^* + P\pi_r \geq \pi_r =>$

  $P(\pi_0 - \pi^* + \pi_r) \geq \pi_r =>$

$$\mathbf{P \geq \frac{\pi_r}{\pi_0 - \pi^* + \pi_r} => P < 1}$$

The fraction is less than one and is positive and therefore the condition $P \in (0,1)$is satisfied.

Regarding the **union**:

- $Pw_0 + (1-P)A_3 \geq w_0 - (1-P)A_2 =>$

  $Pw_0 + A_3 - PA_3 \geq w_0 - (A_2 - PA_2) =>$

  $Pw_0 + A_3 - PA_3 \geq w_0 - A_2 + PA_2 =>$

$$Pw_0 - PA_2 - PA_3 \geq w_0 - A_2 - A_3 =>$$

$$P(w_0 - A_2 - A_3) \geq w_0 - A_2 - A_3 =>$$

$$P \geq \frac{w_0 - A_2 - A_3}{w_0 - A_2 - A_3} => \mathbf{P \geq 1} \text{ or } \mathbf{P \leq 1}$$

- $Pw_0 + (1 - P)A_3 \geq (1 - P)(w_0 - A_2) =>$

$$Pw_0 + A_3 - PA_3 \geq w_0 - Pw_0 - A_2 + PA_2 =>$$

$$Pw_0 - PA_3 + Pw_0 - PA_2 \geq w_0 - A_2 - A_3 =>$$

$$2Pw_0 - PA_2 - PA_3 \geq w_0 - A_2 - A_3 =>$$

$$P(2w_0 - A_2 - A_3) \geq w_0 - A_2 - A_3 =>$$

$$P \geq \frac{w_0 - A_2 - A_3}{2w_0 - A_2 - A_3} => \mathbf{P \geq 0}$$

- $\mathbf{Pw_0 \geq 0}$

The last two inequalities satisfy the condition $P \in (0,1)$. In contrast, the first inequality has two effects depending on the sign of the parentheses. If $(\mathbf{w_0 - A_2 - A_3})$ positive then $\mathbf{P > 1}$ and there is no equilibrium. But if $(\mathbf{w_0 - A_2 - A_3})$ is negative, then $\mathbf{P < 1}$ and consequently Bayesian Nash equilibrium can come out. Therefore, in case there is Bayesian Nash equilibrium, the conclusion is that if the firm chooses a hold-out and then if nature defines a soft union, it will play concede. On the contrary, if he sets up a tough union, it will choose hold-out.

3.4 Case 4

In the fourth game, I start with the case that the union has a soft nature. The payoffs of both players are:

TYPE: SOFT UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w}^* + \boldsymbol{\alpha}_1$, $\boldsymbol{\pi}^*$	$\mathbf{w}_0 + \boldsymbol{\alpha}_2$, $\boldsymbol{\pi}_0$
	HOLD OUT	$\mathbf{w}_r - \boldsymbol{\alpha}_3$, $\boldsymbol{\pi}_r$	$-\boldsymbol{\alpha}_4$,0

Table 10: Payoff matrix with soft attitude of union

Based on Table 10, I notice that the soft union payoffs are different compared to the payoffs in the second and third cases. In particular, the soft union, because it is very condescending in its negotiations with the firm, records a change in its wage ($\boldsymbol{\alpha}_1, \boldsymbol{\alpha}_2, \boldsymbol{\alpha}_3, \boldsymbol{\alpha}_4 > 0$) in each case. So, when the soft union chooses concede, its wage, actually increases ($\mathbf{w}^* + \boldsymbol{\alpha}_1, \mathbf{w}_0 + \boldsymbol{\alpha}_2$) . On the contrary, in case the soft union plays hold-out, its wage for accuracy is reduced ($\mathbf{w}_r - \boldsymbol{\alpha}_3, -\boldsymbol{\alpha}_4$). Therefore, it holds that $\mathbf{w}^* + \boldsymbol{\alpha}_1 > \mathbf{w}_r - \boldsymbol{\alpha}_3$ and $\mathbf{w}_0 + \boldsymbol{\alpha}_2 > -\boldsymbol{\alpha}_4$. To sum up, I conclude that the union, when is soft, has an interest in playing concede regardless of the choice of firm. This means that when the union is soft, then concede is a dominant strategy for the union.

The literature describes an example of **soft union**, which discouraged strike activity in **Argentina in the mid-1980s**. In 1987 some unions were reluctant to call their members out and strikes had only limited participation in the Trade and Services sectors, though almost total among industrial workers; relative isolation and internal divisions weakened the strike movement. In the same year there were three general strikes but, as division grew in the labour movement, a part of the union leadership decided to join the government, accepting the Labour Ministry, for a few months. The demonstration on the occasion of the last of these 1987 strikes gathered only 20.000 people, while in 1985 120.000 people gathered in Buenos Aires to demonstrate against the economic plan during Alfonsin's administration.[38]

38 A century of general strikes. Strikes in Argentina (Nicolas Inigo Carrera)

Furthermore, I investigate the case where the union is of a tough attitude in the negotiations with the firm, because the nature decided so. Due to its hard nature, the union has different yields in different strategy combinations, compared to the soft union, as shown in the table 11.

TYPE: TOUGH UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w^* - A_1}$, $\boldsymbol{\pi^*}$	$\mathbf{w_0 - A_2}$,$\boldsymbol{\pi_0}$
	HOLD OUT	$\mathbf{w}_r$, $\boldsymbol{\pi_r}$	$\mathbf{A_3}$, **0**

Table 11: Payoff matrix with tough attitude of union

According to the table 11, I observe that the tough union presents the same payoffs as the third case. More specifically, when playing concede, receives a reduction of its wage ($\mathbf{A_1}$,$\mathbf{A_2}$) depending on the firm's strategy. In addition, a difference is found in the payoff of the tough union when both choose hold-out ($\mathbf{A_3}$). In particular, parameter $\mathbf{A_3}$ may not be a wage, e.g. it may symbolize the pride and dignity of the tough union, which chose hold-out. Moreover, at this point it should be noted that parameter $\mathbf{A_3}$ is greater than all the reductions that take place in the wages of the tough union ($\mathbf{A_3} > \mathbf{A_2} > \mathbf{A_1} > 0$), because pride and dignity are high values that are bordered higher than wages. In addition, for the convenience of the study, I assume that the parameters ($\mathbf{A_1}$,$\mathbf{A_2}, \mathbf{A_3}$) that affect the payoffs of the tough union receive higher values compared to the parameters ($\boldsymbol{\alpha_1}, \boldsymbol{\alpha_2}, \boldsymbol{\alpha_3}, \boldsymbol{\alpha_4}$) that influence the payoffs of the soft union ($\mathbf{A_i} > \boldsymbol{\alpha_j}$). The reason I make this assumption is because the tough union negotiations with the firm are longer and more painful for both players in relation to the soft union negotiations with the firm. Therefore, when the firm chooses concede, the best choice for the union is hold-out, since $\mathbf{w_r} > \mathbf{w^*} - \mathbf{A_1}$. On the contrary, if the firm plays hold out then the union has the benefit to choose hold-out again, due to the fact that $\mathbf{A_3} > w_0 - \mathbf{A_2}$. To sum up, I conclude that the union, when is tough, has an interest in playing hold-out regardless of the choice of firm. This means that when the union is tough, then hold-out is a dominant strategy for the union.

