

LABOR UNION OBJECTIVES
UNDER A MULTI-CONTRACT PERIOD TIME HORIZON

by
PAUL MICHAEL KIESS-MOSER
B.A., The University of British Columbia, 1984

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in
THE FACULTY OF GRADUATE STUDIES
(DEPARTMENT OF ECONOMICS)

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
January 1987
© Paul Michael Kiess-Moser, 1987

In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Economics

The University of British Columbia
1956 Main Mall
Vancouver, Canada
V6T 1Y3

Date March 6, 1987

Abstract

Most microeconomic models of labor unions take the union's membership size as exogenous, and limit union members' time horizons to a single contract period. Particularly for unions allocating employment by means of a seniority system, and for unions facing stochastic demand for labor conditions, these limitations in current union models lead to unsatisfactory predictions of union behavior.

In this thesis, an n -period majority voting model of a monopoly union facing a fixed demand for labor schedule and allocating employment by seniority is developed to show the interdependence between the union's present wage choice, the size of the union's future voter pool and its future wage choices. Union members are assumed to predict the union's future voting behavior, and to account for the consequences of the retirement of senior union members. The optimal contract wage is shown analytically to be not lower than that wage which causes the layoff of twice the number of retiring workers per contract period in each contract period, and not to exceed the wage level at which half of the union's present voter pool would lose its union employment. Computer simulation solutions for various demand conditions suggest that after a potential sharp first-period increase in the contract wage, the union's contract wage path follows its analytically derived lower limit - with each contract, union employment declines by twice the number of retirees per contract period. The time path of union employment is shown to be largely independent of anticipated changes in demand for labor.

A similar two-period model is developed for stochastic demand for labor conditions. For some cases, the union's wage choice can be shown to be lower when the consequences of this period's wage choice on next period's voter pool are taken into account. Majority voting instability problems cannot be ruled out for this type of model, and are interpreted as a potential cause for a union-internal political process.

These seniority-based models are then compared with models where union employment is allocated by a random draw among union members. With nonstochastic demand for labor, this allows for the analysis of discrete changes in union rules, and yields the principal prediction that the union will eventually replace an employment by random draw rule with employment according to seniority.

The economic approach to the analysis of union behavior is assessed critically, and put in some perspective by an informal discussion of other union-internal determinants of union behavior. In conclusion, it is suggested that the formal prediction of an ongoing gradual decline in union employment may be usefully amended by considering potential benefits from union size maintenance and union membership rejuvenation.

Table of Contents

Abstract	ii
List of Tables	vii
List of Figures	viii
1. Introduction and Overview	1
1.1 Introduction	1
1.2 Outline of Contents	2
2. Survey of Relevant Literature	5
2.1 The Economic Analysis of Unionism: The Monopoly and the Monopoly - Collective Voice Paradigms	7
2.2 Economic Models Of Union Behavior	15
3. Introduction to Multiperiod Union Contract Wage Determination Models	37
3.1 The Setting	38
3.1.1 Principal Assumptions about the Union	38
3.1.2 The Allocation of Employment among Union Members	40
3.1.3 Union Membership Status and Union Voting Rights	42
3.2 Definition of Variables and Functions	43
4. The Choice of Contract Wage under Fixed Demand for Labor, with Employment by Seniority and Voting Rights Loss for Laid-Off Workers	46
4.1 The General N-Period Model	47
4.2 Simulation Solution	59
5. Union Wage Choice under Stochastic Demand for Labor, with Employment by Seniority and Voting Rights Loss for Laid-Off Workers	81
5.1 Demand for Labor with an Additive Stochastic Term	85
5.2 Demand for Labor with a Multiplicative Stochastic Term	109

6. Models for Alternative Union Rules for Unions Allocating Employment by Seniority	116
6.1 Laid-off Workers Retain Union Voting Rights and Union Membership	117
6.1.1 Fixed Demand For Labor	118
6.1.2 Demand for Labor with a Multiplicative Stochastic Term ..	119
6.2 Laid-Off Union Members Lose Voting Rights and Union Membership	120
6.2.1 Fixed Demand for Labor Schedule	120
6.2.2 Demand for Labor with a Multiplicative Stochastic Term .	121
7. Model Variants with Employment and Layoffs by Random Draw ...	122
7.1 Laid-Off Workers Retain Union Membership	123
7.1.1 Fixed Demand for Labor Schedule	124
7.1.2 Demand for Labor with a Multiplicative Stochastic Term ..	127
7.2 Laid-Off Union Members Lose Voting Rights and Union Membership	130
7.2.1 Fixed Demand For Labor Schedule	130
7.2.2 Demand for Labor with a Multiplicative Stochastic Term .	134
8. Results on Optimal Union Rules	135
8.1 Optimal Union Rules under a Fixed Demand for Labor Schedule Regime	136
8.1.1 Rules on Voting Rights and Membership Status of Laid-Off Workers	136
A: Employment is Assigned By Random Draw.....	136
B: Employment is Assigned by Seniority.....	138
8.1.2 Rule Governing the Allocation of Employment Among Union Members	139
8.2 Optimal Union Rules under a Stochastic Demand for Labor Regime	141
8.2.1 Rules on Voting Rights and Membership Status of Laid-Off Workers in a Union with Employment Allocation by Seniority	141
8.2.2 Rule Governing the Allocation of Employment Among Union Members	144

9. An Alternative Model: Cyclical Preferences Case	150
9.1 Introduction	150
9.2 Formal Demonstration	153
10. Critical Assessment of Formal Models	162
10.1 How Do Real-World Unionists Determine Their Contract Wage Preferences?	163
10.2 The Interaction Between Worker Characteristics, the Union Leadership and the Overall Environment	166
11. Alternative Approaches	169
11.1. Earnings and Union Membership Size as Two Primary Determinants of the Union's Choice of Contract Wage	169
11.1.1 Introduction	169
11.1.2 Directly Economic Size Benefits	171
11.1.3 Size Benefits due to Psychological or Sociological Reasons	176
11.2 Economic versus Noneconomic Analysis of Union Behavior	179
12. Concluding Remarks	186
Bibliography	189

List of Tables

I: Alternative Assumptions on Union Rules	116
II: Predicted Evolution of Union Rules	149

List of Figures

1: The Union's Retirement Process	52
2: The Median Worker's Decision Problem	62

Fixed Demand for Labor Model - Simulation Results:

3: Concave Demand - Low Interest Rate Case	67
4: Concave Demand - High Interest Rate Case	67
5: Convex Demand - Low Interest Rate Case	69
6: Convex Demand - High Interest Rate Case	69
7: Concave Demand - Moderate Demand Growth Case	71
8: Concave Demand - High Demand Growth Case	71
9: Convex Demand - Moderate Demand Growth Case	73
10: Convex Demand - High Demand Growth Case	73
11: Convex Demand - Moderate Demand Decline Case	74
12: Rising Alternative Wage Rate Case	77
13: Effects of No Access to Credit Markets Case	77
14: FOC of Uniform Additive Stochastic Term Model	101

1. Introduction and Overview

1.1 Introduction

The analysis of the microeconomic foundations of labor union behavior presents an interesting challenge to combine results from several areas of economic research. Given both the importance of labor unions in modern developed market economies and the availability of relatively advanced results in the theory of individual economic behavior, the theory of social choice, bargaining theory and producer theory, it is therefore somewhat surprising to find the microeconomic foundations of labor union behavior in a comparatively less developed state.

This paper is about one microeconomic aspect of labor union behavior, namely the interdependence of the union's majority preferences regarding the contract wage and changes in union membership characteristics brought about by the union's choice of contract wages.

Most existing relevant models of union behavior take union membership size and related distributions of union membership characteristics as a given and concentrate on deriving the union's majority preference relation regarding the contract wage in a one-period setting. This is an important and only relatively recent contribution to the theory of union behavior. But it is, in some instances, not satisfactory because of its neglect of the consequences of current contract choices on the union's future voting behavior. As a case in point for the importance and empirical likelihood of multiperiod time horizons, consider the behavior

of a stylised labor union that allocates employment by seniority and takes union employment as a condition for union membership: If the members of such a union consider only the contract period governed by the union contract they are presently voting on, they will tend to arrive at a majority vote for a wage which cuts union employment roughly in half; and this outcome will be repeated in future contract votes. Such a rapid decline of union size is both empirically implausible and likely to motivate union members to expand the time horizon under which they form contract wage preferences. But if union members expand their time horizon to cover more than one contract period, they in effect become aware of the consequences of their voting decision regarding the current contract wage on the characteristics of the union voter pool in future contract votes. To analyze this link between current and future union member preferences, current and future contract wage choices and future union membership characteristics is the main concern of this paper.

1.2 Outline of Contents

After a survey of the relevant literature in chapter 2, the two principal formal union models developed for this paper are presented in chapters 3, 4 and 5: In chapter 3, the common structure of these two models of a union allocating employment by seniority is presented and the set of variables and common assumptions defined. Chapter 4 is devoted first to the analytical treatment of and then to simulation results for an n -period model of a union facing a fixed demand for labor schedule.

Chapter 5 presents a two-period model with stochastic demand for labor conditions.

Chapters 6 to 9 contain a number of variations on the principal models of chapters 4 and 5, developed to assess and compare the influence of various assumptions regarding the union's choice of employment allocation, voting and union membership rules and homogeneous membership characteristics. The model variants in chapter 6 are for a union allocating employment by seniority (as in chapters 4 and 5), but with different rules regarding voting and membership rights. Chapter 7 covers one major alternative to the allocation of employment by seniority, namely employment by random draw. Building on the model variants in chapters 4 to 7, chapter 8 suggests, for some circumstances, the path evolving union rules on voting and membership rights and employment allocation among members are likely to take.

As a contrast to chapters 4 to 8, where majority voting instability problems are assumed (and in some instances, shown) to be ruled out by appropriate behavioral assumptions, chapter 9 presents a partly formal model of a union whose members' preferences over contract wages may be double-peaked, and suggests the resulting characterizable voting instability problem as reflecting one possible reason for a type of union leadership behavior at times observable in the real world.

In chapter 10, the empirical merit of the process assumed in the models in the main body of this paper, and the merits of these models' predictions are discussed. This critical review is expanded in chapter 11,

where first alternative economic and then noneconomic determinants of the union's choice of contract wage and membership size are debated informally.

In sum, this paper proceeds in three stages: Chapter 2's literature review lays out the framework in economic terms. Accepting and building on this economic approach to the analysis of union behavior, chapters 3 to 9 develop a number of formal union models – two core models first, and then a number of variants demonstrating the effects of alternative model assumptions. Finally, the empirical validity of these models, their specific economic approach and of the economic approach to the analysis of union behavior in general are debated in chapters 10 and 11 to put the treatment of union behavior in this paper in some perspective.

2. Survey of Relevant Literature

The economic analysis of modern labor unions has its origin in the now classic debate between Arthur Ross¹ and John Dunlop² in the 1940s. Ross argued that the political and economic determinants of labor union behavior are very much intertwined and often inseparable from a specific union's history. To him, the generalizing analysis of labor union behavior with straightforward tools of economics alone was therefore almost doomed to do injustice to its subject, particularly since he believed the interests of a heterogeneous union membership to differ substantially from those of the union's leadership. Dunlop took a more pragmatic position, claiming that labor unions as collectives of economic agents operating in an economic environment can be assumed to maximize "something", and are therefore amenable to economic analysis, even though economic considerations may not be the only determinants of their actions.³

¹ Arthur M. Ross, Trade Union Wage Policy (Berkeley: University of California Press, 1948).

² John T. Dunlop, Wage Determination under Trade Unions (New York: Macmillan, 1944).

³ "An economic theory of a trade union requires that the organization be assumed to maximize [or minimize] something." (Ibid., p. 4.) Dunlop did not seek to impose a strictly neoclassical model on labor unions by trying to explain all aspects of union behavior as consequences of individual utility maximization. In fact, his model of industrial relations recognizes political and sociological phenomena, and is still regarded as the classic model in the field of Industrial Relations. (Gerald E. Phillips, Labour Relations and the Collective Bargaining Cycle, 2d ed. (Toronto: Butterworths, 1981), p. 3.)

Even though Dunlop's argument eventually prevailed, the economic analysis of labor union behavior has shown relatively slow progress up until the mid 1970s.⁴ In his 1975 survey paper, Johnson still concludes that "the problem of modelling trade union behavior has proved to be virtually intractable. This is because (1) there is no consensus on the goals of union activity [...] such as exists with respect to the firm or consumer and (2) the received pure theory of bargaining is devoid of operational content."⁵ A decade of more intensive research since then has yielded results in two areas: First, at least one formal model of labor union behavior that is grounded in first principles, employs the majority voting model successfully and defines the applicability of collective bargaining models in this context; and second, a fair number of econometric studies which assume a union objective function and are able to show that a significant part of specific real-world unions' behavior can be explained in this way. This more recent literature is discussed in survey papers by Oswald⁶ and Farber⁷. Some of it will be reviewed here, but before, a short discussion of the general perception of labor unions in the field of economics in the last four decades will be given.

⁴ In keeping with the topic of this paper, this literature survey deals with models of union behavior and ignores research on the effects of unions, which appears to have developed faster than work on union behavior.

⁵ G.E. Johnson, "Economic Analysis of Trade Unionism," American Economic Review 65 (May 1975): 23-24.

⁶ A.J. Oswald, "The Economic Theory of Trade Unions: An Introductory Survey," Scandinavian Journal of Economics 87 no. 2 (1985): 160-193.

⁷ Henry S. Farber, "The Analysis of Union Behaviour," Working Paper 1502, National Bureau of Economic Research, November 1984.

2.1 The Economic Analysis of Unionism: The Monopoly and the Monopoly-Collective Voice Paradigms

The traditional paradigm of the labor union in economics has workers form unions for the primary benefit of raising union earnings above equilibrium earnings⁸ in the competitive labor market by restricting the supply of labor to an organized firm or industry. In doing so, unions contribute to allocative inefficiency in the overall economy. Also, workers may form or stay in unions to enjoy benefits from restrictive work rules or to control the adoption of new technology by the firm, with an adverse effect on the firm's technical efficiency. If unions decide to strike (and thus to use one of their primary sources of power directly), the resultant loss of output constitutes an additional loss to the economy. Finally, unions may have an adverse effect on the economy's dynamic efficiency, by reducing the profitability of firms, and reducing research and development spending and investment in turn.⁹

In recent years, this view of the labor union has begun to be challenged by the Monopoly-Collective Voice paradigm of unionism, which holds that in addition to the above-mentioned monopoly consequences of unionism, labor unions can achieve non-earnings economic benefits for workers by

⁸ Econometric work in this context centers on the union wage differential; but the general argument can be made in terms of all forms of financial compensation for workers, be it wages, pension benefits, insurance plans, and paid time-off.

⁹Barry T. Hirsch and John T. Addison, The Economic Analysis of Unions (Boston: Allen and Unwin, 1986), pp. 181 - 85.

serving as the collective voice of workers. This benefit of unionism, collective voice (and the attendant institutional response), does not appear to lend itself well to the generalizing modelling of a tradeoff process that is typical for economics, and it can usually be captured empirically only in indirect ways.¹⁰ This may account for the fact that economic research has ignored the collective voice side of unionism for a long time, and concentrated on some of the comparatively easy-to-measure monopoly consequences of unions. Still, another important reason for the predominance of the monopoly aspect of unionism in the economic literature may be that the whole concept of a labor union goes against the grain of one of the centerpieces of economics, the competitive market. From the point of view of an economics (especially, an applied economics) that labels market imperfections as just that, *imperfections*, at least at times implying that the market mechanism can and should be nurtured to perfection in the real world, it is natural to

¹⁰ Collective voice benefits of unionism are typically not associated with the financial compensation package (wages and fringe benefits) received by workers. Rather, they influence the quality of work life enjoyed by workers, and indirect methods must be used to estimate workers' valuations of this benefit. Also, there is no single small set of well-defined and typical specific collective voice benefits, and for any form of collective voice benefit, the qualitative nature of the cost function faced by the union in providing the benefit is debatable. For the provision of some collective voice benefits, fixed costs may dominate marginal costs; for other voice benefits, the union may face significant diseconomies of scale. In addition, there is no obvious relationship between union size and the union's production function for voice benefits. In sum, these varying characteristics of collective voice benefits make the analysis of voice benefits in a tradeoff model unattractive.

study labor unions primarily in terms of their distorting effect on free market forces.

With his influential paper, "Some Reflections on Syndicalism", Henry Simons seems to have expressed the intellectual climate that fostered the long-term predominance of the monopoly paradigm of unionism.¹¹ He claims passionately that "large and powerful labor unions are integral elements in a total institutional complex whose development is everywhere antithetical to economic freedom, to political liberty, and to world peace..."¹². For him, the analytical conclusion that unions seek to maximize the wage bill goes hand in hand with the view of unionism as a growing and already near-uncheckable force reducing economic freedoms and undermining essential elements of a democratic society. The redistributive effects of unions benefit the most disadvantaged groups in society the least, if at all, he claims; and distributional goals can be achieved much better by appropriate tax measures. With reference to the argument that unions may be a useful counterforce against increasing economic concentration, he argues that unions may have just the opposite effect, by cooperating with firms organized in a cartel to increase the output price incrementally by means of a series of strikes and their resultant output losses.¹³

¹¹ Henry C. Simons, "Some Reflections on Syndicalism," Journal of Political Economy 52 (March 1944): 1 - 25. Simons does not present any formal analysis in this essay, but appears to take unions to attempt to maximize the union wage bill, which corresponds to Dunlop's analysis.

¹² Ibid., p. 23.

¹³ This point is reviewed in Hirsch and Addison, *Economic Analysis of Unions*, pp. 19 - 21.

Simons' essay, written in war-time, appears to remain relevant today at least as a warning against the socially undesirable extremes well-organized unions may steer towards, if the straightforward and strong incentives driving unions as special interest groups are not balanced by an appropriate overall legal framework and a well informed and effective public discussion of national socioeconomic goals. But in general, his predictions from four decades ago have not come about, even though there are clear pockets of socially undesirable union militancy which may substantiate his predictions at least for a few regions or industries.

Labor economists' attitude towards unionism, as represented by Simons' essay, appears to have changed slowly, perhaps helped by a change of unionism itself (at least in North America) towards more internal democracy, less radicalism and increased participation in mainstream political life, and by a decline in the overall economic importance of private-sector organized labor, particularly in the United States.¹⁴ At the same time, the analysis of economic systems and phenomena diverging from the competitive markets model became more sophisticated, and may thus have laid the groundwork for economic research to consider more than the monopoly aspect of labor unions. So, in the last few years, the monopoly-collective voice paradigm of unionism began to emerge. The central feature of this new view of unionism in the present context is that it recognizes that unions may yield an important and

¹⁴ Richard B. Freeman and James L. Medoff, What Do Unions Do? (New York: Basic Books, 1984), pp. 221 - 23.

characteristic benefit to organized workers (and often indirectly to nonunionized workers as well) that is essentially not achieved at a direct cost to nonorganized labor or consumers at large. This is an important point not only for the analysis of union behavior, but also for the analysis of the welfare consequences of unionism, and will therefore be discussed in some detail.

In their 1984 book, What Do Unions Do?¹⁵, Richard Freeman and James Medoff make a landmark case for the monopoly-collective voice paradigm of unionism. Using Hirschman's observation and conceptualization of the socioeconomic phenomenon of collective voice¹⁶, they argue that modern labor unions are able to improve working and employment conditions for union workers by providing a collective voice for workers' grievances, aspirations and positive contributions. The resultant improvements are not only beneficial to unionized workers, but may also lead to firms enjoying enhanced labor productivity and to improved working conditions in the nonunion sector. In principle, their argument for collective voice is this: A worker does not simply trade some of his leisure time against a wage payment by the firm, with the time spent at work lost to his senses, yielding no utility or

¹⁵ Freeman and Medoff, What Do Unions Do?, op. cit. In Richard B. Freeman, "The Exit-Voice Tradeoff in the Labor Market: Unionism, Job Tenure, Quits and Separations," Quarterly Journal of Economics 94 (June 1980): 643 - 674, the monopoly-voice model is tested econometrically. Richard B. Freeman and James L. Medoff, "The Two Faces of Unionism," The Public Interest 57 (Fall 1979): 69-93, contains a short presentation of the monopoly-voice paradigm.

¹⁶ Albert O. Hirschman, Exit, Voice and Loyalty (Cambridge: Harvard University Press, 1971).

disutility.¹⁷ The analysis of wages in relation to hedonic job characteristics, as developed by Rosen¹⁸, also does not fully capture the quality of a person's working life, since many job characteristics and working conditions can change quickly or may be unknown to a worker when he joins a firm, and may therefore not be accounted for in the wage paid to a worker, as decided upon at hiring time, even if those hedonic job characteristics which are well known in advance will command appropriate wage differentials in very well functioning labor markets. So, most workers may at some point in time find that their wage does not fully compensate them for the net (dis)agreeableness of their working conditions. Then, a worker has two options: On the one hand, he may exit from the employment relationship and search for better employment compensation according to present labor market conditions elsewhere. Not only does this option not necessarily lead to an improvement in conditions in the worker's original workplace, because he has not made himself heard, but it may also eventually end in a similar disappointment in the worker's next place of employment. On the other hand, the worker may decide to voice his concerns about unsatisfactory or deteriorating working conditions, thereby risking emotional aggravation and the loss of his job. Further, the firm may choose a piecemeal approach when faced by individual workers voicing their dissatisfaction, trying to accommodate specific workers' wishes in a tradeoff with the costs of replacing an employee, but not deciding for

¹⁷ This is the view taken by the simple income-leisure tradeoff model in basic labor economics.

¹⁸ S. Rosen, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," Journal of Political Economy 82 (February 1974): 34 - 55.

an across-the-board improvement in working conditions. So, the personal and social benefits from a worker choosing the exit option are limited, since worker dissatisfaction may not lead to organizational improvement, and the benefits from an individual worker choosing the voice option are either relatively small or will simply not come about because this option is risky and unattractive for an individual worker to choose.

This is different with workers organized in a labor union: Here, Freeman and Medoff argue, the union can hear about individual workers' concerns and voice them collectively, with more impact and at no risk to individual members.¹⁹ Then, the firm may (or may not) respond to union voice, depending on the union's bargaining power and the firm's attitude towards the union's collective voice function and unionization in general.²⁰ The collective voice benefits of unionism are often enhanced substantially and characteristically by the collective goods nature of many aspects of working conditions, such as safety, lighting, noise, exposure to dangerous substances, and the availability of a formal

¹⁹ The availability of collective voice is important especially for average rather than marginal (that is often, young) workers, since it is the marginal worker whom the nonorganized firm will in general be motivated to please.

²⁰ An enlightened firm may seek to use the established process of worker collective voice via the labor union as a means to learn from workers about ways to improve upon the production process and thereby raise productivity. In addition, the firm may benefit from lower labor turnover when workers are satisfied due to collective voice representation, and labor productivity may increase when workers can easily and effectively contribute to part of the firm's decision process as thinking human beings with a sense of self worth.

grievance procedure: An individual worker's grievance (now more likely than in a nonunion environment, where the worker may either exit or not risk voicing his concerns) will lead, via union voice and institutional response, to an across-the-board improvement for all affected workers.

Freeman and Medoff are able to show with their own and others' econometric work that the collective voice benefits to members of unions in the United States are substantial and may even exceed the benefit arising to union workers from the union's direct wage differential. Further, the potential positive consequences of collective voice to the firm and to labor in general (by way of competition for labor between unionized and nonunionized firms, with the latter trying to remain that way) may outweigh the other net social costs of unionism, especially in an economy where markets are seldomly perfect. Therefore, an appropriate economic analysis of both the effects of modern unionism and the determinants of labor union behavior must account for both the monopoly and the collective voice face of unionism, even if it is not clear, as Hirsch and Addison point out,²¹ that unionism is the only or the optimal institutional framework that can yield the benefits arising from collective voice.

In the present paper, collective-voice benefits to the union membership are not accounted for directly. If there is a link between collective voice benefits and the size of the union's employed membership, it seems possible to incorporate voice benefits to workers by modifying the inverse demand for labor function in the models developed in this

²¹ Hirsch and Addison, *Economic Analysis of Unions*, pp. 191 – 92, 215 – 16.

paper.²² More importantly, collective voice benefits appear to be a potential cause for the divergence of at least some of the theoretical predictions in this paper and observed union behavior.²³

After this brief survey of the changing nature of the overall approach taken in the economic analysis of unionism, we now turn to recent research contributions upon which this paper builds directly.

2.2 Economic Models Of Union Behavior

Almost invariably, the economic literature on union behavior deals with the two main issues in any collective agreement, the contract wage (w)

²² The modified inverse demand for labor function would then express the total compensation to workers (earnings and monetarized net voice benefits) at each level of employment, presuming that worker grievances occur as a steady stream over time, and their resolution is effective only temporarily since grievances are (assumed to be) due to causes which come and go as random events, and assuming that the per-worker costs of the union's collective voice function are fixed. In the n -period model developed in chapter 4, one could allow for a more sophisticated extension by linking the modified inverse demand for labor function in period i to the time-path of the union's choice of contract wage in previous periods. But in the absence of research about the (potential) link between union size and ongoing net voice benefits, such modifications would contribute little to this paper's results. Also, the incorporation of the union's choice of the level of costly collective voice benefits into a model of union wage behavior would face substantial problems in tracing the union's majority voting process. (Cf. *ibid.*, pp. 25–29.)

²³ Chapter 11 addresses this point.

and union employment (E), while ignoring other collective bargaining issues. Union theory then distinguishes three different models of (w, E) determination in the collective bargaining process:

(i) The Monopoly model: Here, the union is assumed to be powerful enough to be able to impose its preferred contract wage on the industry. The industry then sets employment according to its demand for labor schedule.

(ii) Collective Bargaining over Wages model: The union does not have sufficient power to impose its preferred wage, and therefore must bargain with the industry over the contract wage. The outcome depends on the relative bargaining power of both sides, and once an agreement is struck, the industry sets employment according to its demand for labor schedule.

(iii) Efficient Contract Bargaining over Wages and Employment model: Union and industry agree to bargain over both w and E , aiming to achieve an efficient contract, where gains from trade are exhausted since the collective agreement specifies a (w, E) combination at a tangency point of

a union indifference curve over w and E and an industry isoprofit curve over w and E , that is, at a point on the so-called Contract Curve.²⁴

Economic research on union behavior has concentrated on (i), the monopoly model, because this is the only model where no theoretical specification of the bargaining process is required. The Efficient Contracts model is often held to be empirically uncommon, probably not the least because the feasibility of an incentive compatible collective

²⁴ A fourth model, the Bilateral Monopoly case, is deemed to be of limited empirical interest. Unlike in models (i) to (iii), where the industry is assumed to have no power in the labor market, the industry here has monopsony powers, and the (w,E) outcome can be analyzed by means of bilateral monopoly models.

Hirsch and Addison (*ibid.*, pp. 18 – 21) point to two more models with limited empirical appeal, namely the model of the "union-controlled firm" (similar to models of the labor managed firm that is typical for the Yugoslav economic system), and to the model of the "union as a cartelizing device", where labor and a small number of firms cooperate to achieve cartel profits by reducing output via a sequence of strikes.

agreement covering w and E for both the union and the industry side appears to be very limited.²⁵

The present paper deals only with the case where the union has sufficient power to impose its preferred contract wage on the industry, and does not attempt to achieve potential gains from trade by concluding an efficient contract with the industry. This limitation is due to the fact that the inclusion of a bargaining model in an n -period model has been found to be too difficult at this stage, and because the present

²⁵ Farber, "Analysis of Union Behaviour", pp. 19 - 22. Econometric work on this issue is rare and inconclusive: In Felice Martinello, "Wage and Employment Determination in a Unionized Industry: The IWA in the B.C. Wood Products Industry," Carleton Economics Papers 84-09, March 1984, the monopoly model is rejected in favor of the efficient contracts explanation, but the testing procedure is somewhat slanted against the monopoly model. In Thomas MaCurdy and John Pencavel, "Testing between Competing Models of Wage and Employment Determination in Unionized Markets," Journal of Political Economy 94 (July 1986): S3-S39, and in James Brown and Orley Ashenfelter, "Testing the Efficiency of Employment Contracts," Journal of Political Economy 94 (July 1986): S40-S87, data from the International Typographical Union is tested for efficient contracts. The two studies use different models and yield quite different results, with Brown and Ashenfelter concluding that ITU contracts are not on the contract curve, and MaCurdy and Pencavel rejecting the monopoly model quite strongly, but leaving it an open question whether or not ITU contracts are efficient. The strongest support for the efficient contracts model thus far is found in Randall W. Eberts and Joe A. Stone, "On the Contract Curve: A Test of Alternative Models of Collective Bargaining," Journal of Labor Economics 4 (January 1986): 66-81, where data for New York State public school teachers are tested in a multidimensional contract-curve framework which accounts for the hedonic value of a set of contract clauses (such as employment-security provisions) in addition to teachers' contract salary.

paper is principally concerned with the effect of a seniority system governing layoffs on the union's choice of contract wage. As will be seen, layoffs by seniority appear to moderate the union's wage demands if union members consider the impact of their present wage choice on future contract periods. Therefore, the inclusion of seniority based layoffs in the union model appears to work in the same direction as the limitation of union power forcing the union to bargain over the contract wage - both phenomena are likely to lead to a lower contract wage than that imposed by a union with full monopoly power and a time horizon limited to a single contract period. Thus, the "seniority" and the "bargaining" effects are intuitively unlikely to cancel each other out, and both effects may contribute an explanation for the frequent empirical observation of a union putting a relatively large weight on employment (and a correspondingly smaller weight on income) in its contract settlements.

In keeping with this paper's approach, the following survey focuses on research based on the monopoly model of union behavior. Here, one can distinguish two approaches: Some authors assume a union objective function over wages and employment and, at times, other variables such as the alternative wage. Concentrating on econometric work, they are not concerned with (problems in) grounding the assumed union objective function in first principles. An influential and typical paper in this area is by Dertouzos and Pencavel²⁶, who estimate a Stone-Geary

²⁶ J. N. Dertouzos and J. H. Pencavel, "Wage and Employment Determination under Trade Unionism: The International Typographical Union", Journal of Political Economy 81 (December 1981): 1162 - 81.

type union objective function for the International Typographical Union in the U.S. The interesting point about this approach is that it allows for the testing of several different objective functions which have been proposed in past research: Union wage differential maximization, employment maximization, wage bill maximization, and maximization of economic rent. Their results suggest that the ITU values both wages and employment, and accords more importance to employment than implied by wage bill or rent maximization. This finding is typical for most research in this area.²⁷ However, Farber for one questions the usefulness of these findings, arguing that many a real-world union may well value employment much less than suggested by these studies, but may be forced to accept a lower wage than desired since it does not have the full monopoly power assumed in the theory underlying such empirical work, and instead has to accept the lower wage outcome from a collective bargaining process with the industry.²⁸ With the contract wage then lower than the union's preferred wage and the industry setting employment according to its demand for labor schedule, the

²⁷ See Oswald, "Economic Theory of Trade Unions," p. 163, where similar econometric studies are listed.

²⁸ Farber, "The Analysis of Union Behaviour," p. 42.

union appears to accord higher importance to employment than it actually does.²⁹

The second approach taken in the literature focuses on the derivation of the union's objective function from first principles in an expected utility framework, where it is generally assumed that the union allocates union jobs among its members by means of a random draw, held at the beginning of the contract period. With w the union wage rate, \bar{w} the alternative wage, N the union membership, E union employment and $U()$ the individual worker's utility function, the union's objective function is

$$U_{Eu} = [E/N] U(w) + [1 - (E/N)] U(\bar{w}) \quad (2.1)$$

If the union holds a majority vote among members about the contract wage, it will impose the wage preferred by its median member on the industry. With worker preferences assumed to be homogeneous, one can

²⁹ One may add a similar argument regarding the finding (such as in Henry S. Farber, "Individual Preferences and Union Wage Determination: The Case of the United Mine Workers," Journal of Political Economy 86 (October 1978): 935, and in Andrew J. Oswald and Alan A. Carruth, "Miners' Wages in Post-War Britain: An Application of a Model of Trade Union Behaviour," Working Paper 175, Industrial Relations Section, Princeton University, July 1984) of relatively high degrees of risk aversion among union members. Alternatively, these findings may come about for single-period worker decision problem specifications, if workers actually solve a multi-period decision problem with a wage solution lower than in the single-period case. The results of the present paper (particularly in chapter 4) point to this alternative explanation.

therefore take any member's expected utility function (2.1) as the union's objective function.³⁰

The union maximizes U_{eu} subject to $E = \phi(w)$, where $\phi(\cdot)$ is the industry's demand for labor function, since after the union has imposed its preferred wage w^* , the industry is assumed to set employment E according to $\phi(w)$. One interesting property of (2.1) is that the union's preferred wage w^* is independent of N , the union's membership size.³¹ However, Oswald has shown formulation (2.1) to be misspecified when

³⁰ In Farber, "Individual Preferences and Union Wage Determination", union members are assumed to have heterogeneous preferences due to the relative valuation of earnings and fringe benefits varying with workers' age. Farber accounts for a stylised majority voting process in the union, and argues that the union's leadership will thus act according to the preferences of its median member. He models each worker's preferences by means of the expected utility model discussed here, and provides what appears to be the first empirical analysis of union behavior where the union's objective function is explicitly grounded in individual worker preferences, aggregated by means of the majority voting process. A drawback in this influential paper has been identified in Douglas H. Blair and David L. Crawford, "Labor Union Objectives and Collective Bargaining," Quarterly Journal of Economics 99 (August 1984): 547-66. Blair and Crawford show that Farber's model does not necessarily yield a stable majority voting outcome, because the union is voting on more than one issue (wages and a tax on output used to finance union fringe benefits) and the majority voting model breaks down in this case. It is noteworthy that Blair and Crawford's critique would not apply if Farber's union would vote on a single issue only, as it is implied to do in many other studies which do not attempt to ground the union's objective function in first principles.