A typical example of tough unions are **Danish trade unions**. In particular, in Denmark in the first half of the 1980s the Schlüter government made an effort to promote business unionism by weakening the unions under the auspices of 'organizational freedom'. Furthermore, in the winter of 1984-85, Danish unions, inspired of the strikes by the German printers and metalworkers in 1984, demanded a 35-hour working week. After legal industrial action had started with a strike and lockout of 300.000 on 24 March 1985, the government offered a reduction of one hour from 1986 and a wage increase of 2% in 1985 and 1.5% in 1986, which could only be seen as a provocation by the workers as the last proposal of the state mediator was for a 38.5-hour week and a pay rise of 4%. On the day when the second parliamentary session on the intervention was scheduled, 5.000 activists including building workers blockaded the Danish parliament, while 20.000 participated in a demonstration nearby. A day later, 150,000 demonstrated in the capital against any interference in collective bargaining, followed by a huge wave of protest strikes, which reached their peak on 1 and 2 April 1985 and did not stop until 11 April.[39]

At this point, having constructed the two tables depicting the payoffs of union and firm, for probability **p** when union is soft and for probability **1-p** when union is tough, I will create a third table, which will be a combination of the previous two, in order to extract the optimal strategies of the two players. More specifically, there are eight cases that illustrate player payoffs (see Appendix page 46).

39 The persistence of labour unrest. Strikes in Denmark, 1969-2005 (Peter Birke)

3.4.1 Outcome of Case 4

		FIRM	
		CONCEDE	HOLD OUT
UNION	$C_S\, C_T$	$w^* + P\alpha_1 - (1-P)A_1$, π^*	$w_0 + P\alpha_2 - (1-P)A_2$, π_0
	$C_S\, H_T$	$P(w^* + \alpha_1) + (1-P)w_r$ $P\pi^* + (1-P)\pi_r$	$P(w_0 + \alpha_2) + (1-P)A_3$, $P\pi_0$
	$H_S\, C_T$	$P(w_r - \alpha_3) + (1-P) * (w^* - A_1)$, $P\pi_r + (1-P)\pi^*$	$(1-P) * (w_o - A_2) - P\alpha_4$, $(1-P)\pi_0$
	$H_S\, H_T$	$w_r - P\alpha_3, \pi_r$	$(1-P)A_3 - P\alpha_4$, 0

Table 12: Payoff matrix with a combination of the two types of union

In the table 12 I want to check if there is Bayesian Nash equilibrium in case the soft union plays concede, with the tough union and the firm choosing hold-out. In order for this to happen, it is necessary for the union's payoff to the corresponding cell to be greater than its other payoffs on the vertical axis (where the firm holds-out), while at the same time the firm's profits need to be greater than the profits for the same nature of the union combination (where soft union plays concede and tough union hold-out). In general, in any inequality that will be solved with respect to P, the condition must be satisfied $P \in (0,1)$.

In particular for the **firm**:

- $P\pi_0 \geq P\pi^* + (1-P)\pi_r =>$

$$P\pi_0 \geq P\pi^* + \pi_r - P\pi_r =>$$

$$P\pi_0 - P\pi^* + P\pi_r \geq \pi_r =>$$

$$P(\pi_0 - \pi^* + \pi_r) \geq \pi_r =>$$

$$\mathbf{P} \geq \frac{\boldsymbol{\pi_r}}{\boldsymbol{\pi_0 - \pi^* + \pi_r}} => \mathbf{P < 1}$$

The fraction is less than one and is positive and therefore the condition $P \in (0,1)$is satisfied.

Regarding the **union**:

- $P(w_0 + \alpha_2) + (1-P)A_3 \geq w_0 + P\alpha_2 - (1-P)A_2 =>$

$$Pw_0 + P\alpha_2 + A_3 - PA_3 \geq w_0 + P\alpha_2 - (A_2 - PA_2) =>$$

$$Pw_0 + P\alpha_2 + A_3 - PA_3 \geq w_0 + P\alpha_2 - A_2 + PA_2 =>$$

$$Pw_0 + P\alpha_2 - PA_2 - PA_3 - P\alpha_2 \geq w_0 - A_2 - A_3 =>$$

$$P(w_0 - A_2 - A_3) \geq w_0 - A_2 - A_3 =>$$

$$P \geq \frac{w_0 - A_2 - A_3}{w_0 - A_2 - A_3} => \mathbf{P \geq 1} \text{ or } \mathbf{P \leq 1}$$

- $P(w_0 + \alpha_2) + (1-P)A_3 \geq (1-P)(w_0 - A_2) - P\alpha_4 =>$

$$Pw_0 + P\alpha_2 + A_3 - PA_3 \geq w_0 - Pw_0 - A_2 + PA_2 - P\alpha_4 =>$$

$$Pw_0 + P\alpha_2 - PA_3 + Pw_0 - PA_2 + P\alpha_4 \geq w_0 - A_2 - A_3 =>$$

$$2Pw_0 + P\alpha_2 - PA_2 - PA_3 + P\alpha_4 \geq w_0 - A_2 - A_3 =>$$

$$P(2w_0 + \alpha_2 - A_2 - A_3 + \alpha_4) \geq w_0 - A_2 - A_3 =>$$

$$\mathbf{P} \geq \frac{\mathbf{w_0 - A_2 - A_3}}{\mathbf{2w_0 - A_2 - A_3 + \boldsymbol{\alpha_2} + \boldsymbol{\alpha_4}}} => \mathbf{P \geq 0}$$

- $P(w_0 + \alpha_2) + (1 - P)A_3 \geq (1 - P)A_3 - P\alpha_4 =>$

$$Pw_0 + P\alpha_2 + A_3 - PA_3 \geq A_3 - PA_3 - P\alpha_4 =>$$

$$Pw_0 + P\alpha_2 - PA_3 + PA_3 + P\alpha_4 \geq A_3 - A_3 =>$$

$$Pw_0 + P\alpha_2 + P\alpha_4 \geq 0 => P(w_0 + \alpha_2 + \alpha_4) \geq 0 =>$$

$$\mathbf{P} \geq \frac{\mathbf{0}}{\mathbf{w_0 + \alpha_2 + \alpha_4}} => \mathbf{P} \geq \mathbf{0}$$

As in case 3 the last two inequalities satisfy the condition $P \in (0,1)$. In contrast, the first inequality has two effects depending on the sign of the parentheses. If $(\mathbf{w_0 - A_2 - A_3})$ positive then $\mathbf{P > 1}$ and there is no equilibrium. But if $(\mathbf{w_0 - A_2 - A_3})$ is negative, then $\mathbf{P < 1}$ and consequently Bayesian Nash equilibrium can come out. Therefore, in case there is Bayesian Nash equilibrium, the conclusion is that if the firm chooses a hold-out and then if nature defines a soft union, it will play concede. On the contrary, if he sets up a tough union, it will choose hold-out.

3.5 Case 5

In the context of fifth game, I start with the case that the union has a soft nature. The payoffs of both players are:

TYPE: SOFT UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w^* + \alpha_1,}$ $\mathbf{\pi^* - \alpha_1 + d_1}$	$\mathbf{w_0 + \alpha_2,}$ $\mathbf{\pi_0 - \alpha_2 + d_2}$
	HOLD OUT	$\mathbf{w_r - \alpha_3,}$ $\mathbf{\pi_r + \alpha_3 + d_3}$	$\mathbf{-\alpha_4,}$ $\mathbf{\alpha_4 + d_4}$

Table 13: Payoff matrix with soft attitude of union

According to table 13 the soft union, because it is very condescending in its negotiations with the firm, records a change in its wage $(\boldsymbol{\alpha_1, \alpha_2, \alpha_3, \alpha_4} > 0)$ in each case. However, when the soft union chooses concede, its wage, actually increases

$(\mathbf{w}^* + \boldsymbol{\alpha}_1, \mathbf{w}_0 + \boldsymbol{\alpha}_2)$. On the contrary, in case the soft union plays hold-out, its wage is reduced $(\mathbf{w}_r - \boldsymbol{\alpha}_3, -\boldsymbol{\alpha}_4)$. Therefore, it holds that $\mathbf{w}^* + \boldsymbol{\alpha}_1 > \mathbf{w}_r - \boldsymbol{\alpha}_3$ and $\mathbf{w}_0 + \boldsymbol{\alpha}_2 > -\boldsymbol{\alpha}_4$. However, in this case I notice that there are differences in the payoffs of the firm. In particular, the firm has a loss in its profits, which is equivalent to the corresponding increase in the wage of the soft union $(\boldsymbol{\alpha}_1, \boldsymbol{\alpha}_2, \boldsymbol{\alpha}_3, \boldsymbol{\alpha}_4)$ but at the same time there is an increase in its profits, which is due to the increased productivity of the union $(\mathbf{d}_1, \mathbf{d}_2, \mathbf{d}_3, \mathbf{d}_4 > 0)$. Therefore, in order for the original condition in the firm's profits to apply, I consider that $\boldsymbol{\pi}_0 - \boldsymbol{\alpha}_2 + \mathbf{d}_2 > \boldsymbol{\pi}^* - \boldsymbol{\alpha}_1 + \mathbf{d}_1 > \boldsymbol{\pi}_\mathbf{r} + \boldsymbol{\alpha}_3 + \mathbf{d}_3 > \boldsymbol{\alpha}_4 + \mathbf{d}_4$.

The relationship between labor unions and productivity growth has long been a topic of research in economics. According to the literature, although unions may enhance productivity, the magnitude of such enhancement is far smaller than their effects on wages. As a result, unions have a negative overall effect on firm profitability. However, in Japan, firm-based labor unions, which have been a distinct characteristic of the Japanese labor system, actively participated in the productivity growth during the high growth era (1998-2004) and made efforts to enhance productivity in close cooperation with management. The system contributed to strengthen the international competitiveness of the manufacturing industries and to the growth of the Japanese economy.[40]

Moreover, I investigate the case where the union is of a tough attitude in the negotiations with the firm, because the nature decided so. Due to its hard nature, the union has different yields in different strategy combinations, compared to the soft union, as shown in the table 14.

40 Labor unions and productivity: An empirical analysis using Japanese firm-level data (Masayuki Morikawa)

TYPE: TOUGH UNION		FIRM	
		CONCEDE	HOLD OUT
UNION	CONCEDE	$\mathbf{w^* - A_1 , \ \pi^*}$	$\mathbf{w_0 - A_2 , \pi_0}$
	HOLD OUT	$\mathbf{w_r , \pi_r}$	$\mathbf{A_3 , 0}$

Table 14: Payoff matrix with tough attitude of union

At this point, having constructed the two tables depicting the payoffs of union and firm, for probability **p** when union is soft and for probability **1-p** when union is tough, I will create a third table, which will be a combination of the previous two, in order to extract the optimal strategies of the two players. More specifically, there are eight cases that illustrate player payoffs (see Appendix page 49).

3.5.1 Outcome of Case 5

		FIRM	
		CONCEDE	HOLD OUT
	$C_S C_T$	$\mathbf{w^* + P\alpha_1 - (1-P)A_1 ,}$ $\mathbf{\pi^* - P(\alpha_1 - d_1)}$	$\mathbf{w_0 + P\alpha_2 - (1-P)A_2 ,}$ $\mathbf{\pi_0 - P(\alpha_2 - d_2)}$
UNION	$C_S H_T$	$\mathbf{P(w^* + \alpha_1) + (1-P)w_r}$ $\mathbf{P(\pi^* - \alpha_1 + d_1) +}$ $\mathbf{(1-P)\pi_r}$	$\mathbf{P(w_0 + \alpha_2) + (1-P)A_3 ,}$ $\mathbf{P(\pi_0 - \alpha_2 + d_2)}$

	$H_S C_T$	$P(w_r - \alpha_3) + (1-P) * (w^* - A_1)$, $P(\pi_r + \alpha_3 + d_3) + (1-P) * \pi^*$	$(1-P) * (w_o - A_2) - P\alpha_4$, $P(\alpha_4 + d_4) + (1-P)\pi_0$
	$H_S H_T$	$w_r - P\alpha_3$, $\pi_r + P(\alpha_3 + d_3)$	$(1-P)A_3 - P\alpha_4$, $P(\alpha_4 + d_4)$

Table 15: Payoff matrix with a combination of the two types of union

In the table 15 I want to check if there is Bayesian Nash equilibrium in case the soft union plays concede, with the tough union and the firm choosing hold-out. In order for this to happen, it is necessary for the union's payoff to the corresponding cell to be greater than its other payoffs on the vertical axis (where the firm holds-out), while at the same time the firm's profits need to be greater than the profits for the same nature of the union combination (where soft union plays concede and tough union hold-out). In general, in any inequality that will be solved with respect to P, the condition must be satisfied $P \in (0,1)$.