³¹ This property is well known in the literature and derived in chapter 7.1.1.

employment E exceeds the union's membership size N . Correcting for this problem, he writes³²

$$U_{Eu} = U(w) + (U(\bar{w}) - U(w)) \text{MAX} [0, (N-E)/N] \quad (2.2)$$

With the corrected union maximand (2.2), Oswald shows that w^* is no longer necessarily independent of N , since (2.2) can yield a corner solution at $E = \phi(w^*) = N$, and unlike an interior solution, the corner solution varies with N .³³

When union membership N is assumed fixed, a second approach taken in the literature is equivalent to (2.1): A union with utilitarian preferences

³² Andrew J. Oswald, "On Union Preferences and Labour Market Models: Neglected Corners," Seminar Paper 296, Institute for International Economic Studies, University of Stockholm, October 1984, p. 7. The misspecification is due to the fact that if $\phi(w^*)$ in (2.1) exceeds N , the union is providing for the union employment of $\phi(w^*) - N$ workers who did not belong to the union's voter pool at contract closing time. There is no motive for the union's present membership to cause the union employment of outsiders. Rather, once every union member has a union job with certainty, no present member will value the union employment of additional workers.

³³ Oswald argues that corner solutions are empirically relevant here, particularly because of empirical evidence that many a union's membership size is close to the union's employment level.

will maximize total utility to its members, and thus have objective function

$$U_u = E \cdot U(w) + (N - E)U(\bar{w}) \quad (2.3)^{34}$$

Oswald analyzes the implications of this utilitarian model of the labor union in detail, and shows "that the common but ad hoc assumption of an increasing, quasi-concave union utility function can be justified by the assumptions that (i) all union members are risk-averse and (ii) the union has utilitarian preferences."³⁵ This result provides for a link between at least some of the studies referred to earlier, which merely assume the existence of a union objective function, and research on unions with utilitarian as well as median member expected utility preferences. But the grounding of the union's objective function in first principles in existing models still requires restrictive assumptions (such as a fixed union membership size). Thus, as late as 1984 Pencavel introduces an empirical study on the International Typographers Union, in which he assumes a union objective function over wages and employment, with the pragmatic argument, "The prevailing opinion appears to be that the problem of modelling trade union behavior is 'virtually intractable' [Johnson, 1975]. The purpose of this paper is to belie this notion. ... Our

³⁴ Oswald (ibid., p. 7) provides the corrected version of (2.3) as

$$U_u = N \cdot U(w) + [U(\bar{w}) - U(w)] \text{MAX}[0, N-E] \quad (2.4)$$

(2.1) and (2.3) have been discussed here, since these are the objective functions used in virtually all of the literature.

³⁵ Andrew J. Oswald, "The Microeconomic Theory of the Trade Union," Economic Journal 92 (September 1982), p. 592.

objective is ... to demonstrate that the investigation of union goals is fully amenable to empirical analysis."³⁶

Research discussed thus far has concentrated on the Monopoly model of union behavior, ignoring the bargaining process between union and industry. Also, where the allocation of employment among union members has been taken into account explicitly, all studies referred to above have assumed that union jobs are assigned to members by means of a random draw at the beginning of the contract period. Empirical evidence suggests, however, that in most collective agreements the

³⁶ John H. Pencavel, "The Tradeoff Between Wages and Employment in Trade Union Objectives," Quarterly Journal of Economics 99 (May 1984): 215-216.

allocation of union jobs is governed by seniority: the last worker to join the union is the first to be laid off.³⁷

Blair and Crawford's article, "Labor Union Objectives and Collective Bargaining"³⁸ is perhaps the single most important recent contribution towards a microeconomic model of union behavior, which seeks a consistent link between union members' preferences, union group behavior and the collective bargaining process, and incorporates the

³⁷ See, for example, Albert Rees, The Economics of Trade Unions, 2d ed., rev. (Chicago: University of Chicago Press, 1977), p. 141. Rees argues that a feeling of fairness among workers, an "ethics of the queue", is the reason behind the use of worker seniority not only for union employment allocation, but also for other issues which call for a choice (or differentiation) among workers.

Farber ("Analysis of Union Behaviour," p. 51) points out that with job allocation by seniority, "the issue of excludability versus nonexcludability of potential [union] members is not important. Since all workers with zero seniority do not have a right to a union job, they represent no threat to dilute the benefits of unionization to the existing workers. In fact, this may be one reason why seniority rules are so popular."

In Lorne Carmichael, "Does Rising Productivity Explain Seniority Rules for Layoffs?," American Economic Review 73 (December 1983): 1127 - 1131, it is shown that one plausible reason for employment by seniority (layoffs by inverse seniority), namely the human capital argument that senior workers are more productive and thus kept on by the firm, while less productive junior workers are laid off if there is a need for layoffs, is usually not valid. With the firm having no reason to prefer layoffs by seniority from a human capital point of view, the union's motives for such a provision in the collective agreement appear even more important.

³⁸ Op. cit.

collective agreement clause that layoffs are determined by seniority. They start with the observation that "the formulation chosen for union preferences plays a critical role in determining how bargaining can be modeled"³⁹ and develop their results accordingly. Ignoring the bargaining process for the time being, they first derive the median union member's preference relation over wage alternatives in a one-period model with a unionized industry demand for labor function having a stochastic component:

Let $\phi(w) + \varepsilon$ define the industry's demand for labor schedule, where w is the contract wage rate, $\phi(w)$ is the fixed component of labor demand, and ε the stochastic term with expected value $E\varepsilon = 0$. $\phi'(w)$ is assumed < 0 , and $\phi''(w) \leq 0$. The union allocates employment by seniority, and each worker i knows his position L_i in the seniority queue.⁴⁰ Worker i 's von Neumann-Morgenstern indirect utility function is $U_i(w)$, with $U_i'(w) > 0$, and $U_i''(w) \leq 0$ (that is, workers are risk averse or at most risk neutral). Worker preferences regarding the union's contract wage may therefore differ because of differences in workers' indirect utility functions and because of each worker's different position in the seniority queue.

³⁹ Op. cit., p. 547.

⁴⁰ The most senior worker has seniority ranking 1; the most junior worker has seniority ranking N , where N is the union's present membership size.

With \bar{w} the wage in the alternative labor market, worker L_i 's expected utility is:

$$EU(w|L_i) = \begin{cases} U_i(\bar{w}) & \text{if } w < \bar{w} \\ U_i(w)\text{prob}[\phi(w) + \varepsilon \geq L_i] + U_i(\bar{w})\text{prob}[\phi(w) + \varepsilon < L_i] & \text{if } w \geq \bar{w} \end{cases} \quad (2.5)$$

Since a worker can always obtain employment at \bar{w} , only the case where $w \geq \bar{w}$ must be considered. With ε having cumulative distribution function $F(\varepsilon)$ and $w \geq \bar{w}$, worker L_i will therefore solve

$$\max_w U_i(w)\{1 - F(L_i - \phi(w))\} + U_i(\bar{w})F(L_i - \phi(w)) \quad (2.6)$$

The first term in (2.6) covers all realizations of the stochastic term ε which, for a given choice of w , cause industry demand for labor to be at least as large as worker L_i 's seniority ranking and thus ensure his union employment. The second term covers the smaller-valued realizations of ε where, for the same wage level, industry demand for labor is too small for worker L_i to be assigned a union job.

Now, it is assumed that the union leadership will act as if the union had held a majority vote on the contract wage to be imposed on the industry. Thus, union leaders will impose the contract wage w^* that solves the median union member's decision problem (2.6). Blair and Crawford show in detail that model (2.6) yields single-peaked preferences, if the distribution of the additive stochastic term in labor

demand has a nondecreasing hazard rate.⁴¹ Single-peakedness of preferences is a sufficient condition for the majority voting model, and the assumption that the union will choose the contract wage in a majority vote among members is therefore consistent with the specification of worker preferences as in (2.6).⁴²

However, Blair and Crawford show that the union majority preference relation thus derived from individual union members' preference orderings of risky wage-employment outcomes is an ordinal preference ordering only. It cannot be represented by a von Neumann-Morgenstern utility function, and standard bargaining models of the interaction of agents defined by their von Neumann-Morgenstern utility functions are therefore not applicable here.

Blair and Crawford then assume that the industry's side in the bargaining process can be represented by a Von-Neumann Morgenstern utility function, defined by the industry's expected profit function, which is, of course, cardinal. Thus, a bargaining model based on one cardinal (the industry's) and one ordinal (the union's) preference ordering is required. The authors show that within the class of such models, only a relatively small group of model formulations make sense for the task at hand. Fortunately, these formulations are relatively simple and lend themselves to empirical testing.

⁴¹ The hazard rate $h(\epsilon)$ is defined as $h(\epsilon) = f(\epsilon)/(1 - F(\epsilon))$, where $f(\epsilon)$ is the probability density function of ϵ .

⁴² Blair and Crawford's single-period model is the basis for the two-period models developed in chapter 5 of this paper. The equivalent of maximization problem (2.6) will be analyzed in detail there.

In sum, Blair and Crawford's contribution provides what the economic analysis of unions has long been lacking — a model of union behavior covering the whole sphere, from individual member's preferences to the bargaining process. However, their results are based on restrictive assumptions in two areas: First, taking the union leadership to carry out, period by period, exactly the median member's wishes may be ignoring a different and in many unions much more relevant political process. Second, the assumption of union members considering only one choice dimension (the contract wage), required by the limitations of voting theory⁴³, restricts the model's relevance, particularly in light of the increasing importance of the Monopoly-Voice paradigm of unionism, as discussed above. Third, Blair and Crawford develop their model for a single contract period worker time-horizon only. They recognize that a union with a seniority system as modeled by them is likely to vote for an ever-rising contract wage and "eventually ... all but votes itself out of existence"⁴⁴, because it is young workers (whose preferred wage rates are lowest among all union members) who are laid-off first, and the

⁴³ In Gerald H. Kramer, "On a Class of Equilibrium Conditions for Majority Rule," *Econometrica* 41 (March 1973): 285-97, it is shown that the condition of single-peaked preferences (or similar conditions on voter preferences), which can ensure a unique majority outcome for votes with a single choice dimension (for example, the level of the contract wage), are virtually useless if more than one choice dimension is voted upon in a single voting process. The result of a majority vote with more than one choice dimension is stable (independent of the sequence of votes on particular alternatives) practically only if all voters share the same tastes.

⁴⁴ Ibid., p. 556

majority-preferred wage rate will therefore rise over time. [This argument presumes that laid-off union members lose their union voting rights.] Blair and Crawford advance a verbal argument for five factors inhibiting this "the union's upward journey along the demand for labor curve":

"First, unemployed workers continue to vote in some cases. In addition, secular growth in the demand for labor would slow the contraction of the union. Third, the dispersion in most-preferred wage rates would narrow, and the disemployment process would be retarded if, as seems plausible, older (and hence more senior) workers are more risk averse than younger ones. Fourth, workers at intermediate seniority levels presumably realize that voting for higher wage rates hastens the arrival of the moment when their elders vote them out of a job. Finally, the union's most-preferred wage will generally change at a slower rate than the observed wage, which in most cases is the outcome of bargaining with firms."⁴⁵

None of these arguments are executed formally by Blair and Crawford. The prediction of ongoing union decline under a seniority system being one primary motivation for the present paper, Blair and Crawford's first, third and fourth argument quoted here are dealt with formally in this paper. The second argument, appealing to secular growth in the demand for labor, and the fifth argument about the likely divergence between the union's most-preferred contract wage and the actual bargaining outcome, appear to be connected because risk or uncertainty regarding secular growth in demand for labor is likely to be a bargaining issue of fact. Also, the appeal to secular demand growth is debatable because

⁴⁵ Ibid., pp. 556-557.

the union may be more likely to have information about future secular demand growth than about the probability distribution of the stochastic term in labor demand, which it is assumed to know perfectly in Blair and Crawford's analysis.

If one allows for workers' time horizons to extend beyond the immediately upcoming contract period, union members determining their preferences regarding the upcoming collective agreement will attempt to predict the consequences of their choices now on the union membership (voter pool) that will decide on future labor contracts. Therefore, it will in general be important how the union's size (and its membership characteristics) are determined. One can distinguish two stylised cases:

(i) No Union Exclusion Power: The union is unable to prevent nonmembers (whether they are presently employed in the union sector or not) from joining the union and participating in union votes, if they so desire. Such an inability of the union's present membership to prevent an influx of new members from outside the union sector is likely to allow for an equilibration process between the union and nonunion sector. The union's equilibrium size (and membership structure) will then imply union majority preferences which cause the union labor contract to be such that the marginal worker is indifferent between joining the union and remaining in the nonunion sector.

A model of a union lacking the power to exclude nonmembers has been developed recently by Booth⁴⁶. Using an employment by random draw - median voter framework, Booth assumes that workers in the economy's labor pool differ in their reservation wage, due to differences in nonunion jobs available to them, different unemployment insurance claims, and differences in their evaluation of leisure time. Working with specific structural forms, Booth shows that after an inflow (or outflow) of members, the union will attain a (possibly unstable) equilibrium size (and membership structure with respect to the distribution of the reservation wage) where the marginal worker is indifferent between his reservation wage and the expected utility from risky union employment at a wage determined by the union's median member, whose reservation wage (and thus, whose preferred union wage) differs substantially from that of the marginal worker.

Booth's analysis represents an important contribution to the long-standing problem of modelling union membership size endogenously, but it is questionable whether it is empirically sensible to assume that the union cannot directly exclude any number of nonmembers from joining the union (and its voter pool).

(ii) Union Exclusion Power: In this second stylised case, which forms the basis of the present paper, the union is able to limit the number of new members by requiring a job offer in the union sector for union membership, and to require union membership for all workers in the

⁴⁶ Alison Booth, "A Public Choice Model of Trade Union Behaviour and Membership," Economic Journal 94 (December 1984): 883 - 98.

union sector. That is, the union can choose to admit a worker as a new member only if it cannot satisfy the industry's demand for labor at the current contract wage rate from present union ranks. In this case, the industry will hire workers from the non-union labor pool, and these workers are then required to join the union immediately.⁴⁷ In addition, the union may be able to deny voting rights to members who have been laid off.⁴⁸ Intuitively, it appears unlikely that a union with such extensive exclusion powers would ever reach a state where the marginal insider (union member) is indifferent to being an outsider

⁴⁷ This is in keeping with the standard provision in labor law that the union must represent all workers in the collective bargaining unit. With a union-shop clause in place, the union must therefore admit all workers hired by the firm, but requires them to join the union.

⁴⁸ These are substantial rights for the union as a special interest group, which may well be limited by labor law.

(nonmember), especially if the union is able to predict demand for union labor conditions in the near future fairly precisely.⁴⁹

To analyze this proposition in detail in a general dynamic model, one would want to include the use of union exclusion powers as the result of a choice process among the union's current membership. The present paper adopts a much simpler approach, but in general assumes that the union will never admit new members (or equivalently, grant them work and voting rights), unless actual demand for labor (given the union's imposed choice of contract wage) cannot be satisfied from union ranks alone. Regarding the membership and voting rights of laid-off union members, that is, regarding the union's exclusion powers for a distinct part of its current membership, this paper develops model variants for different sets of rules, and uses these variants to predict eventual

⁴⁹ This statement is not necessarily true under stochastic demand. In Gene M. Grossman, "Union Wages, Temporary Layoffs, and Seniority," American Economic Review 73 (June 1983); 277 - 90, Grossman takes a union facing a demand for labor schedule with an additive stochastic term (with a uniform distribution), and assumes that layoffs of union members are by reverse seniority. The essential assumption for his model is that workers who presently are union employed and have decided to join the union (and thus participate in the contract vote) will earn a lower alternative wage during the coming contract period, if stochastic demand materializes at a level causing their layoff, than if they had abstained from union membership and joined the alternative labor market before stochastic demand became known. This essential assumption is well-motivated only for an economy where wages in the non-union sector are downward sticky for workers who have been employed in this sector for some time, and where the unionized industry and the industries providing an alternative labor market for union workers experience adverse demand conditions in the same phase of the business cycle.

unanticipated and discrete changes in such rules. So, union size will be modelled as a lagged endogenous variable in this paper, not as a result of a direct union-nonunion interaction process, but allowance will be made for a step-by-step adjustment of union rules regarding the exclusion of laid-off union members.

This concludes this review of the relevant part of the economic approach to the analysis of union behavior. The main part of this paper (chapters 3 to 9) builds on the median voter expected utility maximization models, as developed by Farber and Oswald (employment allocation by random draw; fixed demand for labor) and Blair and Crawford (employment by seniority; stochastic demand for labor) and summarized above.

3. Introduction to Multiperiod Union Contract Wage Determination Models

In this chapter, the stage is set for the formal union models developed in the core of this paper: The general model structure is laid out, variables and functions defined, and basic assumptions (and, in some instances, their alternatives) are stated. This and all chapters up to chapter 9 are based on the fundamental assumption that both the strictly economic analysis of union behavior and this paper's particular choice from within the set of potential economic determinants of the union's choice of contract wage have sufficient merit. The merits of this fundamental assumption will be debated in chapters 10 and 11, but are left unquestioned for now.

The model variants discussed in the next six chapters are all primarily concerned with the consequences for union majority wage preferences of individual union members employing some degree of foresight when determining their individual wage preferences for the current period union contract vote. Several model variants are presented instead of a single model formulation, since different assumptions about the nature of demand for labor, and about layoff rules, employment requirements for union membership and union voting rights yield often substantially different predictions, and cannot be analyzed in a single unified model. Also, technical difficulties prevent a complete analysis of most individual model variants, and different variants are therefore sometimes used to allow for a reasonably complete analysis of the problem at hand at least in similar settings. However, all of these

model variants share a similar basic structure and employ more or less the same set of variables. Therefore, the basic model structure and variable set are described in this preceding chapter.

3.1 The Setting

3.1.1: Principal Assumptions about the Union

Our stylised industrial union represents all workers in an industry made up of many individual firms, all of whom employ the same technology on the same scale. The union and its members¹ know the industry's demand

¹ In the real world, the collective agreement between union and industry will be concluded by the industry and the union leadership, not individual union members. The union leadership will usually propose a contract wage and conclude a tentative agreement with the industry which will then be subject to an acceptance vote by the union membership. The approach taken in this paper of assuming that the union leadership will act in this process just as the median voter in the union's voter pool (membership with voting rights) would have acted, is typical in the literature. The argument supporting this approach is that the union's leadership wants to remain in office and will therefore seek to please a majority of members. For this paper, this argument must be amended by the assumption that the union leadership can be subject to a recall vote at any time during the contract closing season, and once a particular union leader has lost such a recall vote, his reputation will be damaged for a considerable period of time. Otherwise, it might be the case that under some voting rights and stochastic demand for labor conditions, the union leadership seeks to please a majority in the union's voter pool after the contract has gone into effect, and will therefore propose contract wages which may fail to win the acceptance vote held among the before-contract voter pool. Such circumstances might invite a politization of the process in order to confuse the issues and is therefore ruled out.

for labor schedule for all contract periods within the union's time horizon. Union members choose, in a straightforward and unpoliticised vote, the contract wage preferred by a majority of members; and inform the industry about the chosen contract wage. The industry accepts the wage chosen by the union and sets employment according to its demand for labor schedule. There is no bargaining in the usual sense between the union and the industry, because the union has sufficient monopoly power over the industry to impose its chosen contract wage, and both contract parties do not consider cooperative (and therefore negotiated) contracts covering both wage and employment levels, even though such behavior might leave them both better off than the monopoly contract settlement procedure assumed here. State-contingent contracts are ruled out. There are no strikes or lockouts, nor threats of strikes or lockouts. There is no strategic behavior by union leaders towards union members or the industry, and there is no strategic behavior of the industry directed against the union. There are no collective voice benefits to union members. All union employed workers receive the same wage. There is no worksharing or sidepayments to laid-off union members. There is no relevant union pension plan, nor other fringe benefits that do not accrue exactly parallel to union wage income. All union members work the same number of hours. Their work is such that it causes the same level of disutility for all workers. When laid-off from their union jobs, all workers find work at the same alternative wage elsewhere in the economy without delay. Further, union dues are assumed to be zero (or factored into the demand for labor function and, possibly, the alternative wage, depending on

membership rules), and transactions costs are assumed to be zero as well.

All union members are rational and risk averse, and their preferences are characterized by the same von Neumann-Morgenstern utility function. Union members realize the implications of the governing rules on employment allocation (discussed in section 3.1.2 below) and union membership and union voting rights (see section 3.1.3), and are therefore motivated to determine their preferences over contract wages under a time horizon extending beyond the upcoming contract period if it is in their interest to do so. Each worker's time horizon spans the remainder of his working life², and due to ready access to capital markets, all workers' discount rates for future earnings equal the capital market interest rate.

3.1.2: The Allocation of Employment among Union Members

The formal analysis has its main emphasis on a union which allocates employment by seniority, since this is the primary interest of this paper. The two core models in chapters 4 and 5 and the model variants in chapter 6 are all for unions with employment by seniority: If layoffs are called for, the least senior workers are laid off first. Each worker knows his exact position in the union's seniority queue, and no two workers have exactly the same seniority level. If a union member is laid-off and

² This is true for the models in chapter 4. Due to analytical difficulties, all workers' time horizons are limited to two contract periods in the 2-period models of later chapters.

union rules are such that he loses his union membership as a consequence, he also loses his seniority ranking.

In order to assess the consequences on union behavior of a seniority system relative to a union without such a system, a number of model variants where employment is allocated by random draw have been worked out. These variants (all in chapter 7) are meant to provide a point of reference to the seniority-based models in chapters 4, 5 and 6, rather than an analysis of union behavior that is of interest in its own right.³ The employment by random draw rule used throughout chapter 7 is straightforward: If the union decides for a contract wage higher than the wage necessary for all present union members to be employed, then employment (as given by the industry's demand for labor schedule) will be allocated by means of a random draw among all union members, regardless of whether they have been employed in the present contract period or not.

³ The assumption of employment by random draw is common in the literature, and the differences in predictions between one-period and multi-period models are, in general, not very significant. Therefore, research based on the random draw model concentrates on taking other phenomena, such as the interaction between the union and non-union sector, into account (Cf., for example, the model by Booth discussed in chapter 2.2). The inclusion of the random draw model in a basic form in this paper is intended solely to allow for comparisons with the predictions of the seniority based models.

3.1.3: Union Membership Status and Union Voting Rights

Employment in the unionized industry requires union membership - the union is enforcing a strict union shop, where workers are hired by firms, but must join the union as a condition for employment. For the union membership of a laid-off worker two assumptions are used: In the two principal models in chapters 4 and 5 (and in the corresponding alternative random-draw models in section 7.1), laid-off union members retain their union membership (entitling them to be called back to work before any nonmembers are hired, according to the same rules as govern the future employment allocation among currently employed members) forever.

In section 6.2 (and the corresponding random-draw models in section 7.2), laid-off workers lose their union membership immediately, and stand no better a chance at being called back to work with their old union than any other worker in the general labor market. Attendant with this loss of membership comes the loss of union voting rights and a worker's seniority status.

In the two primary models in chapters 4 and 5, laid-off union members lose their union voting rights, while retaining their union membership. By contrast, in section 6.1 they retain their voting rights and do in fact exercise them forever, even if this is empirically unlikely, as will be shown. (For the random-draw models in section 7.1, where laid-off workers retain their union membership, it will be shown to be irrelevant whether or not laid-off workers retain their union voting rights.)

To sum up: The two primary models in chapter 4 and 5 take employment to be allocated by seniority, and have laid-off union members lose their voting right, but retaining their union membership. Variations of this primary case are found in chapter 6 (different rules regarding voting and membership rights) and in chapter 7, where employment is allocated by random draw.

3.2 Definition of Variables and Functions

The following set of variables and functions is used throughout the paper. All subscripts (i) refer to contract periods (or the contract vote at the beginning of the contract period); with subscript (1) denoting the immediately upcoming contract period and subscript (2) the following one.

(a) Industry Demand for Labor:

$\phi_i = \phi(w_i) \circ \varepsilon_i$	Industry demand for labor in contract period (i). ⁴
$\phi(w_i)$	Deterministic component of industry demand for labor
ε_i	Stochastic component of industry demand for labor
w_i	Contract wage rate (\$ per contract period)

Assumptions:

$\phi'(w) < 0$	Demand for labor is decreasing in w
$\phi''(w) \leq 0$	Demand for labor is concave in w

⁴ \circ stands for addition or multiplication, depending on the model variant.

$f_1(\varepsilon) = f_2(\varepsilon)$ The probability density function of the stochastic term in demand for labor is identical for all contract periods.

ε_1 and ε_2 are independent.

$h(\varepsilon) = \frac{f(\varepsilon)}{1 - F(\varepsilon)}$ The hazard rate of f (where F denotes the cumulative distribution function)

$h'(\varepsilon) \geq 0$ is nondecreasing

(b) The Union and Its Members

$U = U(w)$ Stochastic Demand models: Von Neumann-Morgenstern indirect utility function of each union member, and all workers in general. The contract wage w is interpreted as a measure for the composite good "money income", and consumer goods and services prices are assumed constant, i.e. in particular, unaffected by the union's wage choices and invariable under variable stochastic demand for labor conditions.

Fixed Demand models: Utility function of each worker.

$U'(w) > 0$ Utility is increasing in w .

$U''(w) < 0$ Workers are risk-averse (Utility is concave in w).

N Union membership at the end of contract period $\{0\}$.

In chapters 4, 5 and 6, the union operates a seniority system, with the most senior worker having seniority position 1, and the most junior worker having seniority position N . [The seniority ranking is defined in this counterintuitive manner to allow for union expansion or decline.]

L_i Seniority ranking of the median voter in contract vote (i). It will be shown that the median worker in terms of contract wage preferences is also the median worker in terms of seniority. Therefore,

$L_1 \approx N/2$ This approximation for the median member is used throughout⁵, based on the assumption that N is large.

(c) Parameters

\bar{w} Wage in the alternative labor market (\$ per contract period.)

$c_j = (1+r)^{-j}$ Discounting factor (for j contract periods), where r is the interest rate (per contract period)

R Absolute number of retiring workers per contract period. [Applicable only for some fixed-demand model variants.]

⁵ In the model simulations in chapter 4.2, the exact median is determined when N is odd; when N is even, voting ties are broken in favour of the voter block with higher seniority.

4. The Choice of Contract Wage Under Fixed Demand for Labor, with Employment by Seniority and Voting Rights Loss for Laid-Off Workers

This chapter contains the first of the two primary models developed for this paper: The union's choice of contract wage will be modelled for a fixed demand for labor schedule, with union rules determining that employment is allocated by seniority, and that laid-off workers lose their union voting rights, but not their union membership.

This chapter is divided into two parts: First, the formal n -period decision problem of the first period union member with median seniority is presented, and a verbal proof given for the upper and lower limits between which this median voter's choice of contract wage must fall. Analytical limitations prevent a meaningful further general analysis of this n -period decision problem. In the chapter's second part, the n -period decision problem is therefore solved for a number of specific cases by computer simulation. These simulations predict a quite narrow time path for the union's optimal contract wage. The simulated time path of the contract wage appears to be fairly independent of specific functional forms, and is therefore suggestive of a general, albeit not formally proven, result: In general, a labor union facing a fixed demand for labor schedule, allocating employment by seniority and determining the contract wage by majority vote among employed members, appears to choose a wage w_i for contract period CP_i which causes the immediate layoff of twice the number of workers about to retire during contract

period CP_i .¹ The union is therefore predicted to decline in employed membership size at an increasing rate, and to vote itself practically out of existence² at the latest when the median union member in contract period 1 is about to retire. This result is in stark contrast to the prediction of the single-period model, where the same union cuts its membership size roughly in half with every contract, and thus votes itself essentially out of existence much faster than when union members' time horizons extend to the end of their working lives.

4.1 The General N-Period Model

Demand for labor is a fixed function of the wage rate:

$$\phi_i = \phi\{w_i\} .$$

In contrast to the model formulations in later chapters, we take account of the retirement process by introducing the parameter R , which defines

¹ Minor exceptions to this prediction for very early and for the last contract periods experienced by such a union in decline will be shown.

² This general prediction will be qualified, too.

the absolute number of retiring workers per contract period.³ A second set of parameters used only in this chapter is A_j , the length of the remaining working life (in terms of contract periods) of the worker with seniority ranking j at time 0.

³ R is an absolute number instead of, say, a number in fixed proportion to the present membership size in any one contract period, since the assumption of the union's age distribution spanning the length of a typical working life evenly and the fact of layoffs by seniority mean that a constant number R of workers will retire in each contract period regardless of the present size of the union. R is determined by the initial size N of the union, the length of the typical working life, and the length of the contract period.

For simplicity, it is assumed that retirement takes place at the end of the contract period (instead of sometime within the contract period), but that retiring workers are still replaced by junior workers who are entitled to vote in the immediately upcoming contract vote. Thus, the sequence in time is: End of ontract period i , retirement of R retiring workers, replacement of R retiring workers, contract vote for wage in contract period $i+1$. This simplification is made to avoid the uninformative, but possibly cumbersome accounting for earnings to laid-off workers who are recalled to replace retiring workers. Retiring workers are, however, assumed to be replaced by junior workers, since this reproduces an important part of the membership determination process in a (larger) union where a fairly large number of workers retire at points in time spread evenly throughout the contract period.

The decision problem for L_1 , the median voter in the first contract period, is:

$$\max_{w_1} U\{\alpha_{11}w_1 + (1-\alpha_{11})\bar{w} + \sum_{j=2}^{A_{L_1}} c_{j-1}\{\alpha_{1j}w_j + (1-\alpha_{1j})\bar{w}\}\} \quad (4.1)$$

subject to:

(1) For $j = 1, \dots, A_{L_1}$,

$$\alpha_{1j} = 1 \text{ if } \phi(w_j) \geq (N/2) - (j-1)R$$

$$\alpha_{1j} = 0 \text{ if } \phi(w_j) < (N/2) - (j-1)R$$

(2) For $i = 2, \dots, A_{L_1}$, w_i is the solution to

$$\max_{w_i} U\{\alpha_{ii}w_i + (1-\alpha_{ii})\bar{w} + \sum_{j=i+1}^a c_{j-i}\{\alpha_{ij}w_j + (1-\alpha_{ij})\bar{w}\}\}$$

subject to:

(2.1) For $j = i, \dots, a$,

$$\alpha_{ij} = 1 \text{ if } \phi(w_j) \geq [\phi(w_{i-1})/2] - (j-1)R$$

$$\alpha_{ij} = 0 \text{ if } \phi(w_j) < [\phi(w_{i-1})/2] - (j-1)R$$

where $a = 1 - i + A_{\{L_1 + (i-1)R\}}$

In (4.1), the median worker is maximizing the utility of the present value of his lifetime earnings, not the present value of utility from earnings in

each contract period during his lifetime, since workers are assumed to have ready access to credit markets. They will therefore maximize the present value of their lifetime utility stream by borrowing or lending [depending on the market interest rate and their rate of time preference] according to their utility function and unearned income streams available to them.

The two terms left of the summation sign in [4.1] express the first period median worker's earnings in the first contract period, and the terms under the summation sign the present value of the earnings stream accruing in future contract periods. Earnings to L_1 in the first contract period depend directly on his choice of w_1 , with α_{11} taking the value 0 if L_1 prefers a wage w_1 which causes his layoff in the first period, and α_{11} equalling 1 if L_1 prefers a w_1 sufficiently small to keep him employed in the first contract period. Earnings to L_1 from future contract periods depend indirectly on his choice of w_1 : The chosen level of w_1 determines the size of the union voter pool [employed membership] in the second period, and $L_2 = \phi(w_1)/2$, the median in contract period 2, will determine the choice of w_2 . L_2 's choice will in turn determine L_3 and his choice for w_3 , and so on. Therefore, L_1 must predict the sequence of wage choices taken by future median voters, as determined by his choice of w_1 , in order to arrive at the level of w_1 which will yield the maximized present value of earnings accruing in all contract periods until the end of L_1 's working life.⁴

⁴ The auxiliary term $a = 1 - i + A_{\{L_i + (i-1)R\}}$ expresses the length of median L_i 's remaining working life at the beginning of contract period i .