In particular for the **firm**:

- $P(\pi_0 - \alpha_2 + d_2) + \geq P(\pi^* - \alpha_1 + d_1) + (1-P)\pi_r =>$

$$P\pi_0 - P\alpha_2 + Pd_2 \geq P\pi^* - P\alpha_1 + Pd_1 + \pi_r - P\pi_r =>$$

$$P\pi_0 - P\alpha_2 + Pd_2 - P\pi^* + P\alpha_1 - Pd_1 + P\pi_r \geq \pi_r =>$$

$$P(\pi_0 - \alpha_2 + d_2 - \pi^* + \alpha_1 - d_1 + \pi_r) \geq \pi_r =>$$

$$\mathbf{P \geq \frac{\pi_r}{\pi_0 - \alpha_2 + d_2 - \pi^* + \alpha_1 - d_1 + \pi_r} => P < 1}$$

The fraction is less than one and is positive and therefore the condition $P \in (0,1)$is satisfied.

Respectively for the **union** the same inequalities apply as in the fourth case:

- $P(w_0+\alpha_2) + (1-P)A_3 \geq w_0 + P\alpha_2 - (1-P)A_2 =>$

$Pw_0 + P\alpha_2 + A_3 - PA_3 \geq w_0 + P\alpha_2 - (A_2 - PA_2) =>$

$Pw_0 + P\alpha_2 + A_3 - PA_3 \geq w_0 + P\alpha_2 - A_2 + PA_2 =>$

$Pw_0 + P\alpha_2 - PA_2 - PA_3 - P\alpha_2 \geq w_0 - A_2 - A_3 =>$

$P(w_0 - A_2 - A_3) \geq w_0 - A_2 - A_3 =>$

$$P \geq \frac{w_0 - A_2 - A_3}{w_0 - A_2 - A_3} => \mathbf{P \geq 1} \text{ or } \mathbf{P \leq 1}$$

- $P(w_0+\alpha_2) + (1-P)A_3 \geq (1-P)(w_0 - A_2) - P\alpha_4 =>$

$Pw_0 + P\alpha_2 + A_3 - PA_3 \geq w_0 - Pw_0 - A_2 + PA_2 - P\alpha_4 =>$

$Pw_0 + P\alpha_2 - PA_3 + Pw_0 - PA_2 + P\alpha_4 \geq w_0 - A_2 - A_3 =>$

$2Pw_0 + P\alpha_2 - PA_2 - PA_3 + P\alpha_4 \geq w_0 - A_2 - A_3 =>$

$P(2w_0 + \alpha_2 - A_2 - A_3 + \alpha_4) \geq w_0 - A_2 - A_3 =>$

$$\mathbf{P} \geq \frac{\mathbf{w_0 - A_2 - A_3}}{\mathbf{2w_0 - A_2 - A_3 + \boldsymbol{\alpha}_2 + \boldsymbol{\alpha}_4}} => \mathbf{P \geq 0}$$

- $P(w_0+\alpha_2) + (1-P)A_3 \geq (1-P)A_3 - P\alpha_4 =>$

$Pw_0 + P\alpha_2 + A_3 - PA_3 \geq A_3 - PA_3 - P\alpha_4 =>$

$Pw_0 + P\alpha_2 - PA_3 + PA_3 + P\alpha_4 \geq A_3 - A_3 =>$

$Pw_0 + P\alpha_2 + P\alpha_4 \geq 0 => P(w_0 + \alpha_2 + \alpha_4) \geq 0 =>$

$$\mathbf{P} \geq \frac{\mathbf{0}}{\mathbf{w_0} + \boldsymbol{\alpha}_2 + \boldsymbol{\alpha}_4} => \mathbf{P \geq 0}$$

As in cases 3 and 4 the last two inequalities satisfy the condition $P \in (0,1)$. In contrast, the first inequality has two effects depending on the sign of the parentheses. If $(\mathbf{w_0 - A_2 - A_3})$ positive then $\mathbf{P > 1}$ and there is no equilibrium. But if $(\mathbf{w_0} -$

$\mathbf{A_2{-}A_3}$) is negative, then $\mathbf{P < 1}$ and consequently Bayesian Nash equilibrium can come out. Therefore, in case there is Bayesian Nash equilibrium, the conclusion is that if the firm chooses a hold-out and then if nature defines a soft union, it will play concede. On the contrary, if he sets up a tough union, it will choose hold-out.

4. Concluding remarks

This paper investigated when and if a strike decision is taken during negotiations between trade unions and firms under an asymmetric information regime, where the firm has information about the state (e.g. productivity) that the union ignores or where the union tries to hold private information that is unknown to the firm. In the literature, many economists have dealt with this issue and used various models and theories of strike activity in their research. Typical examples are **Hayes' strike model**, the **model of common costs of strike activities**, the **political strike model of Ashenfelter and Johnson**, the **accident model of strikes** and the **strike theory of Reder-Neumann-Kennan.**

More specifically, in this paper, using game theory, I constructed five different stories with the union having two attitudes (soft and tough, which nature decides) in the negotiations, while the firm presenting one type. Furthermore, it is noteworthy that in the context of the negotiations, any gains and losses of the two players reflected in the payoffs of the games are not monetary but are considered as terms of utility. The purpose of this process is to export Bayesian Nash Equilibria (BNE) in case the firm chooses hold-out with soft union playing concede, the tough union hold-out and therefore a strike activity will take place. In order for BNE to exist any inequality solved with respect to P must satisfy the condition P ∈ (0,1).

In particular, in case 1 where there are differences in the payoffs of the two natures of the union when it chooses concede ($\mathbf{A_1, A_2}$), I conclude that the soft union is motivated to always play concede regardless of the choice of firm. At the same time, BNE is not exported and therefore there is no possibility of strike activity. The conclusion drawn from case 2 with the lack of BNE (and as a result the absence of a strike likelihood) is similar, while the only difference lies in the fact that the tough union has an interest in playing hold-out disregarding to the firm's choice.