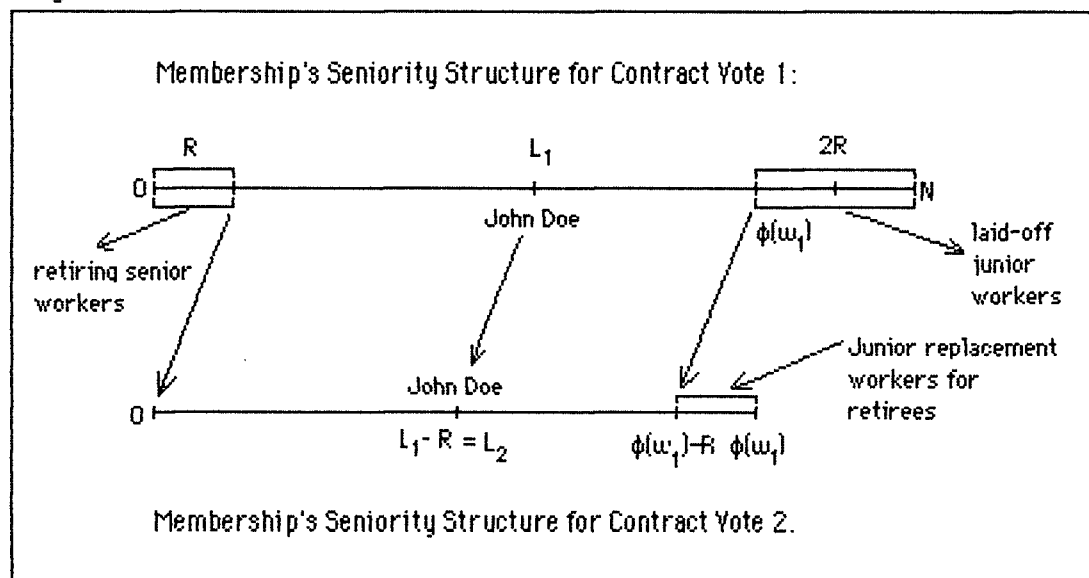
The model incorporates the effects of the retirement of R most senior workers in every contract period by adjusting the seniority ranking of each median L_i with every contract period: In contract period 2, median L_1 will be union-employed as long as $\phi(w_2) \geq L_1 - R$; in contract period 3, L_1 will be union employed as long as $\phi(w_3) \geq L_1 - 2R$, and so on.

There appears to be no way to derive a meaningful expression for w_1^* analytically. But one can derive an upper and a lower limit for w_1^* by means of the following argument:

First, suppose that L_1 chooses w_1 such that $\phi(w_1) = N - 2R$. That is, L_1 causes the union's present employed membership size (size of the voter pool) to decline (at the beginning of contract period 1) by twice the number of workers who will retire during contract period 1. Then, worker L_1 will be the median voter again in the vote on w_2 , the wage in the second contract period. This is so because during contract period 1, R workers retire, and L_1 's seniority position decreases therefore to $L_1 - R$. At the same time, retiring workers are replaced by young workers (new union members or junior union members previously laid-off), who enter the union's seniority queue below those workers who are union-employed at the beginning of contract period 1. In effect, the union's seniority queue is thus shortened at the senior end by R old workers and lengthened at the junior end (of employed workers) by R young workers. For worker L_1 to stay in the median position, he must therefore cause the seniority queue of employed workers to be shortened by $2R$ workers at the beginning of contract period 1. One-half of this reduction is then restored due to young workers replacing retiring workers, and worker L_1

retains his median position. (Figure 1 illustrates this process, for $\phi(w_1) = N - 2R$.)

Figure 1: The Union's Retirement Process



If first period median worker L_1 chooses w_1 such that $\phi(w_1) = N - 2R$ and thus retains his median position for the second contract, he can repeat his strategy by choosing w_2 such that $\phi(w_2) = \phi(w_1) - 2R$, and will then be the median voter again in the vote on w_3 . Worker L_1 can continue to follow this strategy of causing employment to be reduced by twice the number of retirees per contract period until his own retirement.⁵

⁵ If worker L_1 does indeed follow this strategy, there will eventually be a contract period where a further employment decline of $2R$ will cause the layoff of worker L_1 , since employed membership by then is smaller than $4R$. This special case will be discussed shortly.

In order to derive the lower limit for w_1^* , one can now ask: Would it ever be desirable for L_1 to choose a wage \underline{w}_1 lower than $W(N - 2R)$ ⁶? Suppose L_1 chose such a wage \underline{w}_1 . Then, the resultant second period median voter L_2 would be below worker L_1 in the seniority queue. For as long as L_2 's and resultant future median L_i 's wage choices were below $W(N - 2iR)$, which is the wage worker L_1 would have chosen if he had decided to stay in the median position by in effect reducing union employment by twice the number of retirees per contract period, worker L_1 would be worse off than he would have been had he maintained his median seniority position. Therefore, choosing a wage $\underline{w}_1 < W(N - 2R)$ could only be preferable for worker L_1 if the resultant sequence of median voters would eventually determine a wage path sufficiently above $W(N - 2iR)$ to at least compensate for the lower income in contract period 1 and all subsequent periods until \underline{w}_i exceeded $W(N - 2iR)$. But if worker L_1 preferred a higher wage than $W(N - 2iR)$ in any future contract period i , then he could choose this wage if he were the median voter in period i . Since he will be the median voter in period i if he chooses $W(N - 2jR)$ in all earlier periods $j = 1, \dots, i-1$, there is no advantage (in fact, a disadvantage) in choosing $\underline{w}_1 < W(N - 2R)$, even if the resultant sequence of w_i would eventually exceed $W(N - 2iR)$.⁷ Thus, we have shown that in

⁶ $W() = w$ is the inverse demand for labor function.

⁷ Could \underline{w}_1 result in a union membership age and seniority structure which would eventually cause a wage path preferable (to worker L_1) over the wage path he could achieve by choosing $w_1 = W(N - 2R)$? The answer to this question is no, since the only part of the union's age and seniority structure relevant to worker L_1 in this case consists of workers with higher seniority than L_1 , and initial wage choice(s) below $W(N - 2iR)$ cannot affect this part of the union membership.

a union with N employed members and R retirees per contract period, the union member with median seniority will always choose a contract wage not less than $W(N - 2R)$, provided $N \geq 4R$.⁸

The upper limit for L_1 's choice of contract wage w_1 can be shown by a simple argument to be $W(L_1)$: A wage w_1 higher than $W(L_1)$ would cause the immediate layoff of L_1 , and since the lower limit for the second period median voter's choice of w_2 has been shown to be $W(\phi(w_1) - 2R)$, it is obvious that with $w_1 > W(L_1)$, L_1 would never again be employed in the union job.

With the upper and lower limits of the union's choice of contract wage thus determined, there will eventually come a contract i where $\phi(w_{i-1}) < 4R$. Here, the assumption for which the lower limit on w_i has been derived ($\phi(w_{i-1}) \geq 4R$) no longer holds. It is easy to show that if $\phi(w_{i-1}) < 4R$, median L_i has at most two contract periods left in his working life and will choose $w_i = W(L_i)$. This leaves him just employed in contract period i . Depending on how much smaller than $4R$ $\phi(w_{i-1})$ has been, the median voter in contract period $i+1$ will choose a wage somewhere between $W(L_i - R)$ and $W(L_i)$, and worker L_i will end his working life while employed in the union job. The union will continue to exist on a

⁸ The proviso $N \geq 4R$ will be explained shortly.

very small scale (relative to its initial membership size N), with all union members not younger than the initial median worker L_1 having retired.⁹

Does the wage preferred by first period median voter L_1 coincide with the majority voting outcome for the union's present membership N , and do the wage choices of predicted future median voters reflect the (stable) outcome of the majority vote among the union's then members? A formal proof cannot be given, but the following argument points to an affirmative answer: An (older) worker who is above median worker L_1 in the seniority queue will not choose a lower wage than L_1 for the following reason. If L_1 decides for a wage causing the layoff of only $2R$ junior workers, then this older worker will stay union-employed until his

⁹ The exact wage path from this contract period onwards is considered to be of limited interest, and so is the exact nature of the small union membership remaining (due to the replacement of retiring workers in these final periods of the initial union) after everyone in the senior half of the initial union has retired. These final stages are preceded by a contract period where $\phi(w)$ is in the neighbourhood of $4R$, with all employed union members being very close to retirement. Such a state is empirically unlikely. It is even more unlikely that in the final transition phase from small, overaged union to an even smaller union whose employed members consist of those workers in the initial union membership's junior half who have not held union employment for a very long time, but remained as union members, and young new members, the union's behavior will be determined by strict majority voting based on worker preferences determined by a strict interpretation of seniority status. In chapter 11, it will be argued that before the union reaches an employed membership size close to only $4R$, factors not considered in the present model will be increasingly important for the union's choice of contract wage. Therefore, it would be of little interest to analyze the final stages in such a relatively small union by means of the present model.

retirement, and if L_1 chooses a higher wage (than $W(N - 2R)$) and therefore prefers to be laid-off from his union job before retirement, then the older worker, who has fewer remaining years until retirement and therefore fewer union-employed contract periods to lose than L_1 , will again not prefer a smaller employment reduction than L_1 . A (younger) worker with a less favorable seniority ranking than L_1 will not choose a wage higher than the wage preferred by L_1 , since if it is preferable to L_1 to avoid the loss of union earnings in more than a certain number of contract periods before retirement, it will be preferable for the younger worker as well to avoid the loss of union-earnings in at least as many contract periods, since he has more contract periods left in his working life than L_1 .¹⁰

The argument thus far has depicted a highly mechanistic process that is not likely to take place in the real world. For any wage choice w_i by the union, the industry is unlikely to reduce employment to $\phi(w_i)$ immediately, and then to rehire laid-off workers as replacements for retiring workers throughout the contract period. Instead, the industry will probably want to avoid costs incurred with layoffs and rehiring by keeping on $\phi(w_i) + R$ workers at the beginning of the contract period, R of whom can then take the place of the R workers who retire during the contract period. The net result of this more straightforward process is the same as derived above - at the end of each contract period, union employment will have decreased by at least $2R$, and the contract wage rate will increase each period by an amount which causes union

¹⁰ The applicability of the median voter model has been checked to some extent in the simulation solutions presented in chapter 4.2.

employment, as computed by the demand for labor function $\phi(w)$ (and de facto executed at the end of the contract period) to decline by at least $2R$.

The principal arguments above have been made in terms of the more mechanistic process of "firing and rehiring", instead of the straightforward gradual employment reduction process, for two reasons: First, to establish clearly that the union's behavior does not depend on the industry's willingness to employ more workers until the very end of the contract period than implied by its demand for labor schedule; and secondly, to develop in detail how the retirement process is assumed to work. It is important to retain a motive for the industry to in fact replace retiring workers by young workers for the prediction of an employment reduction of at least twice the number of retirees per contract period to hold. If the industry were able to solve the problem of replacing retirees by somehow getting workers to work beyond their retirement date until the end of the contract period, or if workers retired as a group all at the end of the contract period, then it would be unlikely that retiring workers will be replaced by young workers just to participate in the union vote for the next contract, but not to actually work under the current contract. In this case, the union would choose a minimum employment reduction of only R (instead of $2R$) per contract period, since the union's median member would then only have to account for the increase in his own seniority, but not for the influx of R retiree-replacing young workers, when attempting to preserve his median position.

As a final point on the predicted upper and lower limits for the union's contract wage choice, it is significant that these limits (in terms of resultant union employment) do not change if the union expects the industry's demand for labor schedule to change (in a perfectly predictable manner) in future contract periods. That is, the prediction of a minimum employment reduction of $2R$ per contract period and a maximum per-period reduction of half the union's membership size is independent of predictable changes in demand for union labor, since the derivation of these limits relies only on considerations of the union's median member regarding his future relative seniority position, and on majority voting among seniority-ranked union members.

This more general result is of interest both for predictable cyclical and structural changes in demand for union labor: Even with an impending severe cyclical downturn in demand, or under predicted long-term structural decline of demand for union labor, the union will not maintain its membership size; and alternatively, even predicted strong demand growth will not cause the union to share its fortunes with all of its existing members.¹¹

To sum up: In a union allocating employment by seniority and granting voting rights only to employed members, the median voter L_i in contract period i will choose a contract wage w_i not below $W(2L_i - 2R)$ and not

¹¹ Of course, changes in future demand for labor will have an impact on the upper and lower limits for the union's contract choice in terms of the wage rate, and on the actual wage rate chosen in between the limits derived above. The union's actual wage choice is the subject of the next section.

above $W(L_i)$. If $L_i < 2R$, i.e. if the union's employed membership in period i is already very small and the median voter close to retirement, then L_i will choose $w_i = W(L_i)$. These predictions hold for any predictable path of the industry's demand for labor schedule in future contract periods.

In early contract periods, the upper and lower limit for w_i may be fairly wide apart, and it is therefore interesting to analyze the contract wage path in more detail. This appears impossible in a general analysis of (4.1), but simulation results for specific examples in the next section allow one to suggest a more precise answer regarding the time path of the contract wage.

4.2 Simulation Solution

This section builds on the results of section 4.1: It utilizes model (4.1), and the general result that the contract wage w_i will be between $W(\phi(w_{i-1}) - 2R)$ and $W(\phi(w_{i-1})/2)$ for as long as $\phi(w_{i-1}) \geq 4R$, i.e. for as long as the union's employed membership does not consist only of workers who will reach the end of their working lives within the next four contract periods. The purpose of this section is to analyze where exactly between these limits the optimal contract wage path falls. Due to analytical limitations, this is done by means of computer simulations for specific cases.

In the computer simulation, the union's behavior is determined as follows: For a specific union membership structure, a specific demand for labor function and a given interest rate and contract length, all wage

choices $\{w_1\}$ for first period median L_1 between $W(N - 2R)$ and $W(L_1)$ are considered.¹² For each w_1 in the set $\{w_1\}$, the resultant median voter L_2 is computed, and the set $\{w_2|w_1\}$ of wage alternatives open to L_2 determined. For each w_2 in $\{w_2|w_1\}$, the resultant median voter L_3 's set $\{w_3|w_2, w_1\}$ is computed, and so on. In the end, a tree-like structure of earnings paths is thus established, with individual branches ending once all workers from the union's initial senior half have retired. Then, beginning with the outermost branches of this tree, those branches which cause inferior earnings streams to the median voter at the corresponding branching level are gradually eliminated. In the second-last stage of this selection process, for example, it is therefore known what earnings path would be caused by each potential median L_2 , as determined by which w_1 in $\{w_1\}$ median voter L_1 chooses. In the final stage, median L_1 chooses that w_1 which maximizes the earnings stream accruing to him.¹³ The simulation process therefore replicates and

¹² The program considers only wage levels which cause the employment of an integer number of workers.

¹³ The process actually used in the computer program is slightly different: The program passes through all branches of the tree, but eliminates inferior alternatives in passing, taking care to judge each branch's desirability from the point of view of the median L_i who is solving the maximization problem in period i . The program accounts for the fact that the discount rate applied to w_i by each median L_1 to L_i is different due to the different point in time each median solves his decision problem. Since the simulations are done for a union with a very simple age structure, the final stages (where $\phi(w_{i-1}) < 4R$) are easily simulated precisely. The result from chapter 4.1 that the minimum wage choice of any median L_i is $\text{MIN}\{W(\phi(w_{i-1}) - 2R), W(\phi(w_{i-1})/2)\}$ ensures that the tree of wage path alternatives to be considered is of finite depth.

solves the optimization program faced by the first-period median member exactly.¹⁴

Eleven simulations will be presented now. All of them are for a highly stylised union membership structure: The union is assumed to have 39 members, all of whom are presently employed and thus allowed to vote on the wage in contract period 1. The most junior member is 22 years old, the worker with second lowest seniority is 23 years old, and so on, up to the worker with highest seniority, who is 60 years old and will retire at the end of contract period 1. One worker retires per contract period ($R = 1$), contract length is one year, and all workers retire just before their 61st birthday.

The union's majority voting rule is that with an odd-numbered voter pool, a 1-person majority wins the contract vote; with an even-numbered voter pool, ties are resolved in favor of the voter block with higher total seniority.

¹⁴ The term "simulation" points only to the fact that this section deals with fully specified structural forms and solves the programming problem not analytically, but by considering all alternatives.

discounted for one period, and shows the effective wage schedule for L_1 in contract period 2, or in general, median L_i in contract period $i+1$.¹⁶ Line $L_1w_i^{\min}$ shows the contract wage path if first period median L_1 chooses $w_1 = W(N - 2R)$, therefore retains his median position in the next contract vote, and continues to follow this median-preserving strategy, which has been shown in section 4.1 to be the most conservative strategy that is not clearly inferior to other strategies. Line $L_1w_i^{\max}$ shows the present value (at time 1) to worker L_1 of the wage in contract i if w_i were such that it just kept worker L_1 employed in contract period i . That is, it shows the highest wage w_i worker L_1 could choose if he were the median in contract vote i , and would just stay employed in contract period i .

Thus, the V-shaped area between $L_1w_i^{\min}$ and $L_1w_i^{\max}$ is the area within which L_1 's choice of contract wage w_1 and, possibly, later contract wages, will come to be, for as long as worker L_1 remains union-employed¹⁷. As long as worker L_1 chooses a wage on $L_1w_i^{\min}$, he will retain his median position. By contrast, he can choose, while median, a wage on

¹⁶ In Figure 2, the $c_iW(\phi)$ curve for each contract period is shown. Due to lack of space, Figures 3 to 13 show only every third $c_iW(\phi)$ curve.

¹⁷ The full black circles on $L_1w_i^{\min}$ and $L_1w_i^{\max}$ show L_1 's corresponding minimum and maximum discounted wage choice: The third circle from the right on $L_1w_i^{\min}$ shows, for example, the discounted wage for the third contract period if L_1 has decided to stay on the minimum wage increase path up to at least the third contract period. The unshaded smaller circles show the discounted contract wage that is chosen by the median worker in each period. (That is, the unshaded small circles show the time path of the contract wage that solves the model.) Circles with a wide black margin and a white core are for cases where the optimal wage coincides with the wage(s) on $L_1w_i^{\min}$ or/and $L_1w_i^{\max}$.

$L_1 w_i^{\max}$ just once: Such a choice would leave him union employed in the immediately upcoming contract, but cause his layoff afterwards, since the new median's $L_{i+1} w_i^{\min}$ - line is to the left of $L_1 w_i^{\min}$. Finally, if worker L_1 , while still median in contract period i , chooses a wage in between $L_1 w_i^{\min}$ and $L_1 w_i^{\max}$, he loses his median position and will be laid-off at the latest where the resultant median L_{i+1} 's $L_{i+1} w_i^{\min}$ - line crosses L_1 's $L_1 w_i^{\max}$ - line.¹⁸

Line w_i^* shows the actual optimal wage path (in present value terms), as determined by the computer simulation. This line can never be to the right of $L_1 w_i^{\min}$, but if it is to the left of $L_1 w_i^{\min}$, it may eventually cross $L_1 w_i^{\max}$, indicating that from then on, the initial median worker L_1 will no longer be union-employed.

Figure 2 can be used for an intuitive discussion of median worker L_1 's decision problem: He can choose $w_1 = W(N - 2R)$ and continue to follow wage path $L_1 w_i^{\min}$, ensuring thereby that he will retain union employment until he retires. If he chooses a higher w_1 , future medians will all be more senior than he, and will determine a wage path which will cause worker L_1 's layoff before retirement. Until he is laid off, worker L_1 will enjoy higher wages than if he had stayed on $L_1 w_i^{\min}$, and he must

¹⁸ In Figure 2, this is illustrated for an alternative median in the second contract vote: If L_1 had chosen $w_2 = W(8)$ or $w_2 = W(7)$, then the second period median would have been the worker with second-period seniority ranking 4. This median's minimum and maximum wage-choice lines are $L_2 w_i^{\min}$ and $L_2 w_i^{\max}$, and are to the left of L_1 's minimum and maximum wage-choice lines. $L_2 w_i^{\min}$ shows that with $w_1 = W(7)$, L_1 would lose his union job at the latest at the end of the second contract period.

therefore weigh the loss of a relatively high union wage differential in relatively distant contract periods against the gains from a higher union wage path in earlier periods. Intuitively, it becomes more attractive for L_1 to choose a w_1 higher than $W(N - 2R)$ if the interest rate is high, if he has relatively many contract periods left before retirement, and if the demand for labor schedule is convex. In the illustration simulation for Figure 2, none of these factors is strong enough to cause L_1 to choose a wage above $W(N - 2R)$.

The eleven simulations for a union with an initial membership of 39 workers, as discussed above, are for five different arguments: Simulations 1 and 2 show a low-interest rate case and a high-interest rate case for a concave demand for labor function; simulations 3 and 4 are the corresponding set for a convex demand for labor function.

In simulations 5 and 6 the effects of demand for labor growing at a moderate rate and at a high rate, respectively, are shown for the concave demand function of simulation 1. Simulations 7 and 8 present the corresponding case for the convex demand for labor function of simulation 3, and simulation 9 deals with the case of demand for labor declining at a moderate rate.

Finally, simulations 10 and 11 take the setting of simulation 1, but introduce one modification each: In simulation 10, the wage in the non-union labor market is assumed to be rising with time,¹⁹ and in simulation

¹⁹ As mentioned above, the alternative wage \bar{w} is assumed zero in simulations 1 to 9 and 11.

11, workers are assumed to be able only to save, but not to borrow in financial markets.

Simulations 1 and 2 [Figures 3 and 4] – Concave Demand Cases:²⁰ The low interest rate of 10% per contract period in simulation 1 leaves earnings in contract periods in the distant future attractive enough for worker L_1 to forego higher than minimum wage increases in earlier contract periods. L_1 chooses w_1^* to maintain his median position until retirement; employment (in CP 1 to 17) declines by twice the number of retiring workers in each contract period.

With a high interest rate (30%/CP) in simulation 2, L_1 chooses to forego his median position and union earnings from contract period 13 onwards. The second period median (the worker with initial seniority ranking 17) stays on the minimum wage-increase path until his retirement at the end of contract period 17. After a sharp decline in the first contract period, employment declines again by twice the number of retirees per contract period.

Simulations 3 and 4 [Figures 5 and 6] – Convex Demand Cases:²¹ In the low-interest rate case ($r = 10\%/CP$) in simulation 3, union earnings in the distant future are again attractive enough for L_1 to cause employment to decline by only twice the number of retirees per contract period, and

²⁰ In simulations 1 and 2 (and in 5,6, 10 and 11), the inverse demand for labor function is defined as $W(\phi) = \text{LOG}(45 - \phi)$.

²¹ In simulations 3 and 4 (and in 7, 8 and 9), the inverse demand for labor function is defined as $W(\phi) = \{80/(\phi + 10)\}$.

Figure 3: Concave Demand - Low Interest Rate Case

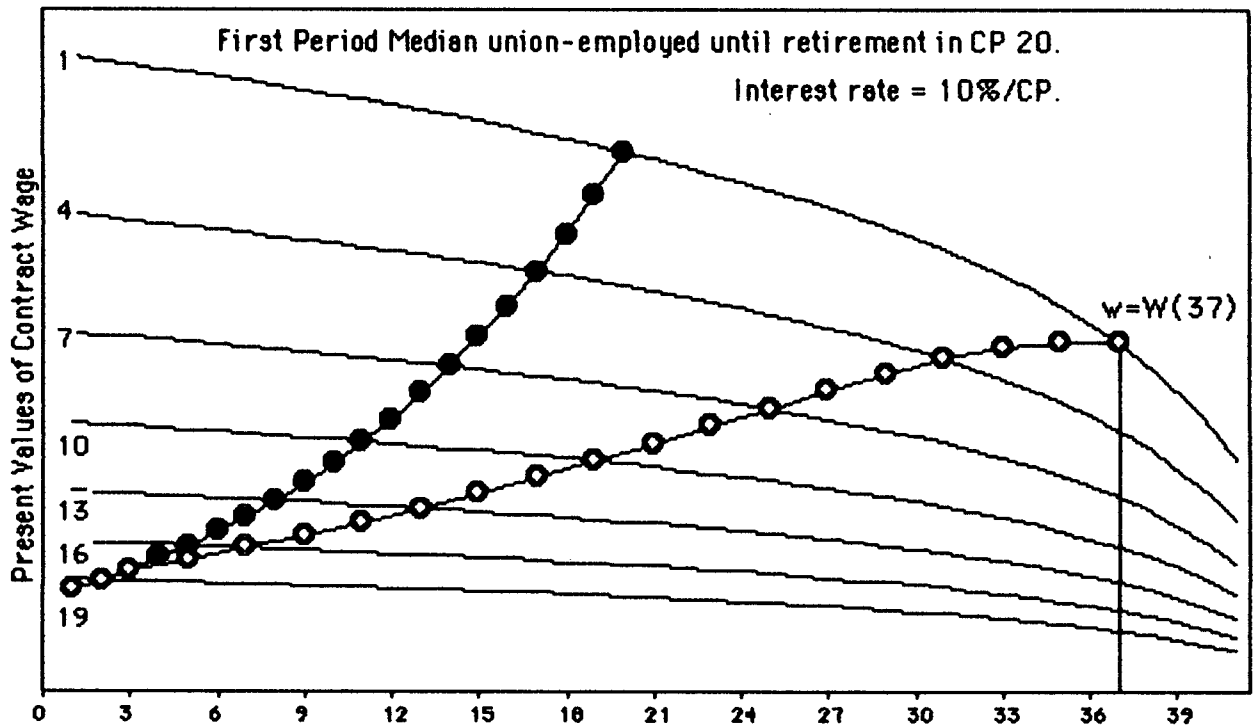
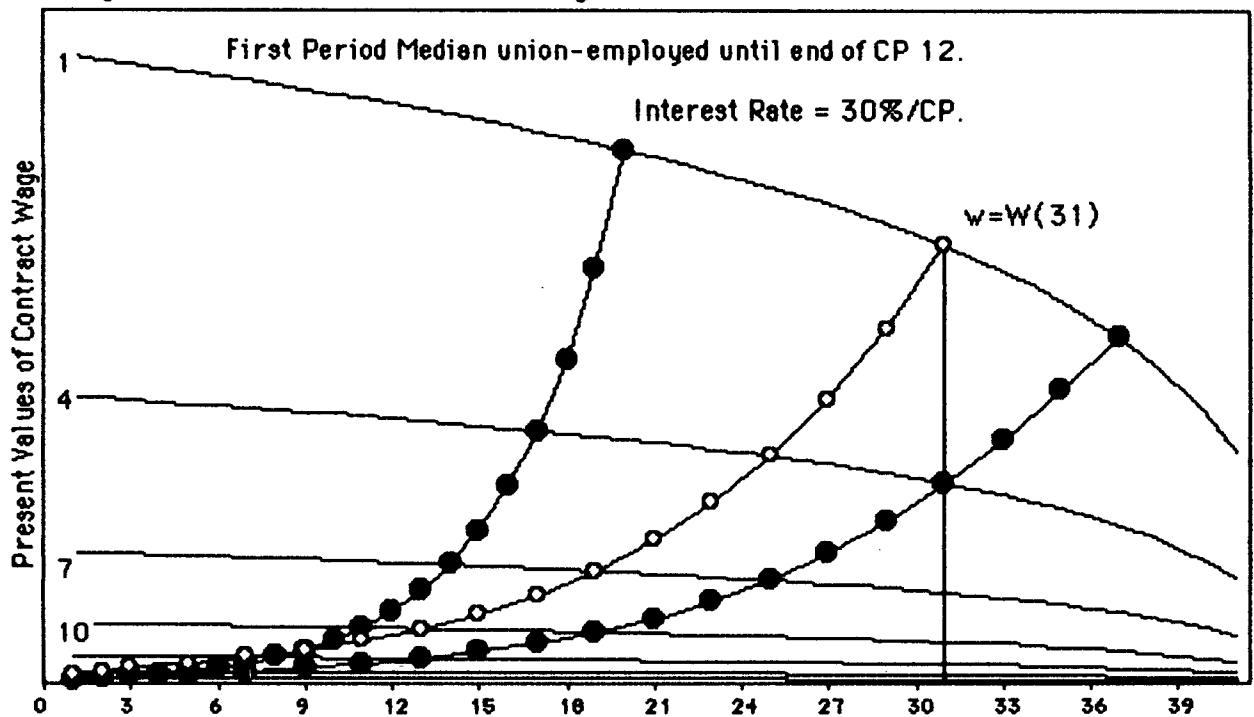


Figure 4: Concave Demand - High Interest Rate Case



thus retain his median position. With $r = 30\%/CP$ in simulation 4, L_1 chooses to give up his median position in favor of higher earnings in the near future, but at the price of losing his union job at the end of contract period 10. After the high initial reduction in union employment from 39 to 29, the resultant median L_2 chooses minimum employment reductions until he retires in contract period 16.

Simulations 1 to 4, and results from similar simulations, suggest two main points: First, employment reductions of more than twice the number of retirees per contract period appear to be mainly motivated by the interest rate (and the length of a person's working life). If demand for labor is concave and highly inelastic at wages near and above the union's current wage (w_0), or convex and highly inelastic only for very low employment levels, then an initial reduction in employment by more than $2R$ is more likely, but only if the interest rate is high enough and the median worker's remaining work life long enough to cause discounted earnings in periods close to the first period median's retirement date to be relatively low in comparison to the relevant earnings range in the near future.

The second suggestive result is that if at all, then an employment reduction by more than twice the number of retirees takes place only with the first contract: L_1 prefers the one-time adjustment over a gradual adjustment. (If one limits L_1 's adjustment to an employment reduction of less than the one preferred by L_1 , the resultant L_2 will choose an employment reduction roughly completing the adjustment process.)

Figure 5: Convex Demand - Low Interest Rate Case

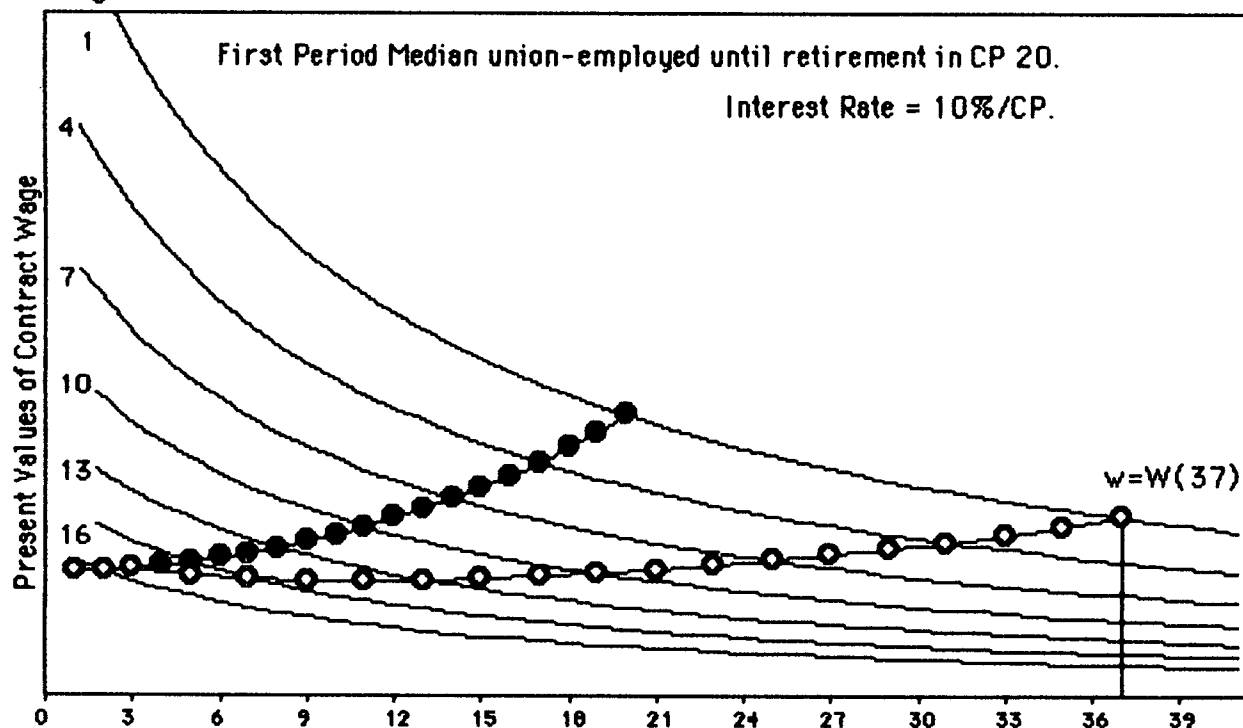
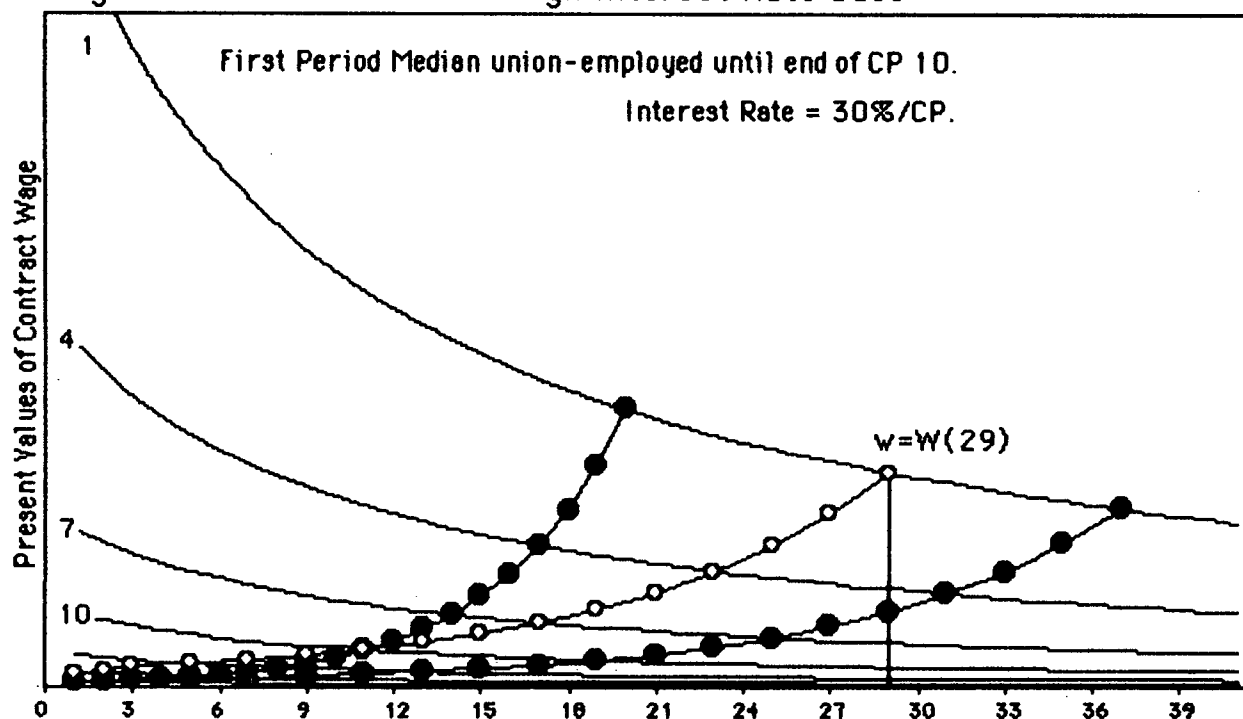


Figure 6: Convex Demand - High Interest Rate Case



Simulations 5 to 8 show how the union reacts to anticipated changes in the demand for labor schedule.²²

Simulations 5 and 6 (Figures 7 and 8) - Growth in Concave Demand Cases:

Both simulations use the setting of simulation 1 (low interest rate case), but have demand for labor grow by 5 percent per contract period in simulation 5, and by 25%/CP in simulation 6. The simulation results confirm the prediction of section 4.1 that anticipated growth in demand does not cause the union to choose a wage path which would not result in the gradual decline of union employment, even if growth in demand is at a fairly high rate: As long as union members are perfectly informed about positive changes in demand, it never pays for the median voter to vote for a employment reduction of less than twice the number of retirees.

Simulations 5 and 6 are for a relatively low interest rate. [The corresponding fixed-demand simulation 1 has shown the optimal wage path to be the path of minimum employment decline]. For a higher interest rate, it is conceivable that anticipated strong demand growth will cause an initial optimal employment decline smaller than in the static-demand case, but still at least as large as twice the number of retirees per contract period. This is because with strong demand growth, discounted earnings in relatively distant future contract periods are

²² These simulations are intended to confirm section 4.1's prediction of the independence of the upper and lower limits for the union's choice of employment level from predictable changes in demand, and to suggest the impact of demand changes on the optimal employment (wage) path in between these limits.

Figure 7: Concave Demand - Moderate Demand Growth Case

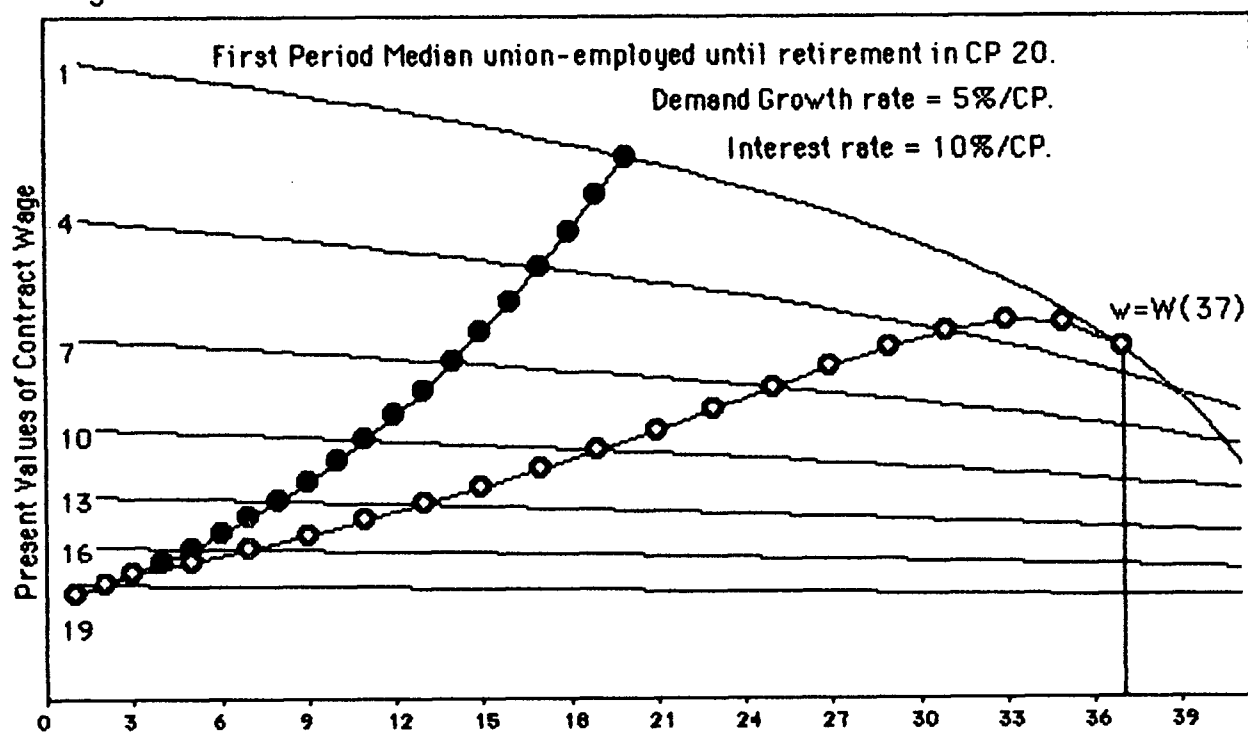
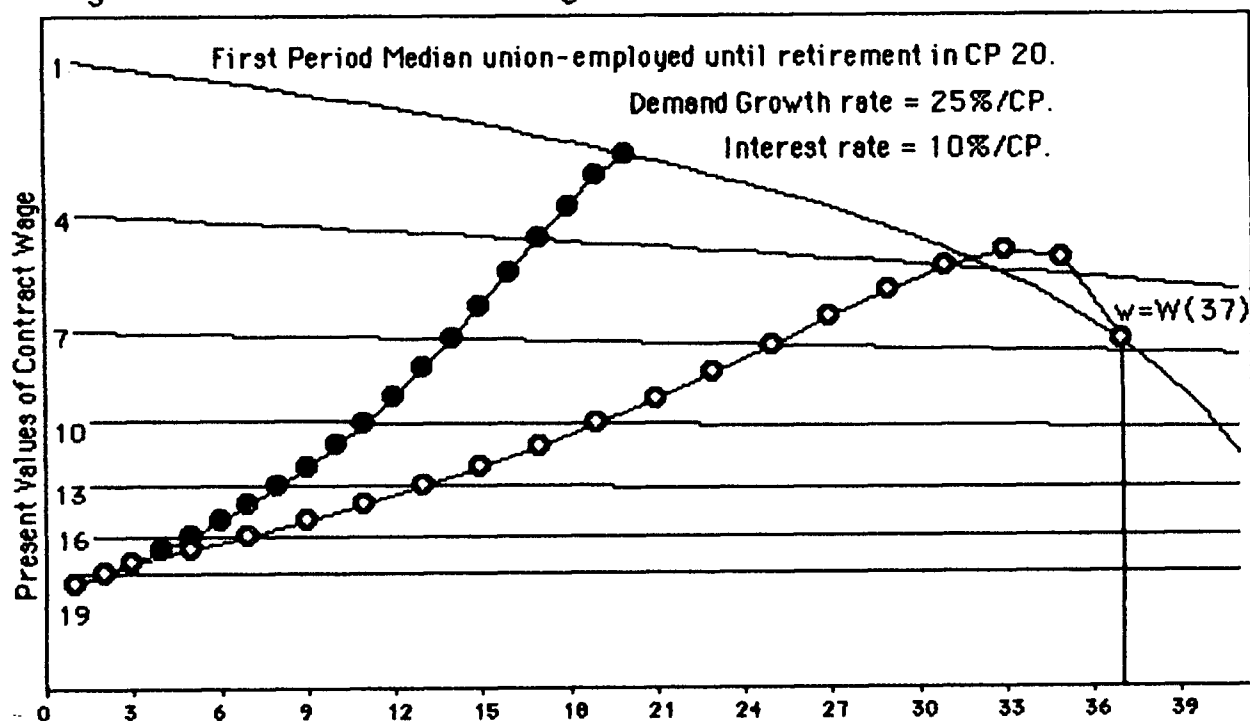


Figure 8: Concave Demand - High Demand Growth Case



somewhat higher than with static demand, and a high initial employment reduction caused by a high interest rate may thus become less attractive. This impact of demand growth is, however, limited as long as demand for labor is a concave function of the wage rate.

Simulations 7 and 8 (Figures 9 and 10) - Growth in Convex Demand Cases:

Both simulations use the setting of simulation 3, but assume demand to grow by 5%/CP in simulation 7 and by 25% in simulation 8. The union does not choose an employment reduction of less than twice the number of retirees, even if growth in demand is substantial. If the interest rate were as high as in simulation 4 (30%), it is again likely that the optimal first period employment reduction (9 workers in simulation 4) will be smaller (but still at least as large as 2R) if demand grows at a rapid pace: Earnings in low-employment regions of the demand curve rise relatively quickly with shifts in demand if demand is convex, and it is therefore less appealing to opt for the loss of future union earnings for a gain in near-term earnings.

Simulations 5 to 8 (and the underlying model) do not emphasize the fact that growth in demand yields higher union earnings even if the employment path implied by the union's wage choice does not change. Also, growth in concave demand decreases the size of the per-period wage increase caused by an ongoing employment decline of 2R; whereas growth in convex demand increases this wage gain. Therefore, adjustment costs to workers from employment level changes (which are not considered in the present model) may make ongoing small employment reductions relatively less attractive particularly if demand

Figure 9: Convex Demand - Moderate Demand Growth Case

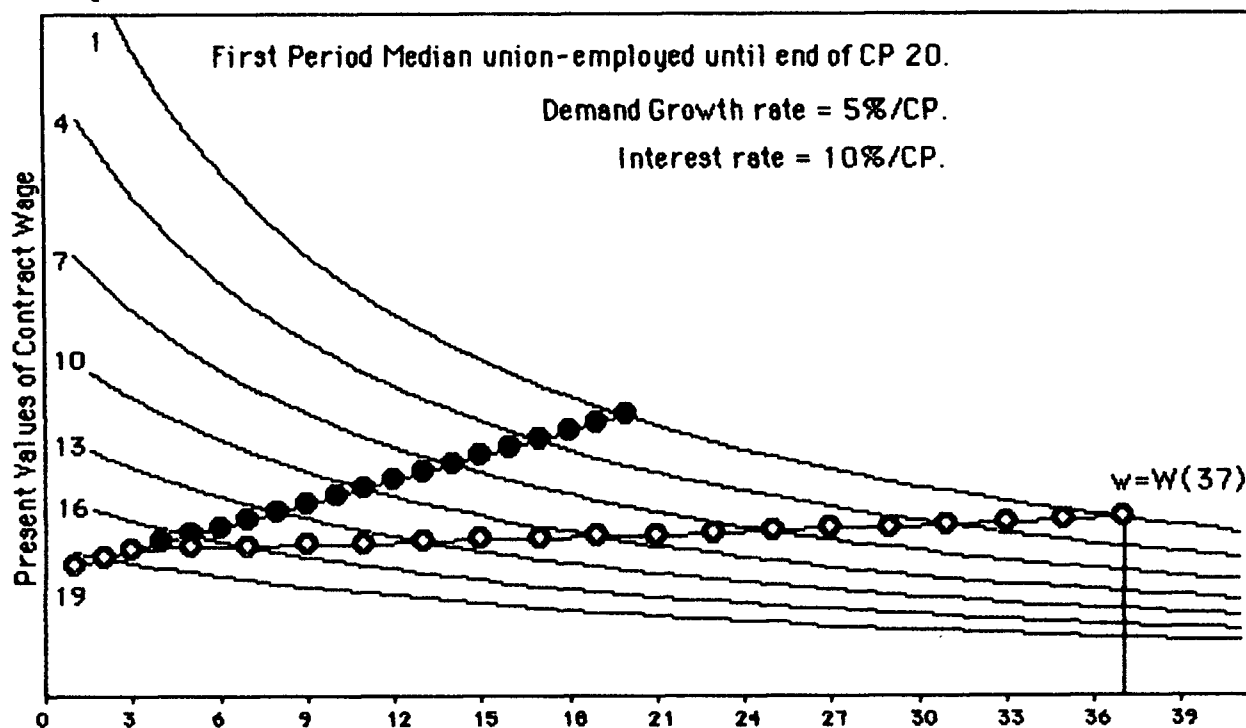
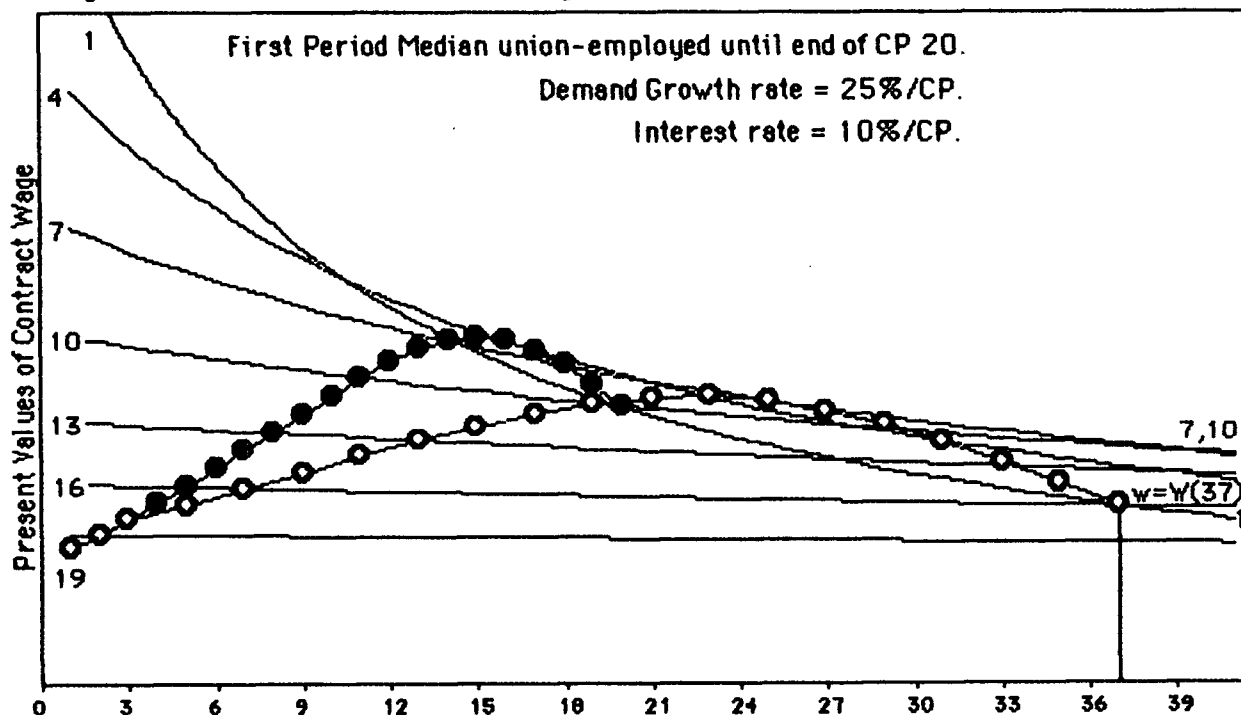


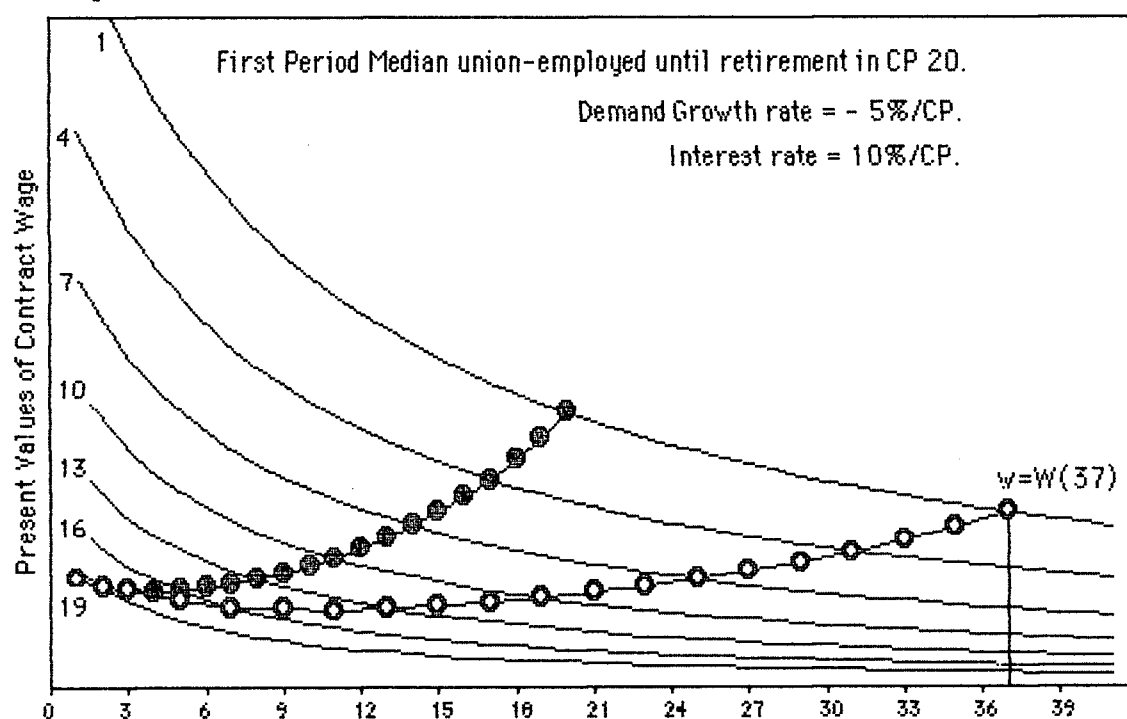
Figure 10: Convex Demand - High Demand Growth Case



is concave and growing, and the union may therefore prefer employment stability over ongoing union decline. Section 11.1 will address this question.

Simulation 9 (Figure 11) - Decline in Convex Demand Case: This simulation takes the setting of simulation 3 (low interest rate case) and assumes demand to decline by 5 percent per contract period. Comparing figures 5 and 11, it appears that with declining demand, the union is likely to reduce employment by at least as much as if demand were stable, because future earnings in low-employment ranges become less and less attractive, and the union may therefore choose to take advantage of favorable demand conditions in earlier periods.

Figure 11: Convex Demand - Moderate Demand Decline Case



Simulations 5 to 9 have dealt with anticipated changes in the demand for labor. For unanticipated demand changes, one can make the following argument:

(i) Unanticipated one-time positive shock in demand: The contract wage having been set before the unanticipated demand shock, employment (and therefore the union voter pool) will increase. In the next contract vote, the median voter is now younger (lower in the seniority queue) than he would have been had the one-time voter pool expansion not taken place. The new median may choose a one-time employment reduction of more than $2R$, but not necessarily so. Employment will not be reduced to a level below what the pre-shock expected next period median would have reduced employment to²³, and it may be reduced by only $2R$. Thus, a one-time unanticipated positive shock in demand for labor would leave the union on a wage path not above, and possibly below, the optimal wage path in the undisturbed case.

(ii) Permanent unanticipated positive shift in demand: If the demand schedule changes permanently from $\phi(w)$ to $\phi(w) + a$ and this change has not been anticipated, the union will react, in principle, as in (i), since for the change in the union's voter pool, it does not matter whether the change in demand is only for one period or permanent. However, it appears that with a concave demand for labor schedule, it is more likely

²³ If the new median would cut employment to below this benchmark, then the initial median's wage choice would not have been optimal for the initial median, since the new median is necessarily younger than the worker the initial median had expected to be the median voter in the next contract period.

now than under case (i) that the new median will choose a one-time employment reduction in excess of $2R$, since the shape of the new demand curve is now more favorable for a high initial employment reduction. Similarly, it is less likely than under case (i) that an employment reduction of more than $2R$ will be chosen by the new median if the demand for labor schedule is convex.

Simulation 10 [Figure 12] - Increasing Alternative Wage Case: The unionisation of an industry is often strongest towards the end of the industry's life span, and may therefore coincide with an era where the productivity of labor (in money terms) in the unionised industry is declining relative to the productivity of labor in emergent industries. One can capture this situation by incorporating a rising alternative wage into the model, and simulating the median union member's optimal path for the union wage differential. This is done in simulation 10, which corresponds to simulation 1 except for the fact that \bar{w} is no longer assumed zero, and taken to increase by 5 percent per contract period.²⁴

Figure 12 shows that in such a unionised industry experiencing long-term decline relative to the overall economy, the union's initial wage choice (and the resultant wage path in general) will be higher than under

²⁴ Figure 12 shows the increasing alternative wage by showing $(1 + r)^{-(t-1)}W(\phi) - [1.05]^{t-1}\bar{w}$ instead of $(1 + r)^{-(t-1)}W(\phi)$. Compared to figure 3, the resultant union wage differential curves are spread out vertically. The fact that the union wage differential in relatively distant contract periods is negative in the low wage/high employment area of the demand curve does not affect the median's decision directly, since this area of the demand curve is no longer effective in these contract periods.

Figure 12: Rising Alternative Wage Rate Case

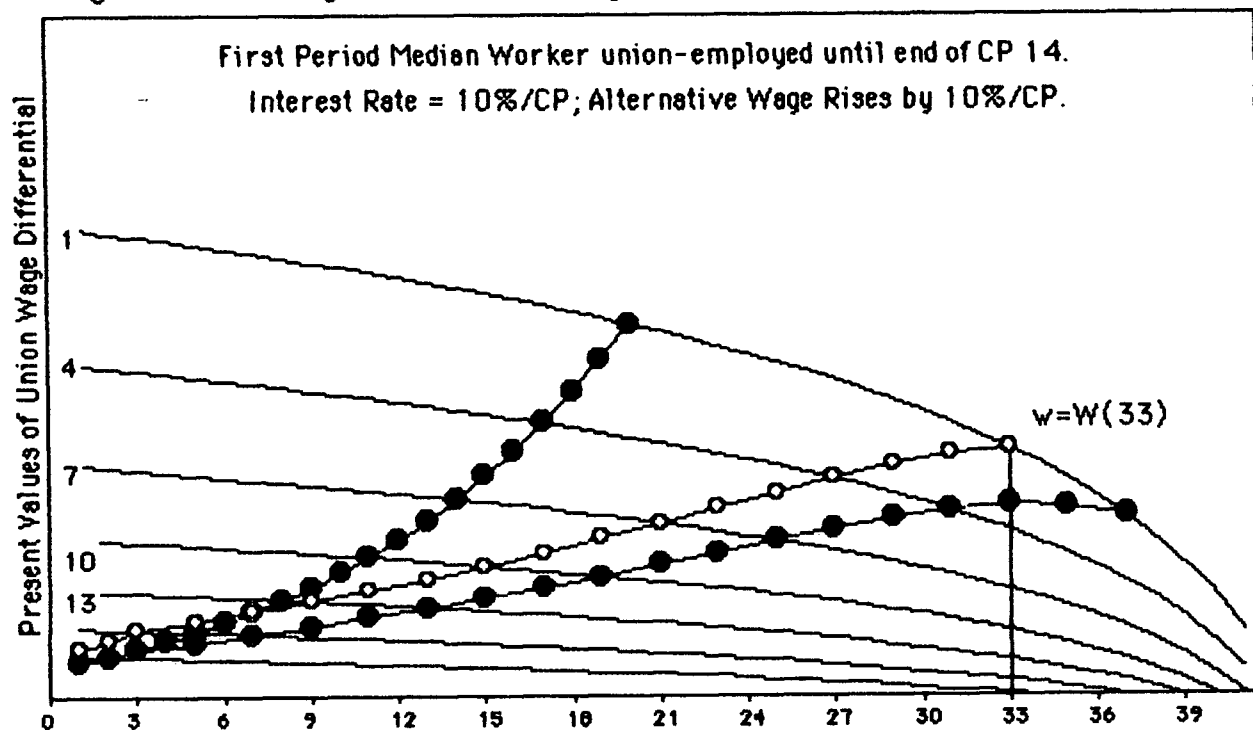
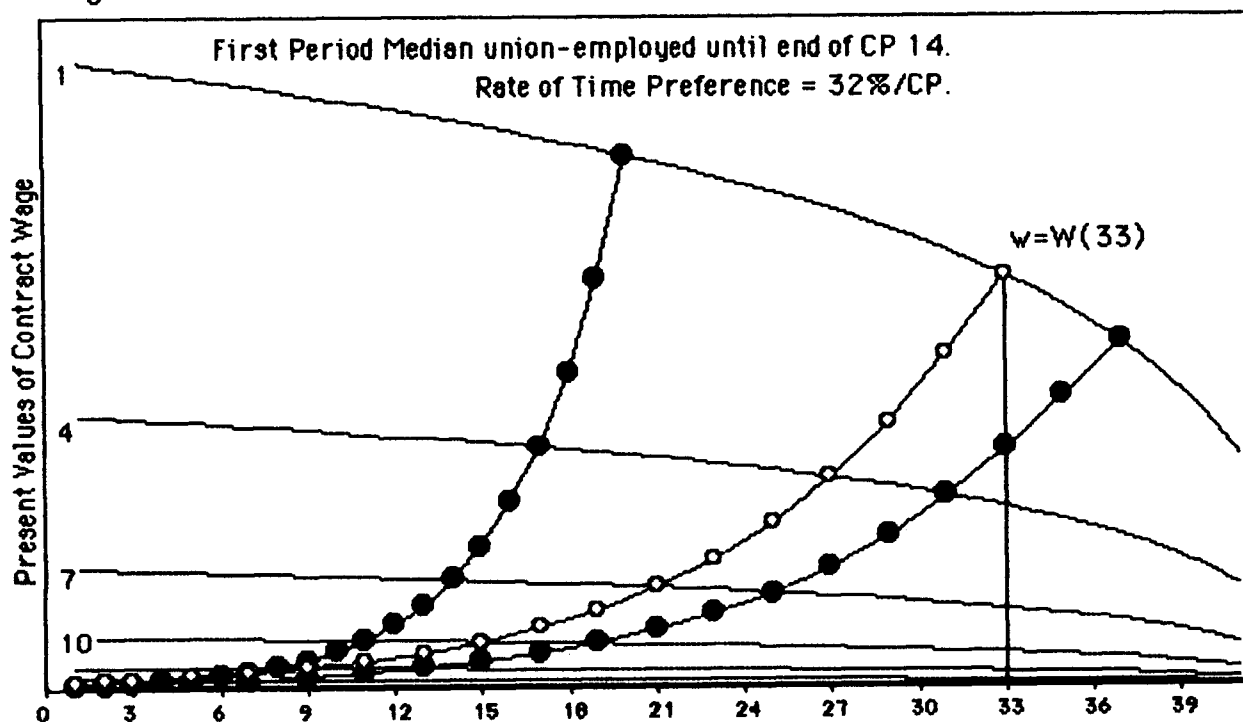


Figure 13: Effects of No Access to Credit Markets Case



conditions where relative labor productivity remains unchanged. This is a somewhat surprising result, and coincides with the impression that unions in declining "smoke-stack" industries sometimes choose to hasten the decline of their industry. But the result depends in an important way on the assumption that even relatively old union members expect to find employment in the alternative labor market without delay, adjustment costs nor negative wage consequences due to age or skills deficiency.

Simulation 11 (Figure 13) - Limited Access to Credit Market Case: Thus far, it has been assumed that workers have perfect access to capital markets and can therefore equalize the rate of time preference for which they optimize their earnings path with the interest rate in the capital market. If this assumption is not realistic and if workers have a rate of time preference for consumption not below the market rate of interest, then workers calculating a rising union wage would want to borrow money now against rising future earnings, but could not do so. Thus, the median union worker would not strive to maximize the present value of the earnings stream accruing to him, but to maximize the present value of the utility stream from earnings per contract period.

Simulation 11 deals with this case: The demand for labor function is as in simulation 2. The rate of time preference is slightly higher (32%) than the interest rate in simulation 2 (30%). Unlike before, workers now consider the discounted utility achieved in each period from earnings in that period.²⁵ As Figure 13 shows, L_1 will choose $w_1^* = W(33)$. For this

²⁵ The utility function used is $U(w) = w^{0.2}$.

simulation case, the first-period wage (and resultant wage path) under utility maximization is lower than under earnings maximization.²⁶ With utility a concave, nondecreasing function of earnings, the utility gain from a wage increase is now faster outweighed by the utility loss from the resultant earlier loss of the total union wage differential due to earlier layoff.

This concludes this chapter on the behavior of a union with a seniority system, facing a fixed demand for labor schedule. The simulation results for such a union have predicted that after a possible, but for moderate interest rates not very likely initial large employment reduction, such a union will decide for a wage path causing the layoff of twice the number of retirees per contract period. If an employment adjustment of more than twice the number of retirees per contract period is indeed called for in the union's first modelled contract, union organizers should have been not unlikely to make use of this prediction during the drive to establish the union and in proposing the first collective agreement. Presumably, the union's first contract will result from a far more complex (and political) set of determinants than modelled here. Nevertheless, the prediction of a majority-supported large wage increase (large employment reduction) may be an attractive illustration of the benefits of unionization (under a seniority system), and may therefore influence the union's first contract choices significantly. If this is so, the union's later contracts (for which the model developed here is

²⁶ Simulation 2 (Earnings maximization for same demand function) found $w_1^* = W(31)$ for $r = 30\%$. For $r = 32\%$, w_1^* would have been equal or higher under earnings maximization.

intended) are likely to be decided upon by a voter pool already small enough to choose an initial (modelled) adjustment not exceeding $2R$ by much.

For as long as the union's employed membership is relatively large (and the median age of its members not far above the average person's age at the midterm of one's working life), the prediction of an ongoing employment reduction by twice the number of retirees per contract period appears to be relatively moderate. Nevertheless, the predicted wage path leads to a steady decline in union employment, and eventually to a very small union composed of relatively old workers.

In section 1 of chapter 11, a number of arguments about potential forces counteracting the union's rapid decline in later contract periods will be presented. But for now, the paper turns to a model of the behavior of a union facing a demand for labor schedule subject to random shocks.

5. Union Wage Choice under Stochastic Demand for Labor, with Employment by Seniority and Voting Rights Loss for Laid-Off Workers

This chapter presents the second principal model developed in this paper. The setting is the same as for the model discussed in chapter 4, except that the demand for labor schedule is no longer fixed. It now contains a stochastic term with a known, serially independent distribution with an expected value such that there is no expected secular change in the demand for labor schedule over time.

The main goal for this chapter is to show the effect of uncertainty in demand for labor on the union's majority preferences over contract wages in a setting where the time horizon of union members extends beyond the current contract period. Analytical limitations turn out to be severe even for the most simple case, namely a two-period model. Therefore, this chapter proceeds in three parts: The first and most extensive part presents a two-period model where demand for labor has an additive stochastic term. This model is developed as far as possible for the general formulation, and then analyzed in more detail for the case of a uniformly distributed stochastic term in labor demand: For this case, it will be shown that the application of the majority voting model is valid at least under some circumstances, and that union members considering the impact of their wage choice now on the union's voter pool in the next contract will, in general, lower the contract wage preferred by a majority.

The second part of this chapter presents the corresponding two-period model for a multiplicative stochastic term in labor demand. While more attractive than an additive stochastic term¹, the multiplicative stochastic term introduces analytical difficulties which cannot be overcome by assuming a specific distribution for the stochastic term, and the only way to solve the model appears to be to assume specific structural forms for all functions in the model. This is done for one exemplary case in order to show the model's workability for econometric applications.

Throughout chapter 5 (and in chapters 6 and 7), the following reproduction of the union's decision making process is employed:

The union is at the end of the present contract period CP_0 . Its N members, all employed (by definition), decide by majority vote on the contract wage w_1 the union will impose on the industry for the upcoming contract period CP_1 . At the beginning of contract period CP_1 , but after the contract is concluded, the stochastic component of labor demand takes on the realization $\bar{\varepsilon}$, and the industry sets employment according to its demand for labor schedule amended by $\bar{\varepsilon}$, as determined by the union's choice of w_1 . If this quantity of labor demanded exceeds N , workers are hired by the industry from the outside labor market and enter the union immediately. If the union operates a seniority system

¹ The multiplicative stochastic term is more attractive than an additive random demand component, since it maintains the proportion between fixed and random demand components at all wage levels. This appears sensible empirically and also avoids potential analytical problems with corner solutions.