Conversely, in cases 3, 4, 5, in which new parameters are introduced in the players' payoffs such as the parameter of the tough union pride ($\mathbf{A_3}$), the changes recorded in the soft union wages ($\boldsymbol{\alpha_1}, \boldsymbol{\alpha_2}, \boldsymbol{\alpha_3}, \boldsymbol{\alpha_4}$) and the increases that take place in the firm's profits ($\mathbf{d_1}, \mathbf{d_2}, \mathbf{d_3}, \mathbf{d_4}$), I conclude that a BNE can be issued in case the firm chooses hold-out with soft union playing concede, the tough union hold-out and consequently a strike frequency will occur.

References

Ahmed S. M. (1989). The effects of the joint cost of strikes in Canadian Manufacturing industries—A test of the Reder-Neumann-Kennan theory. *Applied Economics,* Vol.21, pg 1353–1367.

Azam Paul Jean and Salmon Claire (2003). Strikes and political activism of trade unions: Theory and application to Bangladesh. *Public Choice,* Vol.119, pg.311-334.

Barlow A. and Buckley A (1998). A firm-level study of strike propensity in Ireland. *Economic and Social Review,* Vol.29 No.1, pg 17–31.

Birke Peter (2007). The persistence of labour unrest. Strikes in Denmark, 1969-2005. *Strikes around the world, 1968-2005*, pg.222-242.

Booth Alison and Cressy Robert (1990). Strikes with Asymmetric Information: Theory and Evidence. *Oxford Bulletin of Economics and Statistics,* Vol.52, No.3, pg 269-291.

Card David (1987). Longitudinal Analysis of strike activity. *National Bureau of Economic Research,* Working Paper No. 2263

Card David (1990). Strikes and Wages: A Test of an Asymmetric Information Model. *The Quarterly Journal of Economics,* Vol.105, No.3, pg 625-659.

Chun Kyung nok, Schaller Zachary and Stergios Skaperdas Stergios (2020). Why are there strikes?

Cousineau J. and Lacroix R (1986). Imperfect information and strikes: An analysis of Canadian experience, 1967-82. *Industrial and Labor Relations Review,* Vol.39, No.3 pg 377–387.

Cramton C. Peter and Tracy S. Joseph (1992). Strikes and Holdouts in Wage Bargaining: Theory and Data. *The American Economic Review,* Vol.82, No.1, pg 100-121.

Farber H. S. (1978). Bargaining theory, wage outcomes, and the occurrence of strikes: An econometric analysis. *American Economic Review,* Vol.68, No.3, pg 262–271.

Geraghty, T. and Wiseman, T. (2007). Wage strikes in 1880s America: A test of the war of attrition model. *Explorations in Economic History,* Vol.45, No.4, pg 303–326.

Hart Oliver (1989). Bargaining and Strikes. *The Quarterly Journal of Economics,* Vol.104, No.1, pg. 25-43.

Hayes Beth (1984). Unions and Strikes with Asymmetric Information. *Journal of Labor Economics,* Vol.2, No.1, pg 57-83.

Ingram, P. Metcalf, D. and Wadsworth, J. (1993). Strike incidence in British Manufacturing in the 1980s. *Industrial and Labor Relations Review,* Vol.46, No.4, pg 704–717.

Inigo Carrera Nicolas (2004). A century of general strikes. Strikes in Argentina. *Strikes around the world, 1968-2005*, pg.61-85.

Kennan, J. (1980). Pareto optimality and the Economics of strike duration. *Journal of Labor Research,* Vol.1, No.1, pg 77–94.

Maki, D. R. (1986). The effect of the cost of strike activity on the volume of strike activity. *Industrial and Labor Relations Review,* Vol.39, No.4, pg 552–563.

Mauro, M. (1982). Strikes as a result of imperfect information. *Industrial and Labor Relations Review,* Vol.35, No.4, pg 522–538.

McConell Sheena (1989). Strikes, Wages and Private Information. *The American Economic Review,* Vol.79, No.4, pg 801-815.

Morikawa Masayuki (2010). Labor unions and productivity: An empirical analysis using Japanese firm-level data. *Labour Economics*, Vol.17, pg. 1030-1037.

Mumford Karen (1995). Strikes and Profits: Considering an Asymmetric Information Model. *Applied Economics Letters,* Vol.3, pg 545-548.

Nelson B. William, Stone W. Gerald, JR. and Swint J. Michael (1981). An Economic Analysis of Public Sector, Collective Bargaining and Strike Activity. *Journal of Labor Research,* Vol.2, No.1, pg. 77-98.

Nicolitsas, D. (2000). Accounting for strikes: Evidence from UK Manufacturing in the 1980s. *Labour,* Vol.14, No.3, pg 417–440.

Pantsios Archontis L. and Polachek Solomon (2017). How Asymmetrically Increasing Joint Strike Costs Need Not Lead to Fewer Strikes. *Atlantic Economic Journal,* Vol.45, No.2, pg 149-161.

Rabinovitch Ramon and Swary Itzhak (1976). On the Theory of Bargaining, Strikes, and Wage Determination under Uncertainty. *The Canadian Journal of Economics,* Vol. 9, No. 4, pg. 668-684.

Reder, M. W and Neumann, G. R. (1980). Conflict and contract: The case of strikes. *Journal of Political Economy,* Vol.88, No.5, pg 867–886.

Siebert W. Stanley and Addison John T. (1981). Are Strikes Accidental? *The Economic Journal,* Vol.91, No.362, pg. 389-404.

Siebert, W. S. (1985). The political model of strikes: A new twist. *Southern Economic Journal,* Vol.52, No.1, pg 23–33.

Sopher, B. (1990). Bargaining and the joint-cost theory of strikes: An experimental study. *Journal of Labor Economics,* Vol.8, No.1, pg 48–74.

Tracy S. Joseph (1987). An Empirical Test of an Asymmetric Information Model of Strikes. *Journal of Labor Economics,* Vol.5, No.2, pg 149-173.

Varoufakis Yanis (1996). Bargaining and strikes: Towards an evolutionary framework. *Labour Economics,* Vol.3, pg 385-398.

Visser Wessel (2006). A racially divided class. Strikes in South Africa, 1973-2004. *Strikes around the world, 1968-2005*, pg.40-60.

Appendix

Case 1

FIRST CASE: <u>TOUGH AND SOFT UNION PLAY CONCEDE WITH THE FIRM CHOOSING CONCEDE</u>

Union's Payoff = $\mathrm{P} * \mathrm{w}^* + (1 - \mathrm{P}) * (\mathrm{w}^* + \mathrm{A}_1)$

= $\mathrm{Pw}^* + \mathrm{w}^* - \mathrm{Pw}^* + (1 - \mathrm{P}) * (\mathrm{A}_1)$

$= \mathbf{w}^* + (\mathbf{1} - \mathbf{P})\mathbf{A_1}$

Firm's Payoff = $\mathrm{P}\pi^* + (1 - \mathrm{P})\pi^* = \mathrm{P}\pi^* + \pi^* - \mathrm{P}\pi^* = \boldsymbol{\pi}^*$

SECOND CASE: <u>TOUGH AND SOFT UNION PLAY CONCEDE WITH THE FIRM CHOOSING HOLD OUT</u>

Union's Payoff = $\mathrm{P} * \mathrm{w}_0 + (1 - \mathrm{P}) * (\mathrm{w}_0 - \mathrm{A}_2)$

= $\mathrm{Pw}_0 + \mathrm{w}_0 - \mathrm{Pw}_0 + (1 - \mathrm{P}) * (-\mathrm{A}_2)$

$= \mathbf{w_0} - (\mathbf{1} - \mathbf{P})\mathbf{A_2}$

Firm's Payoff = $\mathrm{P}\pi_0 + (1 - \mathrm{P})\pi_0 = \mathrm{P}\pi_0 + \pi_0 - \mathrm{P}\pi_0 = \boldsymbol{\pi_0}$

THIRD CASE: <u>TOUGH UNION PLAYS CONCEDE, SOFT UNION CHOOSES HOLD OUT AND FIRM PLAYS CONCEDE</u>

Union's Payoff = $\mathbf{Pw^* + (1 - P)w_r}$

Firm's Payoff = $\mathbf{P\pi^* + (1 - P)\pi_r}$

FOURTH CASE: <u>TOUGH UNION PLAYS CONCEDE, SOFT UNION CHOOSES HOLD OUT AND FIRM PLAYS HOLD OUT</u>

Union's Payoff = $Pw_0 + (1 - P) * 0 = \mathbf{Pw_0}$

Firm's Payoff = $P\pi_0 + (1 - P) * 0 = \mathbf{P\pi_0}$

FIFTH CASE: <u>TOUGH UNION PLAYS HOLD OUT, SOFT UNION CHOOSES CONCEDE AND FIRM PLAYS CONCEDE</u>

Union's Payoff = $\mathbf{Pw_r + (1 - P) * (w^* + A_1)}$

Firm's Payoff = $\mathbf{P\pi_r + (1 - P) * \pi^*}$

SIXTH CASE: <u>TOUGH UNION PLAYS HOLD OUT, SOFT UNION CHOOSES CONCEDE AND FIRM PLAYS HOLD OUT</u>

Union's Payoff = $P * 0 + (1 - P) * (w_o - A_2)$ = $\mathbf{(1 - P) * (w_o - A_2)}$

Firm's Payoff = $P * 0 + (1 - P)\pi_0 = \mathbf{(1 - P)\pi_0}$

SEVENTH CASE: <u>TOUGH AND SOFT UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING CONCEDE</u>

Union's Payoff = $Pw_r + (1 - P) * w_r = Pw_r + w_r - Pw_r = \mathbf{w_r}$

Firm's Payoff = $P\pi_r + (1 - P)\pi_r = P\pi_r + \pi_r - P\pi_r = \boldsymbol{\pi_r}$

EIGHTH CASE: <u>SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING HOLD OUT</u>

Union's Payoff = $P * 0 + (1 - P) * 0 = \mathbf{0}$

Firm's Payoff = $P * 0 + (1 - P) * 0 = \mathbf{0}$

Case 2

FIRST CASE: <u>SOFT AND TOUGH UNION PLAY CONCEDE WITH THE FIRM CHOOSING CONCEDE</u>

Union's Payoff = $P * w^* + (1 - P) * (w^* - A_1)$

$= Pw^* + w^* - Pw^* - (1 - P) * (A_1)$

$= \mathbf{w^* - (1 - P)A_1}$

Firm's Payoff $= P\pi^* + (1 - P)\pi^* = P\pi^* + \pi^* - P\pi^* = \boldsymbol{\pi^*}$

SECOND CASE: <u>SOFT AND TOUGH UNION PLAY CONCEDE WITH THE FIRM CHOOSING HOLD OUT</u>

Union's Payoff $= P * w_0 + (1 - P) * (w_0 - A_2)$

$= Pw_0 + w_0 - Pw_0 + (1 - P) * (-A_2)$

$= \mathbf{w_0 - (1 - P)A_2}$

Firm's Payoff $= P\pi_0 + (1 - P)\pi_0 = P\pi_0 + \pi_0 - P\pi_0 = \boldsymbol{\pi_0}$

THIRD CASE: <u>SOFT UNION PLAYS CONCEDE, TOUGH UNION CHOOSES HOLD OUT AND FIRM PLAYS CONCEDE</u>

Union's Payoff $= \mathbf{Pw^* + (1 - P)w_r}$

Firm's Payoff $= \mathbf{P}\boldsymbol{\pi}^* + \mathbf{(1 - P)}\boldsymbol{\pi_r}$

FOURTH CASE: <u>SOFT UNION PLAYS CONCEDE, TOUGH UNION CHOOSES HOLD OUT AND FIRM PLAYS HOLD OUT</u>

Union's Payoff $= Pw_0 + (1 - P) * 0 = \mathbf{Pw_0}$

Firm's Payoff $= P\pi_0 + (1 - P) * 0 = \mathbf{P}\boldsymbol{\pi_0}$

FIFTH CASE: SOFT UNION PLAYS HOLD OUT, TOUGH UNION CHOOSES CONCEDE AND FIRM PLAYS CONCEDE

Union's Payoff = $\mathbf{Pw_r} + (\mathbf{1} - \mathbf{P}) * (\mathbf{w^*} - \mathbf{A_1})$

Firm's Payoff = $\mathbf{P\pi_r} + (\mathbf{1} - \mathbf{P}) * \boldsymbol{\pi}^*$

SIXTH CASE: SOFT UNION PLAYS HOLD OUT, TOUGH UNION CHOOSES CONCEDE AND FIRM PLAYS HOLD OUT

Union's Payoff = $P * 0 + (1 - P) * (w_o - A_2) = (\mathbf{1} - \mathbf{P}) * (\mathbf{w_o} - \mathbf{A_2})$

Firm's Payoff = $P * 0 + (1 - P)\pi_0 = (\mathbf{1} - \mathbf{P})\boldsymbol{\pi}_\mathbf{0}$

SEVENTH CASE: SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING CONCEDE

Union's Payoff = $Pw_r + (1 - P) * w_r = Pw_r + w_r - Pw_r = \mathbf{w_r}$

Firm's Payoff = $P\pi_r + (1 - P)\pi_r = P\pi_r + \pi_r - P\pi_r = \boldsymbol{\pi}_\mathbf{r}$