[chapters 5 and 6], these new workers enter at the bottom of the seniority ranking. However, new workers are taken to be hired one-by-one, so that no two workers have exactly the same seniority ranking. Alternatively, if the quantity of labor demanded for the first contract period is less than the present union membership N , an appropriate number of union members with the lowest seniority ranking are laid off [chapters 5 and 6], or a random draw determines which members will receive union employment [for the full contract period], and which will have to rely on the alternative wage \bar{w} for at least this contract period [chapter 7].

As contract period CP_1 comes to a close, the process repeats itself: A majority vote for w_2 , the wage for the second contract period CP_2 , is held; at the beginning of CP_2 , the stochastic component of demand for labor takes on a realization $\bar{\epsilon}_2$, and depending on the union's choice for w_2 , union members are laid off or new workers are hired.

The basic model structure consists of two stages: First, the maximization problem faced by a worker who considers only one contract (the then immediately upcoming contract) is solved and its solution (an optimal wage) expressed as a function of the worker's seniority ranking [chapters 5 and 6] or the union's second-period membership [chapter 7]. Every worker is assumed to derive this general function or at least to be aware of it. This one-period maximization problem is referred to in the text as the second period median voter's maximization problem, since by assumption, union members voting on the second period contract consider only that contract.

Second, the maximization problem faced by a worker who considers two contract periods (the immediately upcoming and the following contract) is solved. This maximization problem consists of two parts. The first part deals with the immediately upcoming contract period and looks very much like the one-period maximization problem referred to above. In chapters 5 to 6, the second part calculates the seniority position of the median voter resulting from the choice of w_1 in the first part of the maximization problem and inserts this seniority position for the full range of the stochastic demand component into the solution function for the one period maximization problem, thus arriving at a value for w_2 . In chapter 7, the second part of the two-period maximization problem has a similar form, with the median member's seniority position replaced by the union's second-period membership as the determinant of w_2 . Finally, the expected utility accruing to the original worker (who solves the two-period problem) from the second period median's choice for w_2 is computed. The sum of the first and the discounted second part form the complete maximization problem.

5.1 Demand for Labor with an Additive Stochastic Term

For this model, the demand for labor schedule is defined as

$$\phi_1 = \phi(w_1) + \varepsilon_1$$

where the independent, identically distributed random variable ε_1 has expected value $E\varepsilon_1 = 0$, probability density function $f(\varepsilon_1)$ and cumulative density function $F(\varepsilon_1)$.

Following Blair and Crawford's single-period model, the maximization problem for L_2 , the median voter in the second contract vote, is:²

$$\max_{w_2} U(w_2)\{1 - F(L_2 - \phi(w_2))\} + U(\bar{w})F(L_2 - \phi(w_2)) \quad (5.1)$$

The first order condition is:

$$U'(w_2)\{1 - F(L_2 - \phi(w_2))\} + \phi'(w_2)f(L_2 - \phi(w_2))(U(w_2) - U(\bar{w})) = 0 \quad (5.2)$$

or,

$$\frac{f(L_2 - \phi(w_2))}{1 - F(L_2 - \phi(w_2))} = \frac{-U'(w_2)}{\phi'(w_2)(U(w_2) - U(\bar{w}))} \quad (5.3)$$

Let w_2^* be the solution to (5.3), and define

$$G(L_2) = G((\phi(w_1) + \varepsilon_1)/2) \equiv w_2^* \quad (5.4)$$

² Blair and Crawford, "Labor Union Objectives," p. 554; the reasoning behind (5.1) has been reviewed (for [2.6]) in the literature review in chapter 2.2.

Thus, the function G yields the wage chosen by the second period median voter L_2 .

To derive the two-period maximization problem for L_1 , the median voter in the first period, it is useful to develop separate expressions for the expected utility to L_1 in the first and in the second period, and then to combine them. As discussed above [(2.6) in section 2.2], single-period expected utility, rewritten to express expected utility to L_1 in the first period of the two-period problem, is:

$$EU(w_1 | L_1) = \begin{cases} U(\bar{w}) & \text{if } w_1 < \bar{w} \\ U(w_1) \text{prob}[\phi(w_1) + \varepsilon_1 \geq L_1] + U(\bar{w}) \text{prob}[\phi(w_1) + \varepsilon_1 < L_1] & \text{if } w_1 \geq \bar{w} \end{cases} \quad (5.5)$$

This can be written as

$$EU(w_1 | L_1) = \begin{cases} U(\bar{w}) & \text{if } w_1 < \bar{w} \\ U(w_1) \int_{L_1 - \phi(w_1)}^{\infty} f(\varepsilon_1) d\varepsilon_1 + U(\bar{w}) \int_{-\infty}^{L_1 - \phi(w_1)} f(\varepsilon_1) d\varepsilon_1 & \text{if } w_1 \geq \bar{w} \end{cases} \quad (5.6)$$

For a given second-period median L_2 , second-period expected utility to first period median L_1 is:

$$EU(L_1, L_2) = \begin{cases} U(\bar{w}) & \text{if } G(L_2) < \bar{w} \\ U(G(L_2))\text{prob}[\phi(G(L_2)) + \varepsilon_2 \geq L_1] + U(\bar{w})\text{prob}[\phi(G(L_2)) + \varepsilon_2 < L_1] & \text{if } G(L_2) \geq \bar{w}, \end{cases} \quad [5.7]$$

where $G(L_2)$ is the optimal second-period wage from the perspective of second-period median L_2 .³ The first option in (5.7), $EU(L_1, L_2) = U(\bar{w})$, will never apply, since L_2 will never have chosen a contract wage $G(L_2)$ lower than the wage in the alternative labor market. This term will therefore be dropped in future references to (5.7).

By definition, L_2 is determined by L_1 's first-period wage choice and the realization $\bar{\varepsilon}_1$ of the stochastic demand component in the first period:

$$L_2 = [\phi(w_1) + \bar{\varepsilon}_1] / 2 \quad [5.8]$$

Therefore, (5.7) can be expressed as

$$EU(L_1, w_1, \bar{\varepsilon}_1) = EU(L_1, L_2) \quad [5.9]$$

To account for all possible realizations of ε_1 (and thus for all possible values of L_2 for a given first-period wage choice w_1 by L_1), the

³ $G(L)$ has been defined above as the solution to the single-period choice problem (5.1).

probability-weighted sum of $EU(L_1, w_1, \bar{\varepsilon}_1)$ over the range of ε_1 must be taken. Modifying (5.7) and allowing w_1 to vary again, second-period expected utility to first-period median L_1 is therefore

$$EU(w_1 | L_1) = \int_{-\infty}^{\infty} f(\varepsilon_1) \{ U(G((\phi(w_1) + \varepsilon_1)/2)) \text{prob}[\phi(G((\phi(w_1) + \varepsilon_1)/2)) + \varepsilon_2 \geq L_1] + U(\bar{w}) \text{prob}[\phi(G((\phi(w_1) + \varepsilon_1)/2)) + \varepsilon_2 < L_1] \} d\varepsilon_1 \quad (5.10)$$

Combining (5.6) and the present value of (5.10), the present value of the two-period expected utility stream to L_1 is:

$$PV \sum_{i=1}^2 EU(w_i | L_1) = \quad (5.11)$$

$$= \begin{cases} \text{if } w_1 < \bar{w}: \\ U(\bar{w}) + c_1 U(\bar{w}) \\ \text{if } w_1 \geq \bar{w}: \\ \int_{L_1 - \phi(w_1)}^{\infty} f(\varepsilon_1) \{ U(w_1) + c_1 U(G((\phi(w_1) + \varepsilon_1)/2)) \text{prob}[\phi(G((\phi(w_1) + \varepsilon_1)/2)) + \varepsilon_2 \geq L_1] + \\ \quad + c_1 U(\bar{w}) \text{prob}[\phi(G((\phi(w_1) + \varepsilon_1)/2)) + \varepsilon_2 < L_1] \} d\varepsilon_1 + \\ \int_{-\infty}^{L_1 - \phi(w_1)} f(\varepsilon_1) \{ U(\bar{w}) + c_1 U(G((\phi(w_1) + \varepsilon_1)/2)) \text{prob}[\phi(G((\phi(w_1) + \varepsilon_1)/2)) + \varepsilon_2 \geq L_1] + \\ \quad + c_1 U(\bar{w}) \text{prob}[\phi(G((\phi(w_1) + \varepsilon_1)/2)) + \varepsilon_2 < L_1] \} d\varepsilon_1 \end{cases}$$

Expression (5.11) points to a problem that does not exist in the single-period case: In the two-period problem, the first-period median may conceivably choose a first-period wage w_1 that is lower than the alternative wage \bar{w} , motivated by a desire to keep first-period

employment at a high level and thereby enhance his chances for a union job in the second period. But as soon as the actual value of stochastic demand in the first period is known, union members will evaluate whether it is indeed to their advantage to remain in the union job for the duration of the first contract period. Only if first-period stochastic demand turns out to be relatively small will it be in the interest especially of relatively young workers to stay in their union jobs, since only then will they predict second period expected utility levels sufficient to compensate them for the disadvantage of their first-period wage being below the alternative wage. If first-period stochastic demand is relatively large, especially young workers are likely just to walk away from their union job; and if first-period stochastic demand exceeds the union's present membership size, the industry may not be able to satisfy its demand for labor by drawing on the alternative labor market, where a higher wage than the present union wage is paid.

Consequently, the calculation of the exact two-period expected utility for $w_1 < \bar{w}$ is very complex and requires additional assumptions on union rules for voluntary withdrawal from the union and on the industry's behavior when demand for labor remains unsatisfied. To sidestep these difficulties, it has been assumed for [5.11] that the union will cease to exist in its present structure if its median member chooses a first-period wage below the wage in the alternative labor market. The following

analysis is therefore applicable only for unions which choose a nonnegative union wage differential in the two-period case.⁴

Rewriting (5.11) in the analytically most convenient form, the two-period maximization problem for L_1 , the median voter in the first period, is:

$$\begin{aligned} \max_{w_1} & U(w_1)\{1 - F(L_1 - \phi(w_1))\} + U(\bar{w})F(L_1 - \phi(w_1) + \\ & + c \int U(G((\phi(w_1) + \varepsilon_1)/2))f(\varepsilon_1)\{1 - F(L_1 - \phi(G((\phi(w_1) + \varepsilon_1)/2)))\}d\varepsilon_1 + \\ & + cU(\bar{w}) \int f(\varepsilon_1)F(L_1 - \phi(G((\phi(w_1) + \varepsilon_2)/2)))d\varepsilon_1 \end{aligned} \quad (5.12)$$

To make the following analysis more readable, the argument for function G , $\phi(w_1) + \varepsilon_1 = L_2$ is from now on denoted just by L_2 . The maximization problem in this shortened form is:

$$\begin{aligned} \max_{w_1} & U(w_1)\{1 - F(L_1 - \phi(w_1))\} + U(\bar{w})F(L_1 - \phi(w_1) + \\ & + c \int U(G(L_2))f(\varepsilon_1)\{1 - F(L_1 - \phi(G(L_2)))\}d\varepsilon_1 + \\ & + cU(\bar{w}) \int f(\varepsilon_1)F(L_1 - \phi(G(L_2)))d\varepsilon_1 \end{aligned} \quad (5.13)$$

⁴ This qualification is quite likely to be met, even though it must be satisfied by the actual economic position of the union (membership size not too large in relation to industry demand for labor at the alternative wage rate; moderate risk aversion of union members; no excessive fluctuations in stochastic demand for labor). The following analysis will not apply if only political considerations override the median union member's economic preference of a contract wage below the alternative wage.

Using Leibniz' rule for partial differentiation of an integrand, the first order condition is:

$$\begin{aligned}
 & U'(\omega_1)\{1-F(L_1 - \phi(\omega_1))\} + [U(\omega_1) - U(\bar{\omega})]f(L_1 - \phi(\omega_1))\phi'(\omega_1) + c(\phi'(\omega_1)/2) \cdot \\
 & - \left\{ \int f(\varepsilon_1)G'(L_2)\{U'(G(L_2))(1-F(L_1 - \phi(G(L_2)))) + U(G(L_2))f(L_1 - \phi(G(L_2))\phi'(G(L_2))\}d\varepsilon_1 - \right. \\
 & \left. - U(\bar{\omega}) \int f(\varepsilon_1)G'(L_2)f(L_1 - \phi(G(L_2))\phi'(G(L_2))d\varepsilon_1 \right\} = 0
 \end{aligned} \tag{5.14}$$

To show a solution by inspection for the first integral in (5.14), define:

$$H(\varepsilon) \equiv U(G(L_2))\{1-F(L_1 - \phi(G(L_2)))\} + U(\bar{\omega})F(L_1 - \phi(G(L_2))) \tag{5.15}$$

The first derivative of H is

$$\begin{aligned}
 H'(\varepsilon) = & (1/2)G'(L_2)\{U'(G(L_2))(1-F(L_1 - \phi(G(L_2)))) + \\
 & + [U(G(L_2)) - U(\bar{\omega})]f(L_1 - \phi(G(L_2))\phi'(G(L_2))\}
 \end{aligned} \tag{5.16}$$

This captures most of the integrands in (5.14), and one can rewrite the first order condition as:

$$\begin{aligned}
 & U'(\omega_1)\{1-F(L_1 - \phi(\omega_1))\} + [U(\omega_1) - U(\bar{\omega})]f(L_1 - \phi(\omega_1))\phi'(\omega_1) + \\
 & + c(\phi'(\omega_1)) \int f(\varepsilon_1)H'(\varepsilon_1)d\varepsilon_1 = 0
 \end{aligned} \tag{5.17}$$

Unfortunately, there does not appear to be a straightforward and analytically manageable solution to the integral in (5.17). In order to be able to derive meaningful results from the model, one must assume a specific functional form for at least one of the factors in the integral in (5.17). The most appealing assumption is to take ε_1 and ε_2 to have identical, but independent uniform distributions

$$f(\varepsilon) = 1/2a \text{ for } -a < \varepsilon < a, \text{ and } 0 \text{ elsewhere.} \quad (5.18)$$

The previous assumption of $E\varepsilon = 0$ is fulfilled by this specification. It is convenient to express $F(\varepsilon)$ as a specific function now, too. The cumulative probability distribution function for $f(\varepsilon) = 1/(2a)$, is

$$F(x) = \int_{-a}^x (1/2a) d\varepsilon = x/2a + 1/2. \quad (5.19)$$

The uniform distribution also fulfills the requirement (for a majority voting equilibrium at least in the second-period contract vote) of a nondecreasing hazard rate. The hazard rate $h(x)$ is

$$h(x) = \frac{1/2a}{1 - x/2a - 1/2} = 1/(a-x) \quad (5.20)$$

$$\text{and } h'(x) = (a-x)^{-2} > 0.$$

With the stochastic term being uniformly distributed between $-a$ and a , it is no longer possible to assume that the model's solution will be such that the relevant range of the probability function will be within the distribution's limits. Therefore, several cases must be analyzed separately in order to avoid points where the probability function is not continuously differentiable.⁵ For simplicity, $U(\bar{w})$ is assumed to be zero in the following analysis.

⁵ Where $(L - \phi(w))$ equals the distribution's upper or lower limit, the probability density function $f()$ of $(L - \phi(w))$ is discontinuous.

The second period median L_2 's decision problem is:

$$\max_{w_2} U(w_2)\{1 - F(L_2 - \phi(w_2))\} \quad (5.21)$$

With $f(\cdot)$ as defined in (5.18), there are three cases:

Case A1: $L_2 - \phi(w_2) \leq -a$: Then, the decision problem is:

$$\max_{w_2} U(w_2) \quad (5.22)$$

The first order condition is:

$$U'(w_2) = 0 \quad (5.23)$$

Assuming nonsatiation in $U(\cdot)$, (5.23) indicates a corner solution implicitly defined by $L_2 - \phi(w_2^*) = -a$.

Case A2: $-a < L_2 - \phi(w_2) \leq a$: Here, the decision problem is:

$$\max_{w_2} U(w_2)\{1 - F(L_2 - \phi(w_2))\} \quad (5.24)$$

The first-order condition is:

$$U'(w_2)\{1 - F(L_2 - \phi(w_2))\} + U(w_2)f(L_2 - \phi(w_2))\phi'(w_2) = 0 \quad (5.25)$$

The second order condition is:

$$U''(w_2)\{1-F(L_2-\phi(w_2))\} + 2U'(w_2)f(L_2-\phi(w_2))\phi'(w_2) + U(w_2)\phi''(w_2) < 0 \text{ at } w_2 = w_2^*. \quad (5.26)$$

Since the second order condition is fulfilled for all w_2 in the range for case A2, and since case A1 yields a corner solution, w_2^* will be such that $-a \leq L_2 - \phi(w_2^*) < a$.⁶

$$\text{Defining, as before, } G(L_2) = w_2^*, \quad (5.27)$$

we need to know the sign of $G'(L_2)$: For case A1, $L_2 - \phi(w_2^*) = -a$. Therefore,

$$dL_2 - \phi'(w_2)dw = 0. \quad (5.28)$$

$$\text{Thus, } G'(L_2) = 1 / \phi'(w_2) < 0. \quad (5.29)$$

For case A2, totally differentiating the first order condition yields:

$$\begin{aligned} [U''(w_2)\{1-F(L_2-\phi(w_2))\} + 2U'(w_2)f(L_2-\phi(w_2))\phi'(w_2) + U(w_2)\phi''(w_2)]dw = \\ U'(w_2)f(L_2 - \phi(w_2))dL \end{aligned} \quad (5.30)$$

Thus,

$$G'(L_2) = dw_2/dL_2 < 0 \quad (5.31)$$

⁶ Case A3: $L_2 - \phi(w_2) \geq a$: Here, expected utility to L_2 is zero, and w_2^* will therefore be such that $L_2 - \phi(w_2) < a$.

This means that in general, the one-period wage choice of the median voter will be the higher the smaller the size of the union's voter pool.

Using $L_2 = (\phi(w_1) + \varepsilon_1)/2$ to denote the second period median, the two-period decision problem for first period median L_1 is:

$$\max_{w_1} U(w_1)\{1 - F(L_1 - \phi(w_1))\} + c \int U(G(L_2)f(\varepsilon_1)\{1 - F(L_1 - \phi(G(L_2)))\}d\varepsilon_1 \quad (5.32)$$

It is easiest to analyze the two principal parts of (5.32) separately, for the time being. Therefore, define

$$S(w_1) = U(w_1)\{1 - F(L_1 - \phi(w_1))\} \quad , \text{ and} \quad (5.33)$$

$$T(w_1) = c \int U(G(L_2)f(\varepsilon_1)\{1 - F(L_1 - \phi(G(L_2)))\}d\varepsilon_1 \quad . \quad (5.34)$$

$S()$ expresses expected utility to L_1 in the first period; $T()$ captures discounted second period expected utility to first period median L_1 ; and the decision problem is therefore

$$\max_{w_1} S(w_1) + T(w_1) \quad , \quad (5.35)$$

and the complete first order condition is

$$S'(w_1) + T'(w_1) = 0 \quad (5.36)$$

$S(w_1)$ is equivalent to the maximand in the single-period problem (5.21), with L_2 replaced by L_1 . Therefore, $S'(w_1)$ is defined by:

$$\text{Case B1: } L_1 - \phi(w_1) \leq -a : S'(w_1) = U'(w_1) \quad (5.37)$$

$$\text{Case B2: } -a < L_1 - \phi(w_1) \leq a : S'(w_1) = U'(w_1) \{1 - F(L_1 - \phi(w_1))\} + U(w_1) f(L_1 - \phi(w_1)) \phi'(w_1) \quad (5.38)$$

$$\text{Case B3: } L_1 - \phi(w_1) > a : S'(w_1) = 0 \quad (5.39)$$

The derivation of $T'(w_1)$ is more complicated. To ensure a continuously differentiable integrand in $T(w)$, define two auxiliary functions:

$$\alpha = \alpha(w_1) \text{ is defined implicitly by } L_1 - \phi(G\{\{\phi(w_1) + \alpha(w_1)\}/2\}) = a \quad (5.40)$$

$$\beta = \beta(w_1) \text{ is defined implicitly by } L_1 - \phi(G\{\{\phi(w_1) + \beta(w_1)\}/2\}) = -a \quad (5.41)$$

Using these auxiliary functions, [5.34] can be rewritten as

$$T(w_1) = \int_{\max\{\alpha(w_1), -a\}}^{\max\{\min\{\beta(w_1), a\}, -a\}} U(G(L_2)f(\varepsilon_1)\{1 - F(L_1 - \phi(G(L_2)))\})d\varepsilon_1 + \int_{\min\{\max\{\beta(w_1), -a\}, a\}}^a U(G(L_2)f(\varepsilon_1)d\varepsilon_1 \quad (5.42)$$

To evaluate $T'(w_1)$, five cases must be considered⁷:

Case C1: $\alpha(w_1) < -a$, $\beta(w_1) < -a$: Then,

$$T(w_1) = \int_{-a}^a U(G(L_2)f(\varepsilon_1)d\varepsilon_1 \quad (5.43)$$

Case C2: $\alpha(w_1) < -a$, $\beta(w_1) < a$: Then,

$$T(w_1) = \int_{-a}^{\beta(w_1)} U(G(L_2)f(\varepsilon_1)\{1 - F(L_1 - \phi(G(L_2)))\})d\varepsilon_1 + \int_{\beta(w_1)}^a U(G(L_2)f(\varepsilon_1)d\varepsilon_1 \quad (5.44)$$

⁷ A sixth case, where $\alpha(w_1) \geq -a$, $\beta(w_1) < a$, and therefore

$$T(w_1) = \int_{\alpha(w_1)}^{\beta(w_1)} U(G(L_2)f(\varepsilon_1)\{1 - F(L_1 - \phi(G(L_2)))\})d\varepsilon_1 + \int_{\beta(w_1)}^a U(G(L_2)f(\varepsilon_1)d\varepsilon_1 ,$$

can be shown not to exist: We know from Cases A1, A2 and A3 that

$L - a \leq \phi(G(L)) \leq L + a$. For $\alpha(w_1) \geq -a$, $\beta(w_1) < a$, we would need:

$\phi(G((\phi(w_1 - a)/2)) + a \leq L_1 < \phi(G((\phi(w_1 + a)/2)) - a$. Combining this information yields:

$\phi(w_1)/2 - a/2 \leq \phi(G((\phi(w_1 - a)/2)) + a \leq \phi(w_1)/2 + 3a/2 \leq L_1 < \phi(w_1)/2 - 3a/2 \leq \phi(G((\phi(w_1 + a)/2)) - a \leq \phi(w_1)/2 + a/2$. Since $a > 0$, this is not possible.

Case C3: $\alpha(w_1) < -a$, $\beta(w_1) \geq a$: Then,

$$T(w_1) = c \int_{-a}^a U(G(L_2)) f(\epsilon_1) (1 - F(L_1 - \phi(G(L_2)))) d\epsilon_1 \quad (5.45)$$

Case C4: $\alpha(w_1) \geq -a$, $\beta(w_1) \geq a$: Then,

$$T(w_1) = c \int_{\alpha(w_1)}^a U(G(L_2)) f(\epsilon_1) (1 - F(L_1 - \phi(G(L_2)))) d\epsilon_1 \quad (5.46)$$

Case C5: $\alpha(w_1) \geq a$, $\beta(w_1) \geq a$: Then,

$$T(w_1) = 0 \quad (5.47)$$

To derive $T'(w_1)$, we again exploit the fact that $\partial T / \partial w$ is similar to $\partial T / \partial L$ to solve the integral in $T'()$ by inspection. Using L_2^+ to denote $(\phi(w_1) + a)/2$ and L_2^- to denote $(\phi(w_1) - a)/2$, the solutions for the five cases are:

Case C1:

$$T'(w_1) = (c/a) \int_{-a}^a U'(G(L_2)) G'(L_2) \phi'(w_1) d\epsilon_1 = (c/2a) \phi'(w_1) [U(G(L_2^+)) - U(G(L_2^-))] \quad (5.48)$$

Case C2:

$$\begin{aligned}
 & \beta(w_1) \\
 T' &= (c/a) \int_{-a}^a [U'(G(L_2))G'(L_2)\phi'(w_1)\{1-F(L_1-\phi(G(L_2)))\} + U(G(L_2))\phi'(G(L_2))G'(L_2)\phi'(w_1)] d\epsilon_1 \\
 & + \beta'(w_1)U(G(L\beta))f(\beta)\{1-F(L_1-\phi(G(L\beta)))\} + \\
 & + (c/a) \int_{-a}^a U'(G(L_2))G'(L_2)\phi'(w_1) d\epsilon_1 - \beta'(w_1)U(G(L\beta))f(\beta) - \\
 & \beta(w_1) \\
 & = (c/2a)\phi'(w_1)[U(G(L_2^+)) - U(G(L_2^-))\{1-F(L_1-\phi(G(L_2^-)))\}] \quad (5.49)
 \end{aligned}$$

Case C3:

$$\begin{aligned}
 & a \\
 T' &= (c/a) \int_{-a}^a [U'(G(L_2))G'(L_2)\phi'(w_1)\{1-F(L_1-\phi(G(L_2)))\} + U(G(L_2))\phi'(G(L_2))G'(L_2)\phi'(w_1)] d\epsilon_1 \\
 & - a \\
 & = (c/2a)\phi'(w_1)[U(G(L_2^+))\{1-F(L_1-\phi(G(L_2^+)))\} - U(G(L_2^-))\{1-F(L_1-\phi(G(L_2^-)))\}] \quad (5.50)
 \end{aligned}$$

Case C4:

$$\begin{aligned}
 & a \\
 T' &= (c/a) \int_{-a}^a [U'(G(L_2))G'(L_2)\phi'(w_1)\{1-F(L_1-\phi(G(L_2)))\} + U(G(L_2))\phi'(G(L_2))G'(L_2)\phi'(w_1)] d\epsilon_1 \\
 & \propto(w_1) \\
 & = (c/2a)\phi'(w_1)[U(G(L_2^+))\{1-F(L_1-\phi(G(L_2^+)))\}] \quad (5.51)
 \end{aligned}$$

Case C5: $T'(w_1) = 0$. (5.52)

$T'(w_1)$ is the product of $c\phi'(w_1)/2a$ and of the difference between expected utility to L_1 resulting from L_2^+ 's second period wage choice and

expected utility to L_1 from L_2^- 's second period wage choice. Beginning with case C1, one can interpret $T'()$ as follows:

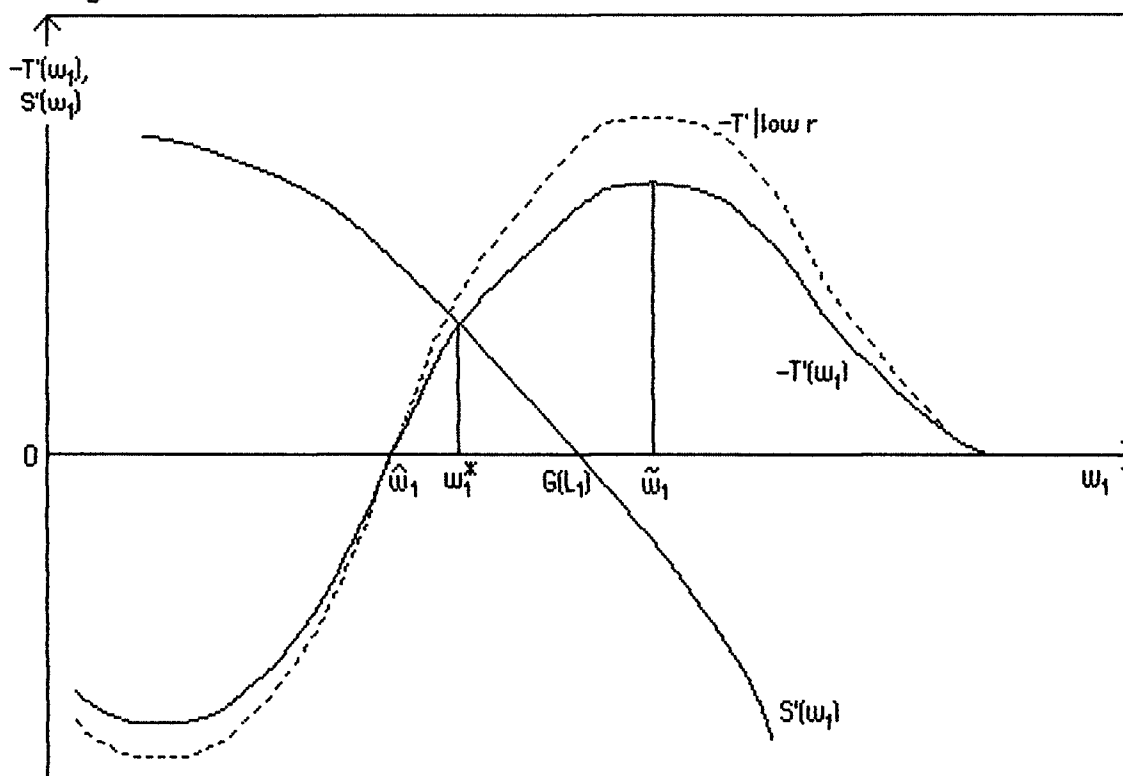
For very low values of w_1 , both L_2^+ and L_2^- will be larger than L_1 , and will therefore both choose wages $G(L_2^+)$ and $G(L_2^-)$, respectively) that are below the wage L_1 would have chosen for the second period.⁸ Since $G(L_2^+) < G(L_2^-)$ and both $G(L_2^+)$ and $G(L_2^-) < G(L_1)$, the difference between expected utility to L_1 from $G(L_2^+)$ and from $G(L_2^-)$ is negative, and $T'(w_1)$ therefore positive, since $\phi''(w)$ is assumed to be negative.

As w_1 rises, L_2^+ and L_2^- decline, and L_2^- will first equal L_1 . If $L_2^- = L_1$, L_2^+ will still be larger than L_1 , and $T'(w_1)$ will thus still be positive. With w_1 rising further, L_2^- declines to below L_1 and L_2^+ will eventually equal L_1 . At that w_1 , $T'(w_1)$ will clearly be negative.

As w_1 rises more, even L_2^+ will be too high to allow for L_1 's second period union employment even if the stochastic demand component materializes as $+a$, and for this high range of w_1 , $T'(w_1)$ is therefore zero (Case C5).

⁸ Since $G(L)$ expresses the single-period wage-choice of median worker L , L_1 's single period wage choice (and thus his second period preferred wage can be expressed as $G(L_1)$). Since $G'(L)$ has been shown above to be negative, $G(L_2^+)$ will be smaller than $G(L_1)$ as long as L_2^+ is higher than L_1 . The same is true for $G(L_2^-)$.

Figure 14: FOC of Uniform Additive Stochastic Term Model



The complete first-order condition is $S'(w_1) - T'(w_1)$ [(5.36)]. Figure 14 illustrates the problem⁹. For low wages, $-T'(w_1)$ is negative; for high wages it is positive, and where $S'(w_1)$ crosses $-T'(w_1)$, the first order condition holds, defining L_1 's optimal wage choice w_1^* . Define \hat{w} as that wage in wage range C2 to C4 where $T'(w_1) = 0$, and define \tilde{w} as that wage

⁹ A proof for the exact curvature of $T'()$ to be as depicted in Figure 14 cannot be offered. But one can argue by tracing $G(L_2^+)$ and $G(L_2^-)$ along L_1 's single period expected utility curve that the difference in expected utility to L_1 from $G(L_2^+)$ and from $G(L_2^-)$ should not follow a path whose slope changes signs more often than in Figure 14. This is especially true if $G''(L) < 0$, which appears likely, but cannot be shown to be necessarily the case.

where $-T'(w_1)$ achieves a maximum. To ensure a unique maximum (and therefore single-peaked preferences over the contract wage), we want \hat{w} to be below $G(L_1)$, and \tilde{w} to be higher than $G(L_1)$. (If these two conditions are met, $S'(w_1)$ will be declining and $-T'(w_1)$ will be rising in the solution range.) For \hat{w} to be smaller than $G(L_1)$, one can derive the following sufficient condition:

Recall that $T'(w_1) = 0$ (in the C2 to C4 wage range) at a wage w_1 where $L_2^+ > L_1$ and $L_2^- < L_1$. Implicitly defining \underline{w} by $(\phi(\underline{w}) + a)/2 = L_1$, \hat{w} will therefore be below \underline{w} , or:

$$\hat{w} = \underline{w} - \gamma_1, \text{ where } \gamma_1 > 0. \quad (5.53)$$

$$\text{For a unique solution, we want: } \hat{w} < G(L_1) \quad , \quad (5.54)$$

$$\text{and therefore: } \underline{w} < G(L_1) + \gamma_1 \quad (5.55)$$

$$\text{or, equivalently: } \phi(\underline{w}) > \phi(G(L_1) + \gamma_1) \quad . \quad (5.56)$$

$$\text{By definition, } (\phi(\underline{w}) + a) / 2 = L_1, \text{ and therefore: } \phi(\underline{w}) = 2L_1 - a \quad . \quad (5.57)$$

Thus, the condition for a unique solution is:

$$2L_1 - a > \phi(G(L_1) + \gamma_1) \quad (5.58)$$

From the discussion of cases A1 and A2 of the single-period decision problem, we know:

$$L_1 - \phi(G(L_1)) \geq -a, \text{ or} \quad (5.59)$$

$$\phi(G(L_1)) = L_1 + a - \gamma_2, \text{ where } \gamma_2 \geq 0. \quad (5.60)$$

Thus, the right hand side of (5.58) can be rewritten as

$$\phi(G(L_1) + \gamma_1) = L_1 + a - \gamma_2 - \gamma_3, \text{ where } \gamma_3 > 0. \quad (5.61)$$

Therefore, the condition for a unique solution is:

$$L_1 > 2a - (\gamma_2 + \gamma_3), \text{ where } \gamma_2 \geq 0, \gamma_3 > 0. \quad (5.62)$$

So, for $T'(w_1)$ to cross the abscissa at a lower wage than $S'(w_1)$, the sufficient condition is that $L_1 > 2a$, and the necessary condition is that L_1 is higher than a somewhat smaller multiple of a .

It appears impossible to derive a meaningful¹⁰ condition for the second requirement for a unique solution, namely for $\tilde{w} > G(L_1)$. But since $\tilde{w} > \hat{w}$ by definition, there will be a range for w_1 where $\hat{w} < w_1 < \tilde{w}$, and if $L_1 > 2a - (\gamma_2 + \gamma_3)$, but not very much larger than $2a$, there will be a unique solution. Still, even if there is a unique solution for L_1 's problem, it is not likely that there will be a unique solution of the same type for workers

¹⁰ The only condition one can derive is that $L_1 < 2a + \gamma_4$, where $\gamma_4 > 0$.

who are much higher or much lower in the seniority queue than L_1 . This problem will be addressed now.

Suppose a unique solution w_1^* exists for median worker L_1 's decision problem. Then, it is likely that condition (5.62) is not fulfilled for at least some of the most senior workers in the union. For these workers, the stochastic range of labor demand $\{\phi(w)-a, \phi(w)+a\}$ is so large in relation to their seniority position that the anticipated risk-averse decision by the high-seniority second period median actually works in their favor. Therefore, these workers will choose a higher first period wage if they consider their two-period decision problem than if they solved the single-period problem only.¹¹ The optimal wage choice of each of these senior workers may not be unique, since $-T'()$ and $S'()$ may both be declining in their solution range. But even if there are multiple solutions for each such senior worker, all of them will be greater than or at least equal to the worker's single-period optimal wage $G()$, and will therefore also be greater than $G(L_1)$, since $G'()$ has been shown to be always negative.

Similarly, even if condition (5.62) holds and if there is a unique solution to L_1 's two-period solution problem, there will be a number of fairly young workers with substantially lower seniority than L_1 . For these young workers, there may not be a unique solution, since their $-T'()$ curves may cross their $S'()$ curves where both are positive, but declining.

¹¹ Formally, such a senior worker SW's optimal two-period problem first contract period wage $w_1^* < G(SW)$, since his $-T'()$ -curve crosses his $S'()$ curve where $S'()$ is already negative.

Also, their $-T'()$ curves may be so far to the left of their $S'()$ curves that they do not cross at all, in which case these junior workers would choose their one-period optimal wage as their optimal wage also in the two-period problem. For these young workers, it may simply not be worth it to choose a first-period wage low enough to ensure at least a small probability of employment in the second contract period. But in any case, the wage choices of these young workers, whether unique for each worker or not, will all be smaller or equal to these workers' single-period wage choices $G()$. Each young worker's $G()$ will in turn be below $G(L_1)$, since all such young workers are below L_1 in the seniority queue.

Combining the arguments in the last two paragraphs, one can distinguish two cases:

(i) Very senior workers may choose wages higher than their single-period solutions $G()$, and very junior workers may have non-unique optimal wages equal or below their single-period solutions $G()$. But since all wage choices by these junior workers are below L_1 's unique two-period solution w_1^* , L_1 is still the majority-forming union member, and we can predict that the union will impose wage w_1^* on the industry.

(ii) Alternatively, some wage choices by junior workers may exceed median worker L_1 's unique two-period solution w_1^* , and these junior workers may therefore be able to form a majority with workers more senior than L_1 . But since all such wage choices of junior workers are not higher than these workers' single-period choices $G()$, and since all such

$G\}$ are below $G(L_1)$, the union's wage choice w_1^{**} will be below $G(L_1)$, even if it exceeds L_1 's optimal wage w_1^* .¹²

The argument thus far has assumed that $L_1 > 2a - (\gamma_1 + \gamma_3)$ and that $\tilde{w} > G(L_1)$. Given these conditions, first period median worker L_1 's two-period wage choice w_1^* is unique and smaller than his single-period wage choice $G(L_1)$. As shown in the discussion of cases (i) and (ii), the union's majority wage choice w_1^{**} is not necessarily equal to w_1^* (and, if not, is not necessarily stable), but it is still below $G(L_1)$.¹³ That is, it has been shown that as long as $L_1 > 2a - (\gamma_1 + \gamma_3)$, a union whose workers consider not only the immediately upcoming contract period, but also the contract period thereafter, will choose a contract wage smaller than the wage it would have chosen had workers limited their time horizon to the immediately upcoming contract period. In essence, this result for the case of demand for labor having a stochastic component corresponds to the result of chapter 4, where union workers facing a fixed demand for

¹² If case (ii) applies, it is no longer correct to define the effective first-period deciding voter as $N/2$, both because the exact outcome of the union's vote on the contract wage will then depend on the sequence in which wage alternatives are voted on, and because it is no longer the worker with median seniority who represents any voting outcome. But as long as one considers only the present two-period model, it is still correct to have workers anticipate the second period wage choice to be determined by worker $(\phi(w_1) + \epsilon)/2$, since in the single-period problem solved in contract period two, the majority voting model has been shown to be applicable, with workers' preferred single contract period wages following their seniority ordering.

¹³ If condition (5.62) holds, but $\tilde{w} < G(L_1)$, L_1 's solution is not necessarily unique, but still below $G(L_1)$, and the argument that $w_1^{**} < G(L_1)$ will still hold.

labor schedule were shown to choose generally lower wages as they extend their time horizon beyond the immediately upcoming contract period.

The condition that $L_1 > 2a - (\gamma_1 + \gamma_3)$ is quite likely to be met by a real-world union, since it merely states that the union's present membership size must exceed a relatively small multiple of the maximum size of the stochastic demand disturbance.¹⁴ If condition $L_1 > 2a - (\gamma_1 + \gamma_3)$ is not met, the union's contract vote under a two-period time horizon will yield a likely unstable wage choice that is higher than if workers had considered only the immediately upcoming contract period. It should be stressed that this prediction is for a union facing quite massive random demand fluctuations.¹⁵

To sum up: In this section, the behavior of a labor union facing a demand for labor schedule with an additive stochastic term has been analyzed. For the case of a uniformly distributed stochastic term, it has been shown that the union will choose a lower contract wage if it considers the consequences of its current wage choice on next period's union voter pool (and thus on the next contract wage choice), than if it had

¹⁴ As shown above, $\gamma_1 + \gamma_3 > 0$. The union's present membership size need therefore never exceed twice the total range of the stochastic term ($L_1 = N/2$; range of ϵ is $[-a, a]$), and the condition may still hold even if N is substantially smaller.

¹⁵ Further, it must be stressed that the analysis above has only not been able to rule out a two-period problem contract wage outcome higher than the single-period union wage choice if $L_1 < 2a - (\gamma_1 + \gamma_3)$. It may still be the case that such a high-wage outcome does not exist.

considered only the immediately upcoming contract period. This result is contingent on the maximum stochastic disturbance being of moderate size in relation to the union's current membership size.

The question of the stability of the union's choice of contract wage has been addressed in some detail. Even with a moderate maximum stochastic disturbance (in relation to the union's present size), only a definitive range for the union's choice of contract wage can be predicted. Within this range, majority voting instability problems cannot be ruled out for the general case.

5.2 Demand for Labor with a Multiplicative Stochastic Term

In section 5.1, demand for labor has been taken to have an additive stochastic component, since a relatively detailed analysis of the two-period model is possible at least if one assumes the stochastic term to have a uniform distribution. But the preceding section has shown analytical limitations even for this case. Since a multiplicative random term appears to be more sensible empirically than an additive term (and certainly more sensible than a uniform additive term), the present section discusses the general two-period decision problem with a multiplicative random term for as far as possible, and then demonstrates in a specific functions solution that this model may explain why unions in a stochastic demand for labor environment may choose to avoid ongoing membership size decline. In addition, the specific functions solution shows that the model may be practical and useful for empirical work.

With demand for labor containing a multiplicative stochastic term ε_i with probability density function $f(\varepsilon_i)$ and expected value 1,

$$\phi_i = \phi_i(w_i)\varepsilon_i \quad ,$$

the decision problem for the second-period median voter L_2 is

$$\max_{w_2} U(w_2)\{1 - F(L_2/\phi(w_2))\} + U(\bar{w})F(L_2/\phi(w_2)) \quad [5.63]$$

The first order condition is¹⁶:

$$U'(\omega_2)\{1-F(L_2/\phi(\omega_2))\} + \phi'(\omega_2)f(L_2/\phi(\omega_2))(L_2/\phi^2(\omega_2))(U(\omega_2)-U(\bar{\omega})) = 0 \quad (5.64)$$

or,

$$\frac{f(L_2/\phi(\omega_2))}{1-F(L_2/\phi(\omega_2))} = \frac{-U'(\omega_2)\phi^2(\omega_2)}{L_2\phi'(\omega_2)(U(\omega_2)-U(\bar{\omega}))} \quad (5.65)$$

Let ω_2^* be the solution to (5.65), and define

$$G(L_2) = G(\phi(\omega_1)\varepsilon_1/2) \equiv \omega_2^* \quad (5.66)$$

Thus, the function G yields the wage chosen by the second period median voter L_2 .

The maximization problem for the median voter in the first period, who has all the information necessary to derive G , is therefore:

$$\begin{aligned} \max_{\omega_1} & U(\omega_1)\{1-F(L_1/\phi(\omega_1))\} + U(\bar{\omega})F(L_1/\phi(\omega_1)) + \\ & + c \int U(G(\phi(\omega_1)\varepsilon_1/2))f(\varepsilon_1)\{1-F(L_1/\phi(G(\phi(\omega_1)\varepsilon_1/2)))\}d\varepsilon_1 + \\ & + cU(\bar{\omega}) \int f(\varepsilon_1)F(L_1/\phi(G(\phi(\omega_1)\varepsilon_1/2)))d\varepsilon_1 \end{aligned} \quad (5.67)$$

Using L_2 to denote $\phi(\omega_1)\varepsilon_1/2$, the maximization problem reads:

¹⁶ It is assumed throughout this chapter that the model operates with all probabilities in the open interval $(0,1)$. If $f(\varepsilon)$ is assumed nonzero for all positive ε up to infinity, this assumption will be fulfilled for as long as the model does not have corner-solutions where $\phi(\omega) = 0$.

$$\begin{aligned}
\max_{w_1} & U(w_1)\{1 - F(L_1/\phi(w_1))\} + U(\bar{w})F(L_1/\phi(w_1)) + \\
& + c \int U(G(L_2))f(\varepsilon_1)\{1 - F(L_1/\phi(G(L_2)))\}d\varepsilon_1 + \\
& + cU(\bar{w}) \int f(\varepsilon_1)F(L_1/\phi(G(L_2)))d\varepsilon_1
\end{aligned} \tag{5.68}$$

Using Leibniz's rule for partial differentiation of an integrand, the first order condition is:

$$\begin{aligned}
& U'(w_1)\{1 - F(L_1/\phi(w_1))\} + \{U(w_1) - U(\bar{w})\}f(L_1/\phi(w_1))\phi^{-2}(w_1)L_1\phi'(w_1) + c(\phi'(w_1)/2) \cdot \\
& \{ \int \varepsilon_1 f(\varepsilon_1)G'(L_2)\{U'(G(L_2))(1 - F(L_1/\phi(G(L_2)))) + U(G(L_2))f(L_1/\phi(G(L_2))\phi^{-2}(G(L_2))\phi'(G(L_2))\}d\varepsilon_1 \\
& - U(\bar{w}) \int \varepsilon_1 f(\varepsilon_1)G'(L_2)f(L_1/\phi(G(L_2)))\phi^{-2}(G(L_2))\phi'(G(L_2))d\varepsilon_1 \} = 0
\end{aligned} \tag{5.69}$$

To arrive at a simplified combined integrand, define:

$$H(\varepsilon) \equiv U(G(L_2))(1 - F(L_1/\phi(G(L_2)))) + U(\bar{w})(F(L_1/\phi(G(L_2)))) \tag{5.70}$$

The first derivative of H is

$$\begin{aligned}
H'(\varepsilon) &= L_2G'(L_2) \cdot \\
& \cdot \{ (U(G(L_2)) - U(\bar{w}))f(L_1/\phi(G(L_2)))L_1\phi^{-2}(G(L_2))\phi'(G(L_2)) + U'(G(L_2))(1 - F(L_1/\phi(G(L_2)))) \}
\end{aligned} \tag{5.71}$$

This captures most of the integrands in (5.69), and the first-order condition simplifies to:

$$\begin{aligned}
& U'(w_1)\{1 - F(L_1/\phi(w_1))\} + \{U(w_1) - U(\bar{w})\}f(L_1/\phi(w_1))L_1\phi^{-2}(w_1)\phi'(w_1) + \\
& + c(\phi'(w_1)/\phi(w_1)) \int \varepsilon_1 f(\varepsilon_1)H'(\varepsilon)d\varepsilon_1 = 0
\end{aligned} \tag{5.72}$$

This equation looks manageable enough, particularly since a lot is known about the components of the integrand. However, all attempts at solving the integral in (5.72) or characterizing its sign as a function of w_1 have failed. This is likely to be due to the fact that what is assumed to be known about the nature of the probability distribution in the general problem is insufficient to determine the qualitative impact of stochastic demand on the median member's choice of contract wage. Also, the search for a plausible specific distribution $f(\varepsilon)$ (obeying the assumption of $E\varepsilon = 1$) which would permit a closer characterization of the integral in (5.72) has not been successful.

To show that the model (5.72) can yield a solution, the model is now worked out for the following specific functions, all of which (and especially the probability density function) have been selected for no other reason than mathematical manageability of the resulting equations.¹⁷

Assume the following specific functions:

Utility function (the same for all workers): $U(w) = \sqrt{w}$

Demand for labor function: $\phi(w) = 1/w$

Probability density function of the stochastic factor in labor demand ε :

$f(\varepsilon) = e^{-\varepsilon}$, i.e. ε is an exponential random variable with parameter 1.

¹⁷ All plausible coefficients in these functions have been set to unity or a simple specific value in order to shorten the presentation. The analysis of dependencies between such coefficients and the optimal contract wage did not seem useful.

With these assumptions, we have:

$U'(w) = 1/(2\sqrt{w}) > 0$ Utility is increasing in w .

$U''(w) = -w^{-3/2} / 4 < 0$ Utility is concave in w .

$\phi'(w) = -w^{-2} < 0$ Demand for labor is decreasing in w .

$\phi''(w) = 2w^{-3} > 0$ Demand for labor is convex in w .

$$E\varepsilon = \int_0^{\infty} \varepsilon e^{-\varepsilon} d\varepsilon = 1$$

$$F(x) = \int_0^x e^{-\varepsilon} d\varepsilon = 1 - e^{-x} \quad (5.73)$$

$$\text{Hazard rate } h(x) = f(x)/(1 - F(x)) = e^{-x} / e^{-x} = 1 \quad (5.74)$$

In contrast to the assumption used previously, the specific demand for labor function used here is convex in w . The parallel assumption of $f(\varepsilon) = e^{-\varepsilon}$, which implies a constant hazard rate, ensures a stable majority voting outcome despite the convex demand for labor function.

The alternative wage \bar{w} is assumed to be zero.

Using (5.65) and the above specific functions, the first order condition solved by the median in the second contract vote simplifies to:

$$w_2^* = 1/[2L_2], \text{ and} \quad (5.75)$$

$$G(L_2) = G(\phi(w_1)\varepsilon_1/2) = 1/[2L_2]$$

Using this result and (5.69), the first order condition solved by the median voter in the first contract vote is, already simplified:

$$\max_{\omega_1} \sqrt{\bar{\omega}_1} \{ e^{-L_1 \omega_1} + c \int_0^{\infty} \varepsilon^{-1/2} e^{-\varepsilon L_1 \omega_1 / \varepsilon} d\varepsilon \} \quad (5.76)$$

From tables of integrals, we know:¹⁸

$$\int_0^{\infty} \varepsilon^{-1/2} e^{-\varepsilon L_1 \omega_1 / \varepsilon} d\varepsilon = \sqrt{\pi} e^{-2\sqrt{L_1 \omega_1}} \quad (5.77)$$

Using that, the maximization problem simplifies to:

$$\max_{\omega_1} \sqrt{\bar{\omega}_1} \{ e^{-L_1 \omega_1} + c\sqrt{\pi} e^{-2\sqrt{L_1 \omega_1}} \} \quad (5.78)$$

This yields, after simplification, the first order condition:

$$\frac{e^{\sqrt{L_1 \omega_1} (2 - \sqrt{L_1 \omega_1})}}{c\sqrt{\pi}} = \frac{-(2\sqrt{L_1 \bar{\omega}_1} - 1)}{(2L_1 \omega_1 - 1)} \quad (5.79)$$

The left hand side of (5.79) is necessarily positive, and the right hand side must therefore be positive too for the equation to hold. For the right hand side to be positive, there are 2 cases:

Case (i): $2\sqrt{L_1 \bar{\omega}_1} - 1 > 0$ and $2L_1 \omega_1 - 1 < 0$,

Thus, $1/\omega_1 < 4L_1$ and $1/\omega_1 > 2L_1$,

or, $\phi(\omega_1) < 4L_1$ and $\phi(\omega_1) > 2L_1$ (5.80)

Case (ii): $2\sqrt{L_1 \bar{\omega}_1} - 1 < 0$ and $2L_1 \omega_1 - 1 > 0$: These two inequalities cannot hold at the same time.

¹⁸ Joseph Edwards, A Treatise On The Integral Calculus, 2 vols. (London: Macmillan, 1922), 2: 220-221.

Thus, the pair of inequalities in (5.80) defines the range for the choice of wage taken by the median voter for the first contract. His optimal wage w_1^* will be such that

$$2L_1 < \phi(w_1^*) < 4L_1, \quad (5.81)$$

which means that the union will not decline in size, and will not more than double its size either.

For a numeric example solution, let the discount rate be 10%. Then, $c = 1/(1+0.1)$, and the approximate numeric solution is $\phi(w_1^*) \approx 2.38 L_1$; that is a 19% employment expansion in the first contract. It is noteworthy that if workers considered only the present contract period, the median worker would choose w_1^* such that the present employment level would be maintained. (This can be seen from the first order condition (5.75) of the second period median voter, who does not incorporate the next contract in his decision regarding the present contract.) Therefore, the predicted employment expansion for the case of the specific functions assumed here is not due to the rather threatening nature of $f(\epsilon) = e^{-\epsilon}$ alone, but also to union members incorporating the consequences of this period's wage choice on their relative seniority position in the next contract vote. Evidently, the threat exerted by a membership decline due to a random downswing in labor demand is more than outweighing the discounting of future earnings.

6. Models for Alternative Union Rules for Unions Allocating Employment By Seniority

This and the following chapter contain a number of variants for the two primary models introduced in chapters 4 and 5. In the present chapter, the consequences of different union rules on voting rights and union membership of laid-off workers are discussed. The principal change for the models presented in chapter 7 is that union jobs are allocated by means of a random draw among union members, instead of being assigned by seniority, as they are in chapters 4 to 6. Table I provides an overview of the differentiating features in the model variants to follow.

Table I: Alternative Assumptions on Union Rules

Employment Alloc'n:	Membership/Voting:	Fixed Demand	Stochastic Demand
Employment Allocated by Seniority	Laid-Off Workers Lose Voting Rights Retain Membership	Chapter 4	Chapter 5
	... Retain Voting Rights Retain Membership	Section 6.1.1	Section 6.1.2
	... Lose Voting Rights Lose Membership	Section 6.2.1	Section 6.2.2
Employment Allocated by Random Draw	Laid-Off Workers Lose Voting Rights Retain Membership	Section 7.1.1	Section 7.1.2
	... Retain Voting Rights Retain Membership		
	... Lose Voting Rights Lose Membership	Section 7.2.1	Section 7.2.2

None of the model variants in this and the next chapter is analyzed for its own interest; rather, these variants have been included to allow for an assessment of the consequences of differences in union membership-, voting rights- and job allocation rules. This assessment will be carried out in chapter 8, where a likely path for evolving union rules will be derived. Also, one may interpret the model variants in chapters 6 and 7 and the two principal models in chapters 4 and 5 as extreme cases which sketch a range for the behavior of real world unions.

6.1 Laid-off Workers Retain Union Voting Rights and Union Membership

Here, we have a combination of union rules which seems, at least intuitively, rather unlikely: On the one hand, union members are differentiated by a seniority system governing the distribution of available employment among members, and on the other hand all union members are, in a sense, partially protected from demand fluctuations by the rule that however long they may have been union-unemployed, they still remain union members with full voting rights. On first sight, this situation looks almost too good to be true. But on closer inspection, it turns out to be rather unfavorable for young (low seniority) union members; so unfavorable in fact that it is doubtful whether such a combination of union rules can be maintained effectively over a prolonged period of time in the real world.

6.1.1: Fixed Demand For Labor

With demand for labor a fixed function of the wage rate, a seniority system governing which union members obtain union employment and which ones are laid off, and with laid-off members continuing to be able (and willing) to exercise their union voting rights, the union's majority wage will be constant over time at $w = W(N/2)$, where $W()$ is the inverse demand for labor function. This result is obvious from the fact that the union's senior members will attempt to gather a majority for as high a wage as possible by proposing a wage which will just keep the union's senior half employed and cause the layoff of all workers in the union's junior half. With no stochastic term in labor demand, there is no uncertainty about employment for any worker in this 50 percent majority, and with all junior workers assumed to continue to exercise their union voting rights throughout the foreseeable future, the younger members of the union's senior half need not be concerned about older workers in the union's senior half being able to form a future majority which would cause the eventual layoff of these intermediate workers.

Accounting for the effects of retirement does not change this result qualitatively: In the first-period contract, the majority wage will still be $w = W(N/2)$. Then, R workers retire during the contract period and are replaced by laid-off workers from the union's junior half. For the vote on the second contract wage, the union therefore has $N - R$ members, $N/2$ of whom are employed, and $(N/2) - R$ workers are unemployed. Thus, the second period majority wage will be $W[(N - R)/2]$; the process repeats itself with $w_i = W[(N - (i-1)R)/2]$ the majority wage in the i^{th} contract period.

The union will continue along this pattern at least for a number of contract periods, and finally it will be of such a small size that non-union workers will have to be hired and admitted into the union to replace retiring workers. Eventually, the union would be rejuvenated in this way, with a very small total membership, half of which would be employed for a long period of time, and the other (junior) half would just, by assumption, dutifully serve to prolong its laid-off status by continuing to exercise its union voting rights.

For a relatively short period of time this scheme may be operational, especially for a union with a relatively high median age and therefore a relatively large proportion of retirees in each contract period. But in general, it is very unlikely that the union's junior workers would continue to participate in such a scheme in the real world.

6.1.2: Demand for Labor with a Multiplicative Stochastic Term

The maximization problem solved by L_1 , the median voter in the first contract vote, is

$$\begin{aligned} \max_{w_1} \quad & U(w_1)\{1 - F(L_1/\phi(w_1))\} + c \int_0^{N/\phi(w_1)} U(G(N/2))f(\epsilon_1)\{1 - F(L_1/\phi(G(N/2)))\}d\epsilon_1 + \\ & + c \int_{N/\phi(w_1)}^{\infty} U(G(\phi(w_1)\epsilon_1/2))f(\epsilon_1)\{1 - F(L_1/\phi(G(\phi(w_1)\epsilon_1/2)))\}d\epsilon_1 \end{aligned} \quad (6.1)$$

where G is the solution function to the single-period problem, as defined in (5.66) in section 5.2. Here, the choice of w_1 and the first-period

realization of the stochastic demand component do not affect the second contract vote for as long as actual labor demanded in the first contract is not greater than the union's original membership N (integral from 0 to $N/\phi(w_1)$). But if the union increases its size during the first contract (due to the industry's hiring of outside workers to satisfy labor demand that cannot be met from union ranks), the second-period optimal wage choice will differ from the wage that would have been chosen by a majority of the union's original membership (integral from $N/\phi(w_1)$ to ∞).¹

6.2 Laid-Off Union Members Lose Voting Rights and Union Membership

6.2.1: Fixed Demand for Labor Schedule

With demand for labor a fixed function of the wage rate, the predictions regarding the optimal contract wage of chapter 4, where laid-off workers lose only their voting rights, but not their union membership, are applicable here as well. This is because of chapter 4's result that the union's employed membership will decline in all contract periods by at least twice the number of retiring workers R per contract period.² The only difference between chapter 4 and this subsection arises, possibly, in the earnings outcome for the most senior of the laid-off workers in any one contract: In chapter 4, these workers may be called to work for part of the contract period at the beginning of which they were laid-off in order to replace retiring workers. By contrast, such replacement

¹ Model variant [6.1] will be used in the comparative chapter 8.2.1.

² ... provided the union is still larger than four times the number of retirees per contract period.

workers for retirees are drawn from the non-union labor market in the present subsection. But this difference in earnings is only applicable for workers who are the juniors of the median voter in any one contract, and it will therefore not affect the median worker's wage choice.

6.2.2: Demand for Labor with a Multiplicative Stochastic Term

The two-period maximization problem solved by the first period median voter is

$$\begin{aligned} \max_{w_1} & U(w_1)\{1 - F(L_1/\phi(w_1))\} + \\ & + c \int_{L_1/\phi(w_1)}^{\infty} U(G(\phi(w_1)\epsilon_1/2))f(\epsilon_1)\{1 - F(L_1/\phi(G(\phi(w_1)\epsilon_1/2)))\}d\epsilon_1, \end{aligned} \quad (6.2)$$

where G is the solution function to the second-period maximization problem, as defined in [5.66] in section 5.2. [6.2] is the same as the maximization problem faced by union members who lose only their voting rights [i.e. [5.67]], except for the fact that the integral in the second major term in [6.2] does not cover the whole range of ϵ_1 , but excludes all realizations of ϵ_1 that are not large enough to keep the first-period median actually employed in the first contract period. The reason for this exclusion is that the first-period median worker will not be able to enjoy any benefits from second-period union employment if he is laid-off in the first period and immediately loses his union membership forever.³

³ Model variant [6.2] will be used in chapter 8.2.1.

7. Model Variants with Employment and Layoffs by Random Draw

This chapter goes one step further than the preceding one in providing model variants not only for alternative union rules regarding the membership and voting rights status of laid-off union workers, but by replacing the assumption of employment allocation by seniority, which governed the analysis in chapters 4 to 6, by the rule that in each contract, employment is allocated among present union members by random draw.¹

If the union does not require ongoing employment for union membership, workers who are laid-off in the current contract period have the same chance at employment in the next contract period as workers who are presently employed. Since we assume that all workers have identical utility functions and since there is no relevant seniority system to differentiate between workers, it does not matter whether laid-off workers retain or lose their right to vote in union elections: All workers' preference orderings over contract wages are the same, since the present employment status of a specific worker does not affect his employment chance in the next period. Thus, even if laid-off workers are not allowed to vote on the next contract wage, their employed colleagues will all agree on the same contract wage as if laid-off workers were allowed to vote. Consequently, there is no distinction between a loss of voting rights upon layoff- and a retention of voting rights-case in this chapter.

¹ Like chapter 6, this chapter is understood to serve only to derive comparative results for chapters 4 and 5.

There is a minor exception to this argument, which has to do with retiring union members: Even with identical utility functions of all workers, the length of a worker's remaining working life will play a role in the worker's preference formation regarding the current contract wage. If workers consider a relatively long time horizon and are already relatively old, this role may be quite important. Still, there is not much of a problem since with random layoffs, the age distribution among laid-off members has the same expected characteristics as the age distribution of employed workers: Regardless of their age, workers stand an equal chance of being laid off, and the age distribution among the union as a whole should therefore reproduce itself in the age distributions of laid-off and of employed workers. Even if this reproduction process is not perfect, it is still quite likely that the majority wage choice among employed union members will be the same as the majority wage choice among all members of the union, since it is rather unlikely that, by chance, the group of employed workers turns out to be dominated by a majority of relatively old workers who would then in fact be likely to arrive at a substantially different wage than if all union members were allowed to vote.

7.1 Laid-Off Workers Retain Union Membership

As discussed above, this section applies for unions whose members lose their voting rights when they are laid off, as well as for unions who allow laid-off members to continue to vote in union elections. The distinguishing characteristic to section 7.2 is that in the present section,

laid-off union members get the same chance for a union job in future contract periods as presently employed union members do, whereas in section 7.2 a union member who is laid-off loses his membership and has no better chance at a union job than any other member of the general labor force.

7.1.1 Fixed Demand for Labor Schedule

With demand for labor a fixed function of the wage rate,

$$\phi = \phi(w),$$

the maximization problem solved by all individual union members in the single-period case (using Oswald's corrected formulation) is

$$\max_w U(w) + \{U(\bar{w}) - U(w)\} \text{MAX} [0, (N - \phi(w)/N)] \quad , \quad (7.1)$$

Oswald shows that (7.1) may yield a corner solution $w = W(N)$, where $W()$ is the inverse demand for labor function.² If (7.1) yields an interior solution $w > W(N)$, the decision problem may be written in its conventional form, which is

$$\max_w U(w)\phi(w)/N + U(\bar{w})[1 - (\phi(w)/N)] \quad , \quad (7.2)$$

where $\phi(w)/N$ is the probability of employment for any individual union member given the contract wage w .

² Oswald, *Neglected Corners*, pp. 7 - 9 and 29 - 32. The reason for Oswald's correction in the standard formulation has been discussed in chapter 2.2. The following analysis relies on Oswald's rigorous proofs.

The first order condition for (7.2) is

$$\{U'(w^*)\phi(w^*) + \phi'(w^*)[U(w^*) - U(\bar{w})]\} / N = 0 \quad (7.3)$$

N can be dropped from this equation, and the optimal wage w^* is therefore independent of the union's membership size for as long as N is large enough for w^* to exceed $W(N)$.³

If N is large enough for (7.1) to yield an interior solution $w^* > W(N)$, every union member will take part in a lottery for $\phi(w^*)$ available job openings. The union's size does not decline, however, since laid-off members do not lose their union membership (by assumption). Rather, laid-off union members work in the non-union labor market at the alternative wage \bar{w} for the present contract period and will then take part in next period's union job lottery just as their union-employed colleagues will do.

If N is small enough for (7.1) to yield a corner solution at $w = W(N)$, all present union members will be union employed, the union's size is again unchanged.

For use in the n -period model, denote the wage solving the single-period decision problem by $\hat{w} = \text{MAX}[W(N), w^*]$, where w^* is the solution to (7.2).

³ If the wage solving (7.2) is below $W(N)$, the corrected model's ((7.1)) corner solution at $W(N)$ applies, since a wage below $W(N)$ would imply the hiring of at least some nonunion workers. As discussed in chapter 2.2, the union's present membership has no reason to choose such a wage.

The two-period maximization problem for a fixed demand for labor function is

$$\begin{aligned} \max_{w_1} \quad & U(w_1) + (U(\bar{w}) - U(w_1)) \text{MAX}[0, (N - \phi(w_1))/N] + \\ & + c_1 \{ U(\hat{w}_2) + (U(\bar{w}) - U(\hat{w}_2)) \text{MAX}[0, (N - \phi(\hat{w}_2))/N] \} \end{aligned} \quad (7.4)$$

The optimal first-period wage w_1 is independent of the predicted solution to the second period problem (w_1 and \hat{w}_2 are never in the same term, and \hat{w}_2 does not vary with w_1 , since the union's membership N remains, by assumption, unchanged); and the part of (7.4) where w_1 enters has the same form as the decision problem determining \hat{w}_2 [(7.1)]. Therefore, the optimal wage w^* in all contract periods is the same.⁴ It is noteworthy that if N is larger than $\phi(w^*)$, where w^* is the solution to (7.2), the uncertainty about union employment is never removed - contract after contract, all union members must face a random assignment of union jobs. On the other hand, if the original N is small enough for (7.1) to yield a corner solution at $W(N)$, all union members are guaranteed a union job in all contract periods.

⁴ The n -period decision problem is a straightforward extension of (7.4), yielding the same result.

7.1.2 Demand for Labor with a Multiplicative Stochastic Term

In this subsection, demand for labor is

$$\phi_i = \phi_i(\omega_i)\varepsilon_i \quad ,$$

where the probability density function $f(\varepsilon_i)$ has expected value 1. The main complication in formulating the decision problem arises from the need to split the integral over the probability density function in two parts in order to express the probability of employment in very favorable demand conditions properly. With the alternative wage \bar{w} assumed zero, the one-period maximization problem is

$$\max_w U(w) \left[\frac{\phi(w)}{N} \int_0^{N/\phi(w)} \varepsilon f(\varepsilon) d\varepsilon + U(w) \int_{N/\phi(w)}^{\infty} f(\varepsilon) d\varepsilon \right] \quad , \quad (7.5)$$

where the first integral captures demand conditions below or just meeting the union's present size. The second integral accounts for realizations of ε high enough to require the hiring of new workers from outside the union after all union members have received their union jobs.

Using Leibniz's rule for differentiation under the integral sign with variable limits, the first order condition is

$$\begin{aligned}
 & U'(\omega) \left\{ \left(\frac{\phi(\omega)}{N} \right) \int_0^{N/\phi(\omega)} \epsilon f(\epsilon) d\epsilon + 1 - F(N/\phi(\omega)) \right\} + \\
 & + U(\omega) \left\{ \left(\frac{\phi'(\omega)}{N} \right) \int_0^{N/\phi(\omega)} \epsilon f(\epsilon) d\epsilon - \left(\frac{\phi(\omega)}{N} \right) \left(\frac{N}{\phi(\omega)} \right) f(N/\phi(\omega)) N \phi^{-2}(\omega) \phi'(\omega) + \right. \\
 & \left. + f(N/\phi(\omega)) N \phi^{-2}(\omega) \phi'(\omega) \right\} = 0
 \end{aligned} \tag{7.6}$$

This simplifies to

$$\frac{U'(\omega)}{U(\omega)} = - \frac{\phi'(\omega) \int_0^{N/\phi(\omega)} \epsilon f(\epsilon) d\epsilon}{\phi(\omega) \left\{ \int_0^{N/\phi(\omega)} \epsilon f(\epsilon) d\epsilon + N[1 - F(N/\phi(\omega))] \right\}} \tag{7.7}$$

Since $N[1 - F(N/\phi(\omega))] > 0$, the right hand side of this equation is, for any value of ω , smaller than the right hand side of the first order condition when demand for labor is a fixed function and N is large enough for (7.1) to yield an interior solution,

$$U'(\omega)/U(\omega) = - \phi'(\omega)/\phi(\omega) \quad , \tag{7.8}$$

as derived above (equation (7.3), with $U(\bar{\omega})$ zero.) But $U'(\omega)/U(\omega)$, the left hand side of (7.8), has been shown before to be a decreasing function of ω , and the solution ω^* to (7.8) will therefore be higher than $\hat{\omega}$, the

solution to (7.3), at least for as long as the fixed-demand case does not achieve a corner solution at $w(N)$ due to relatively small union size. This is a somewhat surprising result, since one would intuitively expect that with a stochastic demand for labor component (whose expected value is such that expected demand equals demand in the fixed demand model), the optimal wage would be more "on the safe side", that is, lower, than with a fixed demand for labor schedule. This seems to say that a union member must weigh two opposing benefits - higher utility from a higher wage on the one hand, and higher employment probability from a lower wage on the other hand. If the employment probability gain from a lower wage is made more unattractive (in the eyes of a risk-averse person) due to a stochastic demand for labor component, it appears rational to choose the utility gain from a higher wage instead.

The two-period maximization problem is again the same for all workers. Each worker solves

$$\begin{aligned}
 \max_{w_1} & U(w_1) \left[\frac{\phi(w_1)}{N} \int_0^{\phi(w_1)/N} \epsilon_1 f(\epsilon_1) d\epsilon_1 + U(w_1) \int_{\phi(w_1)/N}^{\infty} f(\epsilon_1) d\epsilon_1 \right] + \\
 & + c \int_0^{\phi(w_1)/N} f(\epsilon_1) \left[\int_0^{\phi(G(N))} \epsilon_2 N^{-1} f(\epsilon_2) U(G(N)) d\epsilon_2 + \int_{\phi(G(N))}^{\infty} f(\epsilon_2) U(G(N)) d\epsilon_2 \right] d\epsilon_1 + \\
 & + c \int_{\phi(w_1)/N}^{\infty} f(\epsilon_1) \left[\int_0^{\phi(w_1)\epsilon_1 / \phi(G(\phi(w_1)\epsilon_1))} \epsilon_2 \phi^{-1}(w_1) \epsilon_1^{-1} f(\epsilon_2) U(G(\phi(w_1)\epsilon_1)) d\epsilon_2 + \right. \\
 & \left. + \int_{\phi(w_1)\epsilon_1 / \phi(G(\phi(w_1)\epsilon_1))}^{\infty} f(\epsilon_2) U(G(\phi(w_1)\epsilon_1)) d\epsilon_2 \right] d\epsilon_1
 \end{aligned} \tag{7.9}$$

where $G()$ is the solution function to the single-period problem (7.5). The first major term discounted by discount factor c covers realizations of ε_1 which do not cause the union to grow in size - workers will thus choose $w_2 = G(N)$ for the second contract period. The second major term discounted by c accounts for second-period contract votes held by the union after high-demand conditions in the first contract period have led to an increase in the union's size.⁵

7.2 Laid-Off Union Members Lose Voting Rights and Union Membership

7.2.1 Fixed Demand For Labor Schedule

The single-period problem is not affected by the rule determining laid-off workers' union membership status. Therefore, (7.1) from section 7.1 is applicable here as well, and we take, as in section 7.1, $\hat{w}_2 = \text{MAX}[W(N), w^*]$, where w^* is the solution to (7.2), as the second (single-) period optimal wage.

To show the solution to the two-period problem, we will make a separate argument for two cases:

(i) Interior Solution Case: Assume that N is large enough for w^* , the solution to the conventional problem (7.2), to be equal or higher than $W(N)$. That is, we assume that the conventional model applies for the

⁵ The first-order condition to (7.9) is not informative in this general case. (7.9) will be used in the comparative chapter 8.

single-period case, and Oswald's correction (as in (7.1)) is not required. One can show⁶ that given the assumptions on union rules applicable here, the second-period solution \hat{w}_2 will then be an interior solution at $w^* \geq w(N)$ at the optimal first-period wage choice in the two-period model. Therefore, we can take \hat{w}_2 to be independent of $\phi(w_1)$ in the solution range, and the two-period problem is, written out in full to show its coming about,

$$\begin{aligned} \max_{w_1} & \frac{U(w_1)\phi(w_1)}{N} + \frac{U(\bar{w})(N-\phi(w_1))}{N} + \\ & + \frac{c_1 U(\hat{w}_2)\phi(\hat{w}_2)}{\phi(w_1)} \cdot \frac{\phi(w_1)}{N} + \frac{c_1 U(\bar{w})(\phi(w_1)-\phi(\hat{w}_2))}{\phi(w_1)} \cdot \frac{\phi(w_1)}{N} + \frac{c_1 U(\bar{w})(N-\phi(w_1))}{N} \end{aligned} \quad (7.10)$$

and simplifies immediately to

$$\max_{w_1} \frac{U(w_1)\phi(w_1)}{N} + \frac{U(\bar{w})(N-\phi(w_1))}{N} + \frac{c_1 U(\hat{w}_2)\phi(\hat{w}_2)}{N} + \frac{c_1 U(\bar{w})(N-\phi(\hat{w}_2))}{N} \quad (7.11)$$

The third and fourth factors in this expression, which capture expected utility in the second contract period, do not involve w_1 , and the solution to (7.10) is therefore the same as in the one-period model.

⁶ ... by an argument similar to that given in the following footnote ...

This result is due to the fact that membership size has no effect on any union member's wage choice, for as long as the conventional model (7.2) applies: The intuitive argument that the threat of membership loss after lay-off will cause workers to prefer a more conservative first-contract wage than in section 7.1 in order to increase their chances at ongoing union employment is not correct, since any first-contract wage lower than the optimal single-period wage would merely shift the lay-off risk to the next period.

(III) Corner Solution case: With N small enough for the single-period model (7.1) to yield a corner solution at $W(N)$, one can show that the optimal first-period wage in the two-period model will be $w_1 = W(N)$ as well.⁷ Given $w_1 = W(N)$, the second-period optimal wage will be $W(N)$ again.

The present subsection is for unions whose members lose their union membership immediately upon layoff. We know therefore that as soon as the union's size is adjusted once according to (7.1), future contract wages will always be the same as the wage in the first contract

⁷ To show this, assume for simplicity that $U(\bar{w}) = 0$, and compare the following options, all for interior solution $w^* < W(N)$:

1: $w_1 > W(N)$: Expected first-period utility is $U(w_1)\phi(w_1)/N$, which is inferior to $U(W(N))$, since $w^* < W(N)$. Second-period expected utility is $c_1\phi(w_1)U(\hat{w}_2=w_1)/N$, which is again inferior to $c_1U(W(N))$.

2: $w_1 < W(N)$, $w_1 < w^*$: First period expected utility is $U(w_1)$, which is inferior to $U(W(N))$, since $w_1 < W(N)$. Second period expected utility is $c_1U(w^*)\phi(w^*)/\phi(w_1)$, and thus inferior to $c_1U(W(N))$, since $w^* < W(N)$.

3: $w_1 < W(N)$, $w_1 > w^*$: First period expected utility at $U(w_1)$ is inferior to $U(W(N))$, since $w_1 < W(N)$. Second period expected utility is $c_1U(\hat{w}_2=w_1)$, which is inferior to $U(W(N))$, since $w_1 < W(N)$.

governed by (7.10), and all remaining (assuming the initial N was too large) workers will find union employment with certainty in all future contracts. Uncertainty is thus removed completely after the first contract, and expected utility to each worker, while constant in the second to n^{th} contract, will be higher (or in the corner-solution case, at least not lower) in these contracts than in the first contract.

An interesting point about this result is that the union cannot make use of the fact that a number of workers retires throughout each contract to achieve a gradual increase in the contract wage, as it was shown in chapter 4 to be able to do if it allocates employment by seniority.⁸

⁸ Chapter 8.2 deals with this point in more detail.

7.2.2 Demand for Labor with a Multiplicative Stochastic Term

For completeness, but without further analysis, the two period decision problem faced by each individual union member if laid-off workers lose their union membership completely and layoffs are by random draw is

$$\begin{aligned}
 & \max_{w_1} \int_0^{\infty} \phi(w_1) N^{-1} \epsilon_1 f(\epsilon_1) [U(w_1) + c \{ \int_0^{\infty} \phi(G(\phi(w_1)\epsilon_1)) \phi^{-1}(w_1)\epsilon_1^{-1} \epsilon_2 f(\epsilon_2) U(G(\phi(w_1)\epsilon_1)) d\epsilon_2 + \\
 & \quad + \int_0^{\infty} f(\epsilon_2) U(G(\phi(w_1)\epsilon_1)) d\epsilon_2 \}] d\epsilon_1 + \\
 & \quad \phi(w_1)\epsilon_1 / \phi(G(\phi(w_1)\epsilon_1)) \\
 & + \int_0^{\infty} \phi(w_1) N^{-1} \epsilon_1 f(\epsilon_1) [U(w_1) + c \{ \int_0^{\infty} \phi(G(\phi(w_1)\epsilon_1)) \phi^{-1}(w_1)\epsilon_1^{-1} \epsilon_2 f(\epsilon_2) U(G(\phi(w_1)\epsilon_1)) d\epsilon_2 + \\
 & \quad + \int_0^{\infty} f(\epsilon_2) U(G(\phi(w_1)\epsilon_1)) d\epsilon_2 \}] d\epsilon_1 + \\
 & \quad \phi(w_1)\epsilon_1 / \phi(G(\phi(w_1)\epsilon_1))
 \end{aligned} \tag{7.12}$$

where $G(\phi(w_1)\epsilon_1) = w_2^*$ is the solution function to the single-period problem, shown here with the union membership size during the first contract period as its argument. (N is no longer the constant argument for G for relatively low realizations of ϵ_1 , as it was in section 7.1, since the union's membership in the present subsection adjusts to the actual quantity of labor demanded in each contract period immediately.)

8. Results on Optimal Union Rules

The results from chapters 4 to 7 will now be used to sketch how union rules regarding voting rights and membership status of laid-off workers on the one hand, and employment allocation rules (seniority system or random draw) on the other hand, may evolve over time. If demand for labor is a fixed function of the wage rate, these predictions can be made in a fairly specific way even for the general case. With uncertainty about demand for labor, the comparisons are, however, usually too complex to allow for definitive predictions in the general case.

For this chapter, the following assumptions are made:

(i) At its inception and for a period of time thereafter, the union operates with the (intuitively) least complex and egalitarian set of union rules: Employment is allocated by random draw among union members; and laid-off union members retain both their union membership and their voting rights until retirement.

(ii) When union members derive their contract wage preferences (under a single or multi-period time horizon), they always assume that the set of union rules applicable today will remain in force forever.

(iii) As time passes, union members become aware that a change of union rules may be desirable for a majority of members holding union voting rights. If that is the case, a majority vote on a single proposed rule change is held during the contract period. If a majority votes for the

proposed rule change, the new rule is applicable for the upcoming contract wage vote and thereafter. That is, when the vote on a union rule change is held, each eligible voter knows the present number of employed workers and his own employment status.

These assumptions are rather restrictive, implying a step-by-step, unanticipated union rule adjustment process. The following predictions must be seen in this light, but should be of interest nevertheless, since it is likely that for union members and a more general modelling effort alike, the decision problem becomes untractable in its most general form, and is therefore solved in stages.

8.1 Optimal Union Rules under a Fixed Demand for Labor Schedule Regime

8.1.1 Rules on Voting Rights and Membership Status of Laid-Off Workers

A: Employment is Assigned By Random Draw

Originally, the union is assumed to allocate employment in each contract by a random draw held at the beginning of each contract period. As discussed in section 7.1, union size will remain constant at N if the solution w^* to the conventional decision problem (7.2) is below $W(N)$ [Corner solution case]. Here, all union members will receive $U(W(N))$ in all future contracts with certainty, with N constant and $W(N) > w^*$.

Alternatively, if the original union membership size N was higher than $\phi(w^*)$, as defined in (7.3), there will be continuing uncertainty about receiving $U(w^*)$ in any one contract for all workers. Clearly, it will be desirable for all workers who have been assigned, by random draw,

union employment in a particular contract period, to vote for the adoption of the rule that effective immediately, laid-off workers lose their union membership status. If $\phi(w^*) < N < 2\phi(w^*)$, the group of employed members will be larger than the group of members assigned to be laid-off during this contract period. In this case, the vote to remove laid-off members from the union will receive a majority, and all $N^* = \phi(w^*)$ presently employed members will receive $U(w^*)$ with certainty in all future contracts.

If $N > 2\phi(w^*)$, the vote to remove laid-off members from the union will not succeed at present. Nevertheless, since N will decline over time because retiring union members are not replaced from outside the union, there will eventually come a contract period i when N_i will be small enough for the new rule of removal from the union of laid-off workers to receive a majority vote, and the post-vote union membership size will be N^* .

In sum, the union will, sooner or later, attain the optimal membership size $N^* = \phi(w^*)$ by eventually voting to remove laid-off members from the union, or it will stay at the optimal original size (corner solution case) N , if $W(N) > w^*$. In the former case, the union will have changed the rule that laid-off workers remain in the union to the new rule that such workers are removed from the union; in the latter case, there will not have been an incentive for such a rule change.

B: Employment Is Assigned by Seniority

If employment is awarded to workers according to their seniority position in the union, it will be in the interest of the union's senior majority to have the union's (post-contract) laid-off junior half remain in the union and exercise their voting rights in all future contracts.¹

In theory (and relying completely on the assumption that laid-off workers continue to exercise their voting rights), the union will never adopt the rule to remove union membership or voting rights from laid-off workers. In practice, however, the continually laid-off junior half of the union is likely to drift away from the union, and the employed senior half will thus then be faced with a situation equivalent to that resulting from the rule that laid-off members lose their voting rights or their union membership altogether. If that is the case, even rather senior union members may eventually decide to vote for the rule that laid-off members lose their voting rights, motivated by the fear that their own employment could, after two or three more contract periods, be endangered if the union continued to behave as if laid-off members did not, in substantial numbers, drift away from the union.

Therefore, in the absence of a formal model of the rational vote participation decision of union members, it seems reasonable to assume that a union operating a seniority system will eventually adopt, formally or informally, the rule that laid-off members lose their voting rights.

¹ This has been discussed in chapter 6.1.1.

8.1.2 Rule Governing the Allocation of Employment Among Union Members

As discussed above, a union which allocates employment by means of a random draw at the beginning of each contract period will eventually reach a point where its then membership size is the smaller of its original membership N and of $\phi(w^*)$, where w^* is the optimal wage in the conventional decision problem [7.2]. This outcome has been predicted without considering the consequences of the ongoing retirement of older union members. Allowing for retirement does not change this result significantly, since retiring workers are replaced immediately by first laid-off union members (by means of another random draw) and then by workers from the outside labor market. The only consequence of allowing for retirement is that the odds of gaining employment at a particular wage are slightly higher for all workers due to the additional chance at retiree-replacement employment for at least part of the contract period.

In chapter 4, it has been predicted that a union allocating employment by seniority will never² choose a wage below $w = W(N - 2R)$, where N is the union's present membership size. This result is, in part, due to the fact that the union's present senior half, which dominates the voting outcome, predicts that due to the retirement process, it will have shrunk to $N/2 - R$ by the end of the contract period, and must therefore at

² ... except if the present size of the voter pool is less than $4R$, as discussed in chapter 4.

worst preserve a buffer of junior workers equal to $N/2 - R$ in order to preserve its dominating senior position. The union's senior half is thus able to use the retirement process to its advantage, and can increase the majority wage choice with every contract without suffering any drawback from doing so.

Comparing the results from chapters 4 and 8.1.1.A, one can predict that at least as soon as the union has reached its optimal size N^* (for the random-layoffs case), it will be in the interest of a majority of the N^* union members to vote for the adoption of the employment-by-seniority rule from the next contract onwards, provided the union's age distribution is more or less uniform. This is so because after the rule change, the union's senior half will be able to command at least $w = W[N^* - 2IR]$ with certainty in the i^{th} contract, whereas without the rule change, the majority wage choice would have been constant at $w = W[N^*]$, earned with certainty.

This result has been derived for a union whose members lose their voting rights upon layoff. If union members retain their voting rights, the adoption of the employment by seniority-rule is even more attractive at least as soon as the union has reached the optimal size N^* under the employment by random draw-rule, since the union's senior half can in that case force the wage so high as to cause the permanent layoff of the union's complete junior half. But it has been discussed before that it is unlikely that this situation can prevail over more than a small number of contract periods, and it is therefore hazardous to predict that the union will adopt or retain the (formal or informal) rule

that laid-off workers continue to hold union voting rights, after it has decided to allocate employment by seniority instead of a random draw.

The main result of this subsection is that with demand for labor a fixed function of the wage rate, the union will converge to a situation where it is rational for a majority of its members to vote for the implementation of a seniority system governing employment and layoffs.

8.2 Optimal Union Rules under a Stochastic Demand for Labor Regime

With the demand for labor schedule containing a stochastic term, it is in general not possible to derive predictions of the sort derived above for the case of a fixed demand for labor schedule. This is directly due to analytical problems in comparing the various maximization problems, which in turn at least intuitively mirrors the fact that with a stochastic term in labor demand, the "certainty" quality of a seniority system for individual workers is diluted by the stochastic nature of demand for labor, making it harder to distinguish the advantages and disadvantages of particular sets of union rules.

8.2.1 Rules on Voting Rights and Membership Status of Laid-Off Workers in a Union with Employment Allocation by Seniority

In this subsection, we consider only unions which face a demand for labor function with a multiplicative stochastic component, and allocate employment by means of a seniority system. Comparing maximization

problems [5.67] (laid-off members lose their voting rights, but not their union membership), [6.1] (laid-off members retain their voting rights and their union membership) and [6.2] (laid-off members lose both voting rights and their union membership), the following result is straightforward:

(i) If laid-off members who continue to hold voting rights do indeed exercise these rights (that is, if one holds this assumption to be sufficiently realistic for the model to be relevant), then the majority of union members will prefer the rule that laid-off workers retain their voting rights.

(ii) A majority of union members will always prefer the rule that laid-off workers retain their union membership and lose their voting rights over the rule that they lose both membership and voting rights.

Result (ii) follows from a comparison of maximization problems [5.67] and [6.2]: In [6.2], the integral capturing expected utility to the first period median voter in the second period has $L_1/\phi(w_1)$ as its lower limit, whereas in [5.67] this integral has 0 as its lower limit. Aside from this difference, the two maximands are identical, and one can therefore conclude that expected utility in [5.67] (laid-off members retain membership) will exceed expected utility in [6.2] (laid-off members lose membership) for all values of w_1 inserted into both expressions. This is because the integrand (expressing second period expected utility) is always positive, and the lower integration limit in [5.67] thus ensures a higher expected utility outcome in [5.67] than in [6.2]. But if expected

utility in (5.67) for any wage level w exceeds expected utility in (6.2) for the same wage level, maximized expected utility in (5.67) will also exceed maximized expected utility in (6.2).

Result (i) is based on a similar comparison: In (6.1) (laid-off members retain voting rights), the integral covering second period expected utility for the first-period median worker is split into two parts: The first part, with lower limit 0 and upper limit $N/\phi(w_1)$, calculates second period expected utility to the first period median as it results from the optimal second-period choice of the first-period median worker. The second part, from lower integration limit $N/\phi(w_1)$ to ∞ , is identical to the corresponding expression in (5.67) (laid-off workers lose their voting rights). In contrast, the second-period integral in (5.67) calculates second-period expected utility to the first-period median worker as it results from the choice of the second period median voter, who is different from the first period median voter for all but one realization of ε_1 , for the whole range of ε_2 .

Since the two expressions (5.67) and (6.1) do not differ in any other respect, the result is that the present value of the expected utility stream arising to the first period median voter in (6.1) exceeds the present value of the expected utility stream from (5.67) at every wage level. Again, this implies that the maximized maximand in (6.1) exceeds the maximized maximand in (5.67).

Results (i) and (ii) are transitive: Maximized (6.1) exceeds maximized (5.67) and maximized (6.2), and maximized (5.67) exceeds maximized (6.2).

The intuitive interpretation of result (ii) is straightforward: There is no drawback to have laid-off members retain their union membership, but it is beneficial to all members to know that in case of a relatively low realization of stochastic demand for labor in period one, which may cause their layoff, they at least have a chance at union employment in period two, instead of such second-period employment opportunities being filled totally from the outside labor market.

Result (i), which corresponds with the prediction for the fixed-demand for labor schedule case, suggests that the seniority-system's enabling of senior workers to hold junior union members as a sort of voting-hostages is preserved under stochastic demand conditions. This is at least true for unions whose workers have a two-period time horizon, as modelled throughout this paper. At the same time, result (ii), among others, gives rise to the question of whether these two-period time horizon predictions are compatible with n -period time horizon predictions, especially under high-variance stochastic demand conditions.

8.2.2 Rule Governing the Allocation of Employment Among Union Members

The second comparative result for a union facing a demand for labor schedule with a multiplicative stochastic component is only suggestive, since it is derived for the single-period case only. In subsection 8.1.2, it has been shown that a union facing a fixed demand for labor schedule will eventually adopt (after a majority vote) the rule that layoffs are

assigned by reverse seniority instead of by random draw. As a contrasting result, it will now be shown (for the single-period case) that with demand for labor containing a stochastic term, it is possible that the union will never adopt a seniority system, because a majority of members may always prefer employment to be assigned by random draw:

For a union with a seniority system, the one-period maximization problem solved by the median voter is, as developed in section 5.2 [5.63],

$$\max_w U(w) \int_{N/(2\phi(w))}^{\infty} f(\epsilon) d\epsilon \quad (8.1)$$

If the union does not operate a seniority system, but allocates employment among all union members by random draw instead, the maximization problem solved by each individual member is ([7.5] from subsection 7.1.2):

$$\max_w U(w) \left[\phi(w)/N \int_0^{N\phi(w)} \epsilon f(\epsilon) d\epsilon + U(w) \int_{N\phi(w)}^{\infty} f(\epsilon) d\epsilon \right] \quad (8.2)$$

A sufficient condition for maximized expected utility in the single-period model to be larger with the random-layoffs system than with the reverse-seniority layoffs system is that expected utility at any positive wage under the former system exceeds expected utility at the same wage under the latter system. This sufficient condition can be written as

$$U(w) \left[\frac{\phi(w)}{N} \int_0^{N/\phi(w)} \epsilon f(\epsilon) d\epsilon \right] + U(w) \int_{N/\phi(w)}^{\infty} f(\epsilon) d\epsilon > U(w) \int_0^{N/\phi(w)} f(\epsilon) d\epsilon + U(w) \int_{N/(2\phi(w))}^{\infty} f(\epsilon) d\epsilon \quad (8.3)$$

This inequality simplifies to

$$\left[\frac{\phi(w)}{N} \int_0^{N/\phi(w)} \epsilon f(\epsilon) d\epsilon \right] > \int_{N/(2\phi(w))}^{N/\phi(w)} f(\epsilon) d\epsilon \quad (8.4)$$

A general analysis of this inequality does not seem possible. But for an interesting example with a specific probability distribution, consider the case of a stochastic labor demand component with the exponential probability density function $f(\epsilon) = e^{-\epsilon}$.

This is the distribution used in the specific functions example in section 5.2. The expression for the corresponding cumulative probability density function is discussed there. As an intermediate result, we need

$$\int_0^x \epsilon f(\epsilon) d\epsilon = -xe^{-x} \Big|_0^x + \int_0^x e^{-\epsilon} d\epsilon = 1 - xe^{-x} - e^{-x} \quad (8.5)$$

For (8.5), inequality (8.4) is therefore

$$(1 - Ne^{-N/\phi(w)}/\phi(w) - e^{-N/\phi(w)})\phi(w)/N > 1 - e^{-N/\phi(w)} - 1 + e^{-N/(2\phi(w))} \quad (8.6)$$

This simplifies to

$$\frac{e^{N/(2\phi(w))} - e^{-N/(2\phi(w))}}{2} > N/\phi(w) \quad [8.7]$$

or, writing x for $N/(2\phi(w))$,

$$\sinh x > x \quad [8.8]$$

[8.8] is known to be true for all x greater than zero. We know therefore that for the case of a stochastic labor demand term with an exponential probability density function with expected value 1, maximized expected utility arising to each union member under a random-layoffs rule exceeds maximized expected utility to the median voter under a reverse-seniority layoffs rule.

Thus, a random-layoffs system is preferred by a majority of union members with single-period time horizons over a reverse-seniority layoffs system, as long as the multiplicative stochastic component of labor demand has an exponential probability density function with expected value 1, regardless of the specific forms of the utility function and the fixed component of the demand for labor function.

This result arises from a sufficient condition; that is, it is more restrictive than necessary and could well hold true for other probability density functions. Intuitively, it seems that the shape of the exponential probability density function, with its high and compacted probability

densities for adverse demand for labor conditions and low, expansive densities for favorable demand conditions, has a lot to do with the superiority of the random-layoffs system over the reverse-seniority layoffs system in this case, in that it dilutes the advantage of the seniority system of "guaranteeing" employment to relatively senior workers. Consequently, one would expect that, for example, a restricted normal distribution of the stochastic demand term could yield a different result.³

Further, we have not accounted for the effects of retirement in any of the stochastic models. Including them in the present comparison would in all likelihood favor the reverse-seniority layoffs system, but not necessarily enough for a qualitatively different result.

The findings of chapter 8 have been summarized in Table II. The significant result for this paper is that under fixed demand for labor conditions, a union can be shown to converge to an institutional state as modelled in chapter 4.

³ One could therefore argue speculatively that a union facing demand conditions which vary at random within a relatively narrow range may be more likely to allocate employment by seniority than a union which faces relatively large random demand fluctuations.

9. An Alternative Model: Cyclical Preferences Case

9.1 Introduction

In section 5.1, it has been shown that for the case of an additive, uniformly distributed random term the two-period stochastic model may yield multi-peaked preferences at least for some union members under some circumstances. For the general stochastic model formulation in section 5.2, it is likely to depend on the nature of the probability distribution of the disturbance term in demand for labor whether the model determines single-peaked worker preferences over contract wages or not. The present chapter is intended to show that multi-peaked preferences do not necessarily render the analysis of union behavior as carried out in parts of this paper useless, but may be used to predict (in at least a suggestive sense) whether a labor union is prone to engage in a relatively politicized contract wage choice or not.

To motivate the discussion of multi-peaked preferences further, it will be shown first that even if the stochastic model in section 5.1 yields single-peaked preferences for all workers, the introduction of a small variation in this model is very likely to cause multi-peaked preferences: If workers are no longer assumed to have identical utility functions, but to differ systematically in their degrees of risk aversion, then multi-peaked preferences over contract wages are likely to result.

The assumption of union members differing in their degrees of risk aversion is not an uncommon one in models of union behavior. Usually, it is assumed that risk aversion increases with age, and in models with

random layoffs (instead of seniority-assigned layoffs) this assumption is employed to introduce an ordered (by age) variation into union members' preferences.

We take the model of section 5.1 and assume that union members vary in their degrees of risk aversion along with age. Also, we assume that the seniority queue has come to be, by historical circumstance, a sequence of workers with increasing age and a uniform age distribution. That is, higher seniority always means higher age, and each age class is represented by the same number of workers. Finally, the number of workers is taken to be sufficiently large that one can describe a worker's degree of risk aversion as a continuous function of seniority.

Before the formal demonstration, consider this intuitive argument: The model in section 5.1, where all workers have the same degree of risk aversion, has workers determine their wage preferences with two consequences in mind: First, each worker considers his optimal wage for the immediately upcoming contract period, given his seniority position and the threat of layoff due to stochastic labor demand. Secondly, each worker knows that the number of workers actually employed in the immediately upcoming contract period will constitute the voter pool for the following contract vote. A relatively small voter pool is likely to increase layoff chances for junior workers in the second contract period. Therefore, workers will often prefer a lower wage for the first contract, in order to preserve the size of the voter pool for the second contract vote, than if they had ignored the second contract altogether, as they do in a single-period model.

Now, introduce the assumption of risk aversion rising with age. If older workers are more risk averse than younger workers, a relatively small voter pool for the second contract vote may yield a lower contract wage than a larger voter pool. This is because a small voter pool will consist of high-risk aversion workers only (younger, less risk averse workers have been laid off first), and if risk aversion increases sufficiently with age, this relatively small number of workers will choose a larger "safety buffer" of junior workers than a voter pool where the high risk aversion of old workers is diluted by the low risk aversion of young workers.

Consequently, young workers do not necessarily have to choose a relatively low first contract wage in order to preserve the voter pool (and their employment chances) for the second contract. Instead, they may want to vote for a relatively high wage now, looking forward to higher first contract period expected utility. Then, the small voter pool in the second contract vote will ensure a second contract wage low enough to yield fairly high second contract expected utility even for relatively junior workers.

This is the basic argument. Even an incomplete formal demonstration of this case requires rather strong assumptions on the relative strength and scale of the model's components. This is because otherwise, the phenomenon becomes intractable, and also because it is not necessarily the case that risk aversion rising with age has a sufficiently strong influence to yield double-peaked preferences for a relevant number of union members.

9.2 Formal Demonstration

We take the model from section 5.1, as set out in equation (5.1) (and (5.12)), and change the definition of the utility function $U(w)$. Since we have assumed that there is a sufficiently large number of workers evenly distributed along the age (seniority) dimension, we include the median worker's seniority position L as an argument in the utility function which modifies the degree of risk aversion expressed by the utility function. Worker L 's utility function is therefore

$$U = U(w, L) \quad , \quad (9.1)$$

where the partial first and second derivative with respect to w have the same signs as before. The relative degree of risk aversion exhibited by U is assumed to be influenced by L in a decreasing, convex relationship: The higher L (that is, the younger the median union member), the lower the utility function's degree of risk aversion, and the lower L , the faster the increase in risk aversion. That is, for

$$\rho = - \frac{w \partial^2 U(w, L)}{\partial w^2} / \frac{\partial U(w, L)}{\partial w} \quad , \quad (9.2)$$

the Arrow-Pratt Measure of Relative Risk Aversion, the influence of L on $U(w, L)$ must be such that

$$(i) \quad \partial \rho / \partial L < 0 \quad [\text{Risk Aversion increases with the age of the median voter}], \text{ and} \quad (9.3)$$

$$(ii) \partial^2 p / \partial L_2 > 0 \text{ (Risk Aversion is convex in } L). \quad (9.4)$$

The first order condition for the second period median voter L_2 can be taken from section 5.1 (equation (5.2)); rewritten with the changed formulation of the utility function it is:

$$\frac{\partial U(w_2, L_2)}{\partial w_2} \{1 - F(L_2 - \phi(w_2))\} + \phi'(w_2) f(L_2 - \phi(w_2)) [U(w_2, L_2) - U(\bar{w}, L_2)] = 0 \quad (9.5)$$

Let w_2^* be the solution to this equation, and define, as in section 5.1,

$$G(L_2) \equiv w_2^*$$

To characterize G , rewrite the first order condition (9.5) for the specific probability distribution $f(\epsilon) = 1/(2a)$, which we need for the maximization problem of the first-period median to be analyzable.¹ The second-period median's first order condition is then:

$$\frac{\partial U(w_2, L_2)}{\partial w_2} (a + \phi(w_2) - L_2) = [U(\bar{w}, L_2) - U(w_2, L_2)] \phi'(w_2) \quad (9.6)$$

Totally differentiating (9.6) and rearranging yields (9.7):

¹ In the following analysis, it is assumed that all arguments for $f()$ and $F()$ are in the interval $[-a, a]$.

$$\begin{aligned}
& \frac{\partial \omega_2^*}{\partial L_2} = \frac{\phi'(\omega_2) \frac{\partial U(\bar{\omega}, L_2)}{\partial L_2} - \phi'(\omega_2) \frac{\partial U(\omega_2, L_2)}{\partial L_2} - [a + \phi(\omega_2) - L_2] \frac{\partial^2 U(\omega_2, L_2)}{\partial \omega_2 \partial L_2} + \frac{\partial U(\omega_2, L_2)}{\partial \omega_2}}{2\phi'(\omega_2) \frac{\partial U(\omega_2, L_2)}{\partial \omega_2} + [a + \phi(\omega_2) - L_2] \frac{\partial^2 U(\omega_2, L_2)}{\partial \omega_2^2} + \phi''(\omega_2)[U(\omega_2, L_2) - U(\bar{\omega}, L_2)]}
\end{aligned}$$

The denominator of this expression is unchanged from (5.30), and has been shown above to be negative. Regarding the sign of the numerator, the following argument can be made:

Conditions (i) and (ii) regarding the influence of L on $U(\omega, L)$ are not sufficient to sign the partial derivatives with respect to L in (9.7) unconditionally. But even if they did, one could still not determine a clear sign-pattern for the numerator in (9.7) without assuming additional conditions on the shape of $\phi(\omega)$. What we are interested in, however, is only whether there exist combinations of admissible $\phi(\omega)$ and $U(\omega, L)$ which cause the numerator in (9.7) to be negative for low values of L and positive for higher values of L . One can show by trial and error with different structural forms for $U(\cdot)$ and $\phi(\cdot)$ that such combinations do indeed exist, and it is thus established that there are cases where $\partial \omega^* / \partial L$ is positive for low values of L and negative for high values of L , instead of $\partial \omega^* / \partial L$ being invariably negative, as it was shown to be in section 5.1, where all workers were assumed to be equally risk averse. For this chapter, it is assumed that $\phi(\omega)$ and $U(\omega, L)$ are indeed such that

$\partial w^*/\partial L$ is positive for small values of L and negative for large values of L .

In other words, $G'(L_2)$ is assumed to be no longer invariably negative, but positive for low values of L_2 . So, if the voter pool for the second contract vote is small (and contains, therefore, a heavy concentration of highly risk averse, old workers), it may be that the smaller the voter pool, the lower the majority-preferred contract wage.

Let us turn to the maximization problem of the first period median voter now. Aside from the difference in $U(w_1, L_1)$, the problem is the same as in (5.31), and the first-order condition (5.36) is also substantially unchanged, since its derivation does not involve the added argument L_1 in $U(w_1, L_1)$.

Further, the first part of the first order condition, defined as $S'(w_1)$ in (5.37)-(5.39), does not contain $G'(L_2)$ in its first derivative. We can therefore continue to take $S''(w_1)$ as nonpositive, as shown in section 5.1.

The second part of (5.36) has been analyzed as $-T'(w_1)$ in (5.48)-(5.52). $-T'(w_1)$ has been shown in section 5.1 to be increasing in the range (\hat{w}, \tilde{w}) . With worker risk aversion rising with age, we know from above that for small values of L_2 , $G'(L_2)$ may be positive, and for relatively high values of w_1 , there may therefore exist pairs of L_2^- and L_2^+ where $G(L_2^-) < G(L_2^+)$. (This is in contrast to section 5.1, where $G' < 0$ always ensured $G(L_2^-) > G(L_2^+)$.) Consequently, $-T'(w_1)$ may now be decreasing even in part of wage range (\hat{w}, \tilde{w}) , since it is now L_2^+ who chooses a wage higher than $G(L_1)$ and L_2^- who chooses a wage lower than $G(L_1)$. So, we may have

$$\begin{aligned}
-T''(\omega_1) &> 0 \text{ for small } \omega_1 \text{ in } (\hat{\omega}, \tilde{\omega}) \\
-T''(\omega_1) &< 0 \text{ for large } \omega_1 \text{ in } (\hat{\omega}, \tilde{\omega})
\end{aligned}
\tag{9.9}$$

With $S'(\omega_1)$, the first part of the first order condition (5.36), continuing to be a decreasing function of ω_1 , and $-T'(\omega_1)$ being increasing first and then decreasing in the interval $(\hat{\omega}, \tilde{\omega})$, there may be more than one solution to (5.36).

For the model formulation to remain meaningful, a rather restrictive assumption is necessary at this point. If $G'(L) > 0$ for low values of L and $G'(L) < 0$ for high values of L , it is quite likely that it is no longer valid to calculate the median voter as the median member in terms of seniority. For a partial remedy, define \hat{L} as that L where the sign of $G'(L)$ changes; that is, $G'(\hat{L}) = 0$. Then, suppose that the given value of L_1 (half of the union's present membership) is substantially larger than \hat{L} , so that we can expect that the set of union members with high enough degrees of risk aversion for their wage preference peaks to sort against the sorting along seniority rank will be confined to the senior half of the union. This should ensure that L_1 can still be taken to be the median member according to seniority.

For L_2 , the median in the second contract, the problem is more difficult. For the double-peaked preference case to come about, we are interested in a model setup where the second period median's degree of risk aversion is high enough for $G'(L_2)$ to be negative. Thus, it is necessarily the case that around such an L_2 , preference peaks with respect to wages sort against the seniority sequence, and we can

therefore not continue to calculate L_2 as the median member in terms of seniority. At the same time, it can be expected that if the median worker in terms of seniority is risk averse enough for $G'(L_2)$ to be positive, then the true second period median voter (in terms of wage preferences) will most prefer a wage at least as high as the median worker in terms of seniority. Thus, while the model fails to capture the true outcome of the second contract vote, it represents a sort of worst-case outcome from the perspective of the first-period median voter, who can be argued to be more interested in the second period contract in a reduction of the layoff threat than in a higher wage, and is therefore likely to derive higher expected utility from the true outcome (lower second period wage) than from the predicted one. Consequently, the existence of the second peak in preferences of many first-period voters is more likely for correctly derived preferences than for the worst-case preferences modelled here.

To conclude this chapter, let us assume that union members do indeed find themselves in a situation where their personal characteristics and the characteristics of labor demand determine the wage preferences of at least some workers in the union's intermediate age (seniority) group to be double-peaked: The low-wage peak in such a worker's preferences is motivated by the gain in personal job security due to a relatively large second-period voter pool with an intermediate median degree of risk aversion. The high-wage peak in the same worker's preferences is due to the relatively low median wage choice taken by a relatively small and highly risk averse second period voter pool, which in turn affords a relatively high degree of second-period job security to the

worker under consideration. Then, the following stylised situations are possible:²

(i) Stylised extreme case: Double peaked-preferences of workers with intermediate seniority cause majority union preferences to be such that $w_1 = \$4$ is preferred by a majority over all lower wages, $w_1 = \$5$ is preferred by a majority over $w_1 = \$4$, and $w_1 = \$6$ is preferred by a majority over $w_1 = \$5$; but $w_1 = \$4$ is preferred by a majority over $w_1 = \$6$. This intransitivity problem could motivate the union leadership (under the threat a suitable recall-vote arrangement) in a union with near-monopoly power to employ the following political scheme: As contract closing time approaches, the union leadership begins a rhetorical process of raising workers' wage expectations: Beginning at wage $w_1 = \$4$, the leadership points towards high industry profits, higher wage settlements elsewhere, and so on, and gradually builds up the expectation that the union should indeed impose a contract wage of \$5, and [eventually] \$6. In doing so, the union covers that wage range where a majority prefers a still higher contract wage, and enhances its reputation as a leadership standing firm for workers' interests. At the same time, the industry will react with displeasure to these seemingly ever-rising wage proposals, which adds to the union leadership's reputation among workers. When it is finally time for the union to (more or less) impose a contract wage (after limited bargaining with the industry), a majority of workers will have made up their minds that the leadership's last public proposal of a \$6 contract wage is really inferior

² For convenience, we assume that the feasible contract wage range for the union is from $w_1 = \$1$ to $w_1 = \$10$.

to a \$4 contract, and will be relieved to see a \$4 contract being concluded, which, under real-world circumstances, may be more prudent for the leadership of even a rather powerful union than a very-high wage contract.

Especially for a union whose leadership must bargain substantially with the industry over each labor contract, this argument suggests that it may be useful for the union leadership to enter contract negotiations with a relatively high wage proposal not only from a bargaining point of view, but also for union-internal reasons. But even for a union with complete monopoly power, the majority-wage preference intransitivity problem due to double-peaked preferences provides one possible explanation of pre-contract political posturing by union leaders as it is observed for some real-world unions.

(ii) Stylised regular case: Double-peaked preferences for intermediate-seniority union members do not necessarily lead to a situation as discussed under case (i). Instead, they may just cause some union members to be, intuitively speaking, somewhat divided between a high-wage and a low-wage contract outcome. Depending on how large and influential the group of workers with double-peaked preferences is, it may nevertheless pay off for the union leadership to try to dilute this ambivalence by means of a political process as suggested for the extreme case (i).

To sum up: It has been shown that the stochastic models in chapter 5 appear more likely to yield multi-peaked preferences if one no longer

assumes workers' utility functions to be identical, but to imply a degree of risk aversion rising with a worker's age. Such preferences over contract wage choices make it plausible to argue that the union's leadership will find it beneficial to slowly build up expectations about an ever rising contract wage until the contract wage proposal has reached a level where a majority of workers prefers a much lower contract wage, which is then also more likely to be acceptable to the industry.

10. Critical Assessment of Formal Models

This and the next chapter are devoted to a critical assessment of the approach taken by this paper, and of its formal work: In chapter 10, the discussion focuses on the empirical relevance of the formal models of chapters 4 to 9 per se. In chapter 11, the focus is expanded first to an evaluation of alternative plausible union-internal determinants of the contract wage (or, hand in hand, union membership size), and then to a debate of the merits and limitations of the strictly economic analysis of union behavior.

Some of the model formulations in chapters 4 to 9 are simple; others, while not intricate in their structure, are cumbersome to evaluate; and for some, it is not apparent how one could analyze them for the general multi-period (more than two periods) case, accounting for differences in workers' remaining working lives, degrees of risk aversion, and the full effects of the retirement process. Also, most of these models are difficult to solve even if one assumes specific structural forms. While it is not necessarily the case that a complicated mathematical model has a more complex solution than a simple one, some of the models proposed in the chapters above nevertheless force the question, "What do union members do with these integrals?".

There are two opposing views: On the one hand, one may argue that it does not matter how contrived an economic model appears to be in terms of complexity or implied decision process, as long as the model yields testable predictions which do not appear to be easily falsified by

econometric analysis. While, in a sense, this is pushing the problem from an evaluation of the model's merits to an evaluation of the merits of the econometric analysis performed by friend or foe, the principal claim of this school of thought is that there is no need to worry whether the process implied by the model is actually taking place in the real world, as long as the model yields predictions which are in accordance with empirical evidence. On the other hand, one may argue that an economic model should not only stand up to empirical tests of its predictions, but should also seek to replicate the process by which real world economic agents arrive at the decisions predicted by the model. The former approach of "black-box" economic theory seems inferior to the latter approach, if for the reason alone that only the latter approach allows for the development of building blocks of economic knowledge which can be integrated in their systems formulations of real world processes, not only in their results. Thus, a critical assessment of both the process formulation and the predictions of the models in chapters 4 to 9 will be given now.

10.1 How Do Real-World Unionists Determine Their Contract Wage Preferences?

In this section, the connection between the decision process implied in the models in chapters 4 to 9 and the behavior of real-world union members will be debated. To begin with, one can argue that particularly the mathematically more cumbersome models in these chapters appear cumbersome more because of formal necessity than process complexity: The decision framework and the process these models depict are fairly

straightforward; what accounts for most of the bulky nature of the mathematical expressions is the need to deal with the full range of possible, even if not likely, situations. Even though this has not been formally shown, it appears possible to reformulate these models (for specific purposes) as "fuzzy" models where formerly continuous variables are redefined as sets with a few fuzzy values, each signifying a situation which the union member perceives as qualitatively different from another one. The fact that one can reproduce the contents of these formal models verbally is partial intuitive proof for that possibility. Yet, the verbal discussion of the formal model expresses not only what one has tried to capture in the model in the first place, but also what one has learned from the model, and also what information about the real world one has sanitized so as to make it consistent with the model's approach and its claims. Therefore, the colloquial reproduction of the model can show, at best, only that union member's may work with a nonformal version of the mathematical model proposed, but not that they necessarily do so. Moreover, it is uncertain whether a nonformal, fuzzy model version will reproduce the predictions of the formal model. Consider, for example, the fuzzy set "massive union expansion, small union expansion, status quo, small union decline, considerable decline, massive layoffs" regarding the employment consequences of the union's choice of contract wages. For many cases, the deepest qualitative distinction in a parallel more general set may be between "union expansion", and "union decline", regardless of the degree of change. In terms of comparative predictive accuracy, it may therefore matter considerably more if the union is predicted to expand by, say, 2 percent of its present membership size by

the formal model, but predicted to suffer a "small union decline" by the fuzzy model, than if the formal model predicts a decline of 25 percent and the fuzzy model suggests "massive layoffs". In some range of the variables involved a small divergence between the formal and nonformal model predictions may matter a lot, whereas even a larger divergence in other value regions of the variables in question may matter little.

Let us assume that the formal models presented in this paper have a nonformal, fuzzy counterpart which effectively reproduces the formal models' process and predictions. Also, assume that whenever union members individually use a rational decision making process, they will apply this nonformal model and no other, qualitatively different one.¹ Then, the question is whether union members do indeed have sufficient systemic and factual information about their situation, and whether they have the analytical skills necessary to solve the nonformal maximization problem. In general, both these questions seem more likely to have an affirmative answer the more established and experienced the union, the more stable and intensive the interaction between workers on the job (as brought about by the type of work typical for the industry), and the more stable the economic situation of the industry as a whole: Intuitively, all these circumstances are beneficial for workers gaining an understanding of their decision problem. Also, they should allow for the sharing of this information among groups of workers with

¹ Among other circumstances, this rules out the case of a highly politicized union where rational choice is likely to be primarily determined by political and strategic considerations.

similar (say, in terms of seniority) interests, which would result in the union's decision to be determined by a meaningful majority vote based on shared individual (or at least group) preferences.

In sum, it may not be implausible that workers in an experienced union can follow a nonformal individual preference determination process which reproduces both the process and the predictions of the formal models presented in this paper: The real-world choice problem is likely to be more straightforward than suggested by the general mathematical formulation; union members with similar interests can exchange factual information and learn from each other's assessment of the situation; and workers can rely on the union's past experience to learn about how the system they are part of works.

10.2 The Interaction Between Worker Characteristics, the Union Leadership and the Overall Environment

Given the above argument that it is not implausible for at least some real-world unions to see workers' preferences determined as suggested in this paper, and given a reasonably sound democratic process in the union, one may conclude that the majority voting model will in fact yield sensible predictions. This is the more likely if the union has near-complete monopoly power and if the overall economic and political environment are relatively stable.²

² This point will be qualified in section 11.2.

In particular, such orderly and clear-cut circumstances do not appear to be a breeding ground for strategic behavior by the union leadership. But the more the union and the overall environment deviate from these characteristics, the more cause there is for this orderly process to be disturbed by strategic behavior and union-internal political debate. Consider, for example, the fact that all of the models in this paper where demand for labor has a stochastic component apply the von Neumann-Morgenstern expected utility model, and assume that workers' information about the probability distribution of the random term in demand for labor is correct and complete. Especially for unions with a seniority system, the union's choice of contract wage can have fundamental consequences for particular workers, and in general, workers enjoying a high union wage differential will also perceive their union employment status as a very important determinant of their quality of life. That is, most workers' choice problem (especially under high-variance stochastic demand conditions) regarding the contract wage may come closer to the \$10 million vs. loss-of-limbs lottery example often cited as a circumstance where the von Neumann-Morgenstern expected utility approach becomes very debatable, than to a game of chance for pennies conducted among friends. One does not have to abandon the von Neumann-Morgenstern approach because of this argument, but one can, for example, take this argument to suggest that union members deciding over contract wage alternatives may be quite likely to change their personal degree of risk aversion based on prevailing moods regarding the condition of their economic environment: Even with immediate circumstances objectively unchanged, workers may become, for example, much more risk averse if the general mood in a

country is one of long-term economic decline, or if it is a temporarily favorite national political device to talk about the world economy getting tougher by the hour, and so on. If such a process is at work, the union's collective decision problem is likely to become more complex and its bargaining strength is likely to decline, both of which suggest that the median voter expected utility maximization models (under monopoly power) presented in this paper will no longer do justice to what goes on in the union. But even if these changes are small enough to allow for the continued usefulness of the modelling approach taken in this paper, the question arises whether the ultimate determinant of the union's behavior is not, in fact, what determines union workers' degrees of risk aversion: If one has reason to believe that each worker's degree of risk aversion (for decision problems with fundamental importance in the worker's life) is not a personal characteristic changing, at most, predictably with age, but is socially determined (and changed) instead, then our model deteriorates into a mere translator of risk aversion into majority choice of contract wage.³

³ Problems such as this are the subject of the general debate in microeconomics and welfare economics about the suitability and limitations of the assumptions of the consistency and institutional neutrality of personal preferences.

11. Alternative Approaches

11.1. Earnings and Union Membership Size as Two Primary Determinants of the Union's Choice of Contract Wage

11.1.1 Introduction

Thus far, the merits of the specific models developed in this paper have been debated (in chapter 10), but we have not considered potential determinants of the union's choice of contract wage other than earnings (or expected utility from earnings) to the median voter. Such potential determinants are legion, of course, and only a small selection can be put forward meaningfully in this paper.

Motivated by predictions derived in the main part of this paper, we will concentrate on considering some union-internal benefits to workers from union size and from maintenance of union size: In chapter 4, a union facing a fixed demand for labor schedule and allocating employment by seniority (as it has been shown in chapter 8 to be likely to do from some point in time onwards) has been predicted to choose a wage causing a decline in union employment of twice the number of retirees per contract period with each contract. If the industry's demand for labor schedule is a concave function of the wage rate, this means that the predicted wage gain in subsequent contracts will decline, both in absolute terms and relative to the union's existing wage differential. At the same time, the number of union members laid off with each contract period, while constant in absolute terms, constitutes an increasing

proportion of the union's remaining employed membership. Finally, as young workers are laid off with every contract period (and no young workers, possibly hired to replace retirees, are allowed to stay in their union job for any length of time), the union's voter pool becomes more and more homogeneous: The age range of (voting) members declines, and most union workers share a longer and longer history of common employment at the firm.

In sum, in the given setting the benefits from ongoing wage increases are declining, while the parallel reduction in employment becomes, at least intuitively, more and more significant. This raises the question whether there are benefits to union members from maintaining the union's membership size - benefits which may eventually counterbalance the declining increase in wage benefits that has been predicted above. Such potential benefits from union size have been ignored in the main part of this paper, primarily because they appear to be more individually spurious and case-dependent than straightforwardly important and measurable wage (earnings) benefits. The reason for their informal debate now is that chapter 4's prediction of an ongoing union employment decline of twice the number of retirees per contract period is moderate in the sense that employment does not decline by more (and not nearly by as much as predicted in the single-period model), but significantly large in the sense that the union will not rejuvenate itself (and will eventually vote itself out of existence), even though it is always fairly close to a wage policy that allows for rejuvenation. Thus, even a relatively small incentive to choose a yet smaller wage increase from, for example, benefits of union size, is important for the qualitative

result of whether or not the union will eventually choose a wage where retirees are replaced by young workers who are allowed to stay with the union and thus maintain a reasonably balanced union age structure.

The following survey of potential benefits from union size deals with primarily economic arguments first, and then considers size benefits that are more psychological or sociological than amenable to direct economic analysis.¹

11.1.2 Directly Economic Size Benefits

Here, the emphasis is on potential economic benefits from union size and its maintenance other than those captured in the expected utility maximization models in chapters 4 to 7².

The first argument concerns the sharing of unpleasant tasks by workers: In many work settings, producing a unit of output will require a set of tasks with varying degrees of pleasantness for most workers. The

¹ The survey is understood to be suggestive, and focusing on benefits from large union size or its maintenance, while ignoring possible benefits of small union size. Also, arguments about size benefits arising from the union's influence on larger political and economic structures are not considered. Finally, it is not unlikely that at least some size benefits will be perceived differently by different union members in a way that leads to problems with majority voting.

² This is to say that the models in chapters 4 to 7 are based on a tradeoff between wages and probability of union employment (or length of union employment in chapter 4). This implies a benefit from size; subsection 11.1.2 deals with other economic size benefits.

proportion of unpleasant tasks may show significant economies of scale and often, older workers will have informal rights to see such chores performed by their juniors. There may be rather extreme forms of such arrangements – older workers may have the informal right to have quite a lot of work done by their juniors, especially if they provide on-the-job training for junior workers in this way. If a union with a seniority system increases the contract wage to a level resulting in the layoff of more and more workers, these arrangements of convenience for senior workers come to an end. Thus, a senior worker with some foresight could be expected to calculate an implicit compensating wage differential for more unpleasant work, and to compare this wage differential with the wage gain the union could achieve by accepting a lower employment level. This could be a straightforward choice problem; but the change in the pleasantness of work may be creeping, with slowly falling employment, and senior workers may argue the other way around: Work seems to become more and more of a chore, and so one should receive an even higher wage.

The second argument for this section builds on the collective voice face of unionism, as summarized in section 2.1. Empirical results suggest that union voice is a never-ending process rather than essentially a once-and-for-all settling of all concerns in any one firm. There is always room for improvement by collective voice, it seems, and plausibly there will also almost always be an initial conflict, which sets the union voice apparatus in motion anew. Thus, workers may make the calculation that with a large union (high employment level at their firm), they are more likely to be able to enjoy the benefits of successful union voice without

being touched personally by the conflict which brought a problem to the union's attention. Consider, for example, a work process which is perceived by most workers to be hazardous, but everyone has only a vague idea what the actual hazards are, and these hazards are known to occur as random events.³ Here, it is in the interest of each worker to have many colleagues to dilute the probability of any one worker to be the first (and then, due to union voice, the last) worker to suffer the consequences of such a hazard's random realization. The same argument can be made for social or psychological hazards⁴, and finally, in a small group of workers there is less of a chance than with many workers sharing the same workplace that there is one worker who does not only perceive a problem, but is able and willing to identify and articulate it.

Many of the above types of risks are fairly small (in relation to a person's total existence), and where there are large risks, one can expect that only individuals with relatively low degrees of risk aversion will choose such jobs, so most individuals will be almost risk neutral

³ Examples for such hazards are, machines where a bolt might come loose and cause injury, an unidentified electrical hazard, an untested load-limit. By contrast, exposure to chemicals with unknown toxic effects would be a continuous hazard where it may be one particular worker who is eventually involved in the grievance that leads to improvements for everyone, but all his colleagues would already have suffered the hazard's consequences, too.

⁴ For example, which worker will it be who finally draws the smoldering conflict with a supervisor out into the open (and reductions in union employment do not always cause proportionate reductions in the number of supervisors or managers)?

towards these hazards, which decreases the disutility consequences of a reduction of workers in the firm. However, many people value the protection they perceive to be offered (and in this case, actually are offered) as members of large groups, and this may be an instance where this phenomenon is well traceable by means of economic analysis.

Thirdly, there may be one-time adjustment costs of employment declines, both financial and in terms of disutility: The firm may change work assignments or work locations for individual workers, and bumping rights may have similar, but union-motivated consequences.

Fourthly, consider an argument based on Leibenstein's modified microeconomic theory: One prediction of Leibenstein's model of the behavior of workers is that the personal effort-level of a worker who is a member of a large group of workers is both lower and harder to increase than the personal effort level in a small group⁵. Consider a firm with a rather complex (differentiated) production process, where groups of workers perform individual steps in the sequence of tasks producing the firm's final output. As production volume increases, each work group increases in size. Assume that these large groups could be more productive (in terms of value added per man-hour) if they were split into smaller groups or at least structured in some hierarchy. The firm recognizes this potential for productivity increases, and so does the union. Then, the firm may be willing to, in a sense, purchase such structuring tasks from the union, since it may be easier for the union

⁵ See Harvey Leibenstein, Beyond Economic Man (Cambridge: Harvard University Press, 1980), chapter 7.

than for management to perform this structuring task - workers may be more receptive towards structures put into place by the union than by management. Such a process may even result in (or be based upon) a union-fostered sense of pride in one's work, as compared with, for example, management-imposed incentive systems which raise productivity at a direct material cost and probably also a cost in terms of union good-will.

If this argument is empirically significant, then a large union (within the union-shop firm) would have more structuring tasks to sell to the firm; and conversely, when there are only a few workers performing each production step under the guidance of a management-level supervisor, there is little structuring left to do for the union. Consequently, the union may be able to in effect shift the firm's demand for labor schedule upwards in the low-wage/high-employment range by implicitly purchasing the higher wage the firm is then willing to pay at any employment level by means of providing productivity-raising structuring tasks to the firm. Thus, the union would have a (partial) incentive to avoid relatively large contract wage increases for as long as it is in the

low wage (or also high elasticity) range of the demand for labor schedule.⁶

Finally, a straightforward economies-of-scale argument for the production of many union services can be made to suggest another potential benefit from union size.

11.1.3 Size Benefits due to Psychological or Sociological Reasons

Consider these arguments for potential social benefits from union size: The union feels "it" is stronger. Union leaders in a large union manage higher dues revenues and may find their enhanced power and prestige appealing. The union apparatus is more anonymous and thus less prone to be mired down in problems with personal relationships. A fixed proportion of members constituting the union apparatus at any level of union size means that in a large union, there will be a larger absolute number of workers who are not part of the union apparatus than in a

⁶ This idea may be better suited for the bargaining model than for the monopoly model of union behavior. Also, in the long run it may be quite dangerous for the union as a viable collective to take on such structuring tasks: Workers may find it hard not to eventually harbor the suspicion that their union leaders have joined the ranks and (narrowly defined) interests of management. Similarly, the firm may think twice before handing over structuring tasks to the union, since the union could then hold the firm at ransom in a more subtle way than, for example, by means of a strike threat or work-to-rule campaign. At the same time, one may modify the overall argument and have the union not sell structuring tasks to the firm, but the promise of either not withholding primary structuring tasks or not engaging in literally destructive behavior.

small union, and members may therefore feel less strapped into union politics the larger the union is. A large union may be more enjoyable as a social group for members – it may allow for more compartmentalization according to common personal member interests, and it may stand a higher chance to find unique personalities among its members, who can inspire, entertain and teach their colleagues .

Also, declining union employment, especially over a long period of time, may lead to remaining members becoming more and more militant: Employed union members may feel a need to justify ongoing wage increases and the by then relatively high wage they are earning (at the expense of consumers and workers in general, and of their former colleagues) before themselves, and may try to do so by greatly magnifying problems and demands at the work place. This psychological reaction of individual workers may accumulate for social group reasons to the increasing militization of the union as a collective. Ultimately, the union may become uncontrollable from within – an active, uncheckable social mass with an opportunistic leadership which tries to stay in power by keeping emotions high.

These arguments raise the question how such benefits are translated into personal motives which influence the union voting behavior of individual members. Can arguments in their favor outweigh the realism of directly personal material calculations (regarding utility gains from contract wage increases), and can they outweigh the justifiable suspicion that those arguing them are in reality advancing the interests of employers, not of the union?

Unlike sociological benefits, directly psychological benefits from union size do not face this translation-into-votes problem. If altruism is a significant human motive⁷, then it is at least questionable whether a small contract wage gain for a union with a seniority system is really worth it to older workers to see a host of young workers laid off over time, young workers who might be the sons and daughters of their colleagues, who might have been their trainees, or their listeners when they told tall tales of the old times over a drink after work. Especially for a union with a long history of employment decline, and therefore a (predicted) relatively old, homogeneous membership, altruism among workers sharing a common work history and similar position in life may be strong enough to counteract further employment cuts significantly.

It is an empirical question whether the size benefits discussed in the two last subsections are relevant; and similarly, only empirical work can determine whether the predictions in the main part of this paper (and the process implied in their derivation) do have merit. Nevertheless, it is interesting to see that on grounds of economic theory alone, a labor union with full powers as a special interest group, that is, with the power to deny voting rights to individuals who are not employed in the

⁷ Altruism has its personal rewards, which may be a stronger motive for the practicing of altruism than the drive to follow an ideal. It is then a philosophical question whether altruism and individual utility maximization are compatible or not; and the exclusion of altruism from standard microeconomic theory (by means of the assumption of the independence of preferences) is then motivated more by analytical convenience than the nature of the economic approach.

union sector, may eventually be motivated to adopt a constant wage policy, primarily due to the consequences of the seniority system, and assisted by some benefits from maintaining union size.⁸

11.2 Economic versus Noneconomic Analysis of Union Behavior

In concentrating on one narrow microeconomic aspect and analyzing it by means of a conveniently abstract model of a labor union, this paper presupposes that many real world labor unions do in fact exhibit a core of common and systematic behavioral characteristics which are independent enough from historical and present-time circumstances to allow for a meaningful analysis. But talk of "a" labor union alone challenges questions like, "in which country, in the public or private sector, in what phase of economic development, in what overall political context?", and it is therefore by no means certain that such a common behavioral core exists for any larger group of labor unions. Moreover, the social and political relevance of labor unions for the present way of life and its coming about, whether it is in Canada, the United States, Western Europe, Poland, Japan or South Africa, makes it seem almost preposterous to argue that one can do analytical justice to any aspect of labor union behavior by concentrating on strictly economic phenomena (or better, their representation by presently accepted paradigms of Economics) alone.

⁸ This [suggestive] prediction is qualitatively different from the prediction of an equilibrium wage and membership size in the model by Booth, as discussed in section 2.2. There, the equilibrium is due to the interaction of the union and nonunion sectors - the union membership's characteristics are changed by an influx of workers with different preferences from the nonunion sector until equilibrium is reached.

Therefore, it seems meaningful to end this paper with some thoughts about the role of economic analysis in the understanding of the behavior of labor unions. To begin with, it is interesting to note that the microeconomic paradigm of the individual as a rational, self-interested utility maximizer does not usually carry a disclaimer restricting its suggested or accepted applicability to American or literate or cheerful individuals. Moreover, this paradigm has been successfully employed in studying a wide variety of national economic systems - it helps to understand problems peculiar to a planning economy as it exists in the Soviet Union, it provides the foundation for most analyses of western market economies, it is useful to understand the Yugoslav economic system of labor managed firms, and it has served as the cornerstone of many a model of economic phenomena in the early stages of a country's economic development. In many instances in a wide variety of national economic systems, the empirical usefulness of this paradigm indicates that it captures an important human trait which is not sufficiently modified by world view, cultural, social and political forces, all of whom may differ strongly between large social groups, to render the paradigm of individual utility maximization without empirical significance. There are other cases, however, which it has become almost fashionable to contrast with the predictions of the individual utility maximization model - the human group-orientation of substantial parts of the Japanese economic system is a prime example. But for the analysis of the majority of at least moderately economically developed nations, the paradigm of individual utility maximization has been taken as a useful foundation, even though one cannot ignore instances of individual economic behavior where the utility maximization model has to be modified to

such an extent that it degrades from an integral model with predictive power towards a mere set of analytical tools.⁹

For the present paper, an additional problem arises: We are not primarily interested in predicting the contract wage preferences of individual union members. Rather, modelling the contract wage choice process undertaken by individual union members serves as an intermediate result for the prediction of the union's behavior as the one party which concludes the collective labor agreement with the firm or the industry bargaining agent. Predicting the union's collective behavior is our primary concern, both because this is of the greatest practical interest in most cases, and because it characterizes the behavior of a collective of economic principals instead of only the behavior of economic principals strapped into a collective, which is, aside from the analysis of union-internal problems, hardly a complete result.

Therefore, we need to aggregate individual union member's preferences into the union's collective preferences. In this paper, this is done by majority voting, primarily because this seems closest to the aggregation process employed by many real world labor unions. The successful modelling of majority voting as a nonpolitical, nonstrategic process requires, however, fairly restrictive conditions regarding voters' preferences to hold. Because our primary interest is the prediction of the union's collective behavior and not that of its individual members,

⁹ Consider, for example, the analysis of volunteer services, the Veblen effect, or the strong evidence of a wide gap between the risk measure requirements of the standard expected utility maximization models and the processing of information on risk by many individuals.

and because venturing into political voting models is quite complex and in all likelihood diluting the chain of reason in one's results, it is tempting to gear one's model of individual unionists' preferences towards fulfillment of the restrictive conditions of the nonpolitical majority voting model.

In other words, one may tend to press empirical reality into an analytically convenient form twice - once by assuming that the voting process in labor unions is indeed determined by unionists' straightforward economic preferences, as modelled, alone; and again that individual union members form preferences of a nature that allows for straightforward, nonpolitical majority voting, instead of almost requiring a political process in order to overcome voting instability within the union. Moreover, in two-period models as developed in this paper, where unionists predict the outcome in next period's contract wage vote given their present choice of contract wage, the potential gap between real and modelled collective behavior may widen significantly