EIGHTH CASE: SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING HOLD OUT

Union's Payoff = $P * 0 + (1 - P) * 0 = \mathbf{0}$

Firm's Payoff = $P * 0 + (1 - P) * 0 = \mathbf{0}$

Case 3

FIRST CASE: SOFT AND TOUGH UNION PLAY CONCEDE WITH THE FIRM CHOOSING CONCEDE

Union's Payoff = $P * w^* + (1 - P) * (w^* - A_1)$

= $Pw^* + w^* - Pw^* - (1 - P) * (A_1)$

$= \mathbf{w^* - (1 - P) A_1}$

Firm's Payoff = $P\pi^* + (1 - P)\pi^* = P\pi^* + \pi^* - P\pi^* = \boldsymbol{\pi^*}$

SECOND CASE: SOFT AND TOUGH UNION PLAY CONCEDE WITH THE FIRM CHOOSING HOLD OUT

Union's Payoff = $P * w_0 + (1 - P) * (w_0 - A_2)$

= $Pw_0 + w_0 - Pw_0 + (1 - P) * (- A_2)$

$= \mathbf{w_0 - (1 - P) A_2}$

Firm's Payoff = $P\pi_0 + (1 - P)\pi_0 = P\pi_0 + \pi_0 - P\pi_0 = \boldsymbol{\pi_0}$

THIRD CASE: SOFT UNION PLAYS CONCEDE, TOUGH UNION CHOOSES HOLD OUT AND FIRM PLAYS CONCEDE

Union's Payoff = $\mathbf{Pw^* + (1 - P)w_r}$

Firm's Payoff $= \mathbf{P\pi^* + (1 - P)\pi_r}$

FOURTH CASE: SOFT UNION PLAYS CONCEDE, TOUGH UNION CHOOSES HOLD OUT AND FIRM PLAYS HOLD OUT

Union's Payoff = $Pw_0 + (1 - P) * A_3 = \mathbf{Pw_0 + (1 - P)A_3}$

Firm's Payoff $= P\pi_0 + (1 - P) * 0 = \mathbf{P\pi_0}$

FIFTH CASE: SOFT UNION PLAYS HOLD OUT, TOUGH UNION CHOOSES CONCEDE AND FIRM PLAYS CONCEDE

Union's Payoff = $\mathbf{Pw_r + (1 - P) * (w^* - A_1)}$

Firm's Payoff $= \mathbf{P\pi_r + (1 - P) * \pi^*}$

SIXTH CASE: SOFT UNION PLAYS HOLD OUT, TOUGH UNION CHOOSES CONCEDE AND FIRM PLAYS HOLD OUT

Union's Payoff = $P * 0 + (1 - P) * (w_o - A_2) = \mathbf{(1 - P) * (w_o - A_2)}$

Firm's Payoff = $P * 0 + (1 - P)\pi_0 = \mathbf{(1 - P)\pi_0}$

SEVENTH CASE: <u>SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING CONCEDE</u>

Union's Payoff = $Pw_r + (1 - P) * w_r = Pw_r + w_r - Pw_r = \mathbf{w_r}$

Firm's Payoff = $P\pi_r + (1 - P)\pi_r = P\pi_r + \pi_r - P\pi_r = \boldsymbol{\pi_r}$

EIGHTH CASE: <u>SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING HOLD OUT</u>

Union's Payoff = $P * 0 + (1 - P) * A_3 = \mathbf{(1 - P)A_3}$

Firm's Payoff = $P * 0 + (1 - P) * 0 = \mathbf{0}$

Case 4

FIRST CASE: <u>SOFT AND TOUGH UNION PLAY CONCEDE WITH THE FIRM CHOOSING CONCEDE</u>

Union's Payoff = $P * (w^* + \alpha_1) + (1 - P) * (w^* - A_1)$

= $Pw^* + P\alpha_1 + w^* - Pw^* - (1 - P) * (A_1)$

$= \mathbf{w^* + P\boldsymbol{\alpha}_1 - (1 - P)A_1}$

Firm’s Payoff = $P\pi^{*} + (1 - P)\pi^{*} = P\pi^{*} + \pi^{*} - P\pi^{*} = \boldsymbol{\pi}^{*}$

SECOND CASE: <u>SOFT AND TOUGH UNION PLAY CONCEDE WITH THE FIRM CHOOSING HOLD OUT</u>

Union’s Payoff = $P * (w_0 + \alpha_2) + (1 - P) * (w_0 - A_2)$

= $Pw_0 + P\alpha_2 + w_0 - Pw_0 + (1 - P) * (- A_2)$

$= \mathbf{w_0} + \mathbf{P}\boldsymbol{\alpha}_\mathbf{2} - (\mathbf{1} - \mathbf{P})\mathbf{A_2}$

Firm’s Payoff = $P\pi_0 + (1 - P)\pi_0 = P\pi_0 + \pi_0 - P\pi_0 = \boldsymbol{\pi}_\mathbf{0}$

THIRD CASE: <u>SOFT UNION PLAYS CONCEDE, TOUGH UNION CHOOSES HOLD OUT AND FIRM PLAYS CONCEDE</u>

Union’s Payoff = $\mathbf{P}(\mathbf{w}^{*} + \boldsymbol{\alpha}_\mathbf{1}) + (\mathbf{1} - \mathbf{P})\mathbf{w_r}$

Firm’s Payoff = $\mathbf{P}\boldsymbol{\pi}^{*} + (\mathbf{1} - \mathbf{P})\boldsymbol{\pi}_\mathbf{r}$

FOURTH CASE: <u>SOFT UNION PLAYS CONCEDE, TOUGH UNION CHOOSES HOLD OUT AND FIRM PLAYS HOLD OUT</u>

Union’s Payoff = $\mathbf{P}(\mathbf{w_0} + \boldsymbol{\alpha}_\mathbf{2}) + (\mathbf{1} - \mathbf{P})\mathbf{A_3}$

Firm’s Payoff = $P\pi_0 + (1 - P) * 0 = \mathbf{P}\boldsymbol{\pi}_\mathbf{0}$

FIFTH CASE: SOFT UNION PLAYS HOLD OUT, TOUGH UNION PLAYS CONCEDE AND FIRM CHOOSES CONCEDE

Union's Payoff = $\mathbf{P}(\mathbf{w_r} - \boldsymbol{\alpha_3}) + (\mathbf{1} - \mathbf{P}) * (\mathbf{w^*} - \mathbf{A_1})$

Firm's Payoff = $\mathbf{P\pi_r} + (\mathbf{1} - \mathbf{P}) * \boldsymbol{\pi^*}$

SIXTH CASE: SOFT UNION PLAYS HOLD OUT, TOUGH UNION PLAYS CONCEDE AND FIRM CHOOSES HOLD OUT

Union's Payoff = $(\mathbf{1} - \mathbf{P}) * (\mathbf{w_o} - \mathbf{A_2}) - \mathbf{P}\boldsymbol{\alpha_4}$

Firm's Payoff = $\mathrm{P} * 0 + (1 - \mathrm{P})\pi_0 = (\mathbf{1} - \mathbf{P})\boldsymbol{\pi_0}$

SEVENTH CASE: SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING CONCEDE

Union's Payoff = $\mathrm{P}(\mathrm{w_r} - \alpha_3) + (1 - \mathrm{P}) * \mathrm{w_r} = \mathrm{Pw_r} - \mathrm{P}\alpha_3 + \mathrm{w_r} - \mathrm{Pw_r} = \mathbf{w_r} - \mathbf{P}\boldsymbol{\alpha_3}$

Firm's Payoff = $\mathrm{P}\pi_r + (1 - \mathrm{P})\pi_r = \mathrm{P}\pi_r + \pi_r - \mathrm{P}\pi_r = \boldsymbol{\pi_r}$

EIGHTH CASE: <u>SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING HOLD OUT</u>

Union's Payoff = $(\mathbf{1}-\mathbf{P})\mathbf{A_3}-\mathbf{P\alpha_4}$

Firm's Payoff = $\mathrm{P}*0+(1-\mathrm{P})*0=\mathbf{0}$

Case 5

FIRST CASE: <u>SOFT AND TOUGH UNION PLAY CONCEDE WITH THE FIRM CHOOSING CONCEDE</u>

Union's Payoff = $\mathrm{P}*(\mathrm{w}^*+\alpha_1)+(1-\mathrm{P})*(\mathrm{w}^*-\mathrm{A}_1)$

= $\mathrm{Pw}^*+\mathrm{P}\alpha_1+\mathrm{w}^*-\mathrm{Pw}^*-(1-\mathrm{P})*(\mathrm{A}_1)$

$=\mathbf{w}^*+\mathbf{P\alpha_1}-(\mathbf{1}-\mathbf{P})\mathbf{A_1}$

Firm's Payoff $=\mathrm{P}(\pi^*-\alpha_1+\mathrm{d}_1)+(1-\mathrm{P})\pi^*=\mathrm{P}\pi^*-\mathrm{P}(\alpha_1-\mathrm{d}_1)+\pi^*-\mathrm{P}\pi^*=$ $\boldsymbol{\pi}^*-\mathbf{P}(\boldsymbol{\alpha_1}-\mathbf{d_1})$

SECOND CASE: <u>SOFT AND TOUGH UNION PLAY CONCEDE WITH THE FIRM CHOOSING HOLD OUT</u>

Union's Payoff = $\mathrm{P}*(\mathrm{w}_0+\alpha_2)+(1-\mathrm{P})*(\mathrm{w}_0-\mathrm{A}_2)$

= $\mathrm{Pw}_0+\mathrm{P}\alpha_2+\mathrm{w}_0-\mathrm{Pw}_0+(1-\mathrm{P})*(-\mathrm{A}_2)$

$=\mathbf{w_0}+\mathbf{P\alpha_2}-(\mathbf{1}-\mathbf{P})\mathbf{A_2}$

Firm's Payoff $=\mathrm{P}(\pi_0-\alpha_2+\mathrm{d}_2)+(1-\mathrm{P})\pi_0=\mathrm{P}\pi_0-\mathrm{P}(\alpha_2-\mathrm{d}_2)+\pi_0-\mathrm{P}\pi_0=$ $\boldsymbol{\pi_0}-\mathbf{P}(\boldsymbol{\alpha_2}-\mathbf{d_2})$

THIRD CASE: <u>SOFT UNION PLAYS CONCEDE, TOUGH UNION CHOOSES HOLD OUT AND FIRM PLAYS CONCEDE</u>

Union's Payoff = $\mathbf{P(w^* + \alpha_1) + (1 - P\ )w_r}$

Firm's Payoff $= \mathbf{P(\pi^* - \alpha_1 + d_1)\ +\ (1 - P)\pi_r}$

FOURTH CASE: <u>SOFT UNION PLAYS CONCEDE, TOUGH UNION CHOOSES HOLD OUT AND FIRM PLAYS HOLD OUT</u>

Union's Payoff = $\mathbf{P(w_0 + \alpha_2) + (1 - P)A_3}$

Firm's Payoff $= \mathrm{P}(\pi_0 - \alpha_2 + \mathrm{d}_2) +\ (1 - \mathrm{P}) * 0 = \mathbf{P(\pi_0 - \alpha_2 + d_2)}$

FIFTH CASE: <u>SOFT UNION PLAYS HOLD OUT, TOUGH UNION PLAYS CONCEDE AND FIRM CHOOSES CONCEDE</u>

Union's Payoff = $\mathbf{P(w_r - \alpha_3) + (1 - P\ ) * (w^* - A_1)}$

Firm's Payoff = $\mathbf{P(\pi_r + \alpha_3 + d_3) +\ (1 - P) * \pi^*}$

SIXTH CASE: <u>SOFT UNION PLAYS HOLD OUT, TOUGH UNION PLAYS CONCEDE AND FIRM CHOOSES HOLD OUT</u>

Union's Payoff = $(\mathbf{1-P})*(\mathbf{w_o - A_2}) - \mathbf{P\alpha_4}$

Firm's Payoff = $\mathbf{P(\alpha_4 + d_4) + (1-P)\pi_0}$

SEVENTH CASE: <u>SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING CONCEDE</u>

Union's Payoff = $P(w_r - \alpha_3) + (1-P) * w_r = Pw_r - P\alpha_3 + w_r - Pw_r =$ $\mathbf{w_r - P\alpha_3}$

Firm's Payoff $= P(\pi_r + \alpha_3 + d_3) + (1-P)\pi_r = P\pi_r + P(\alpha_3 + d_3) + \pi_r - P\pi_r =$ $\mathbf{\pi_r + P(\alpha_3 + d_3)}$

EIGHTH CASE: <u>SOFT AND TOUGH UNION PLAY HOLD OUT, WITH THE FIRM CHOOSING HOLD OUT</u>

Union's Payoff = $\mathbf{(1-P)A_3 - P\alpha_4}$

Firm's Payoff = $P(\alpha_4 + d_4) + (1-P) * 0 = \mathbf{P(\alpha_4 + d_4)}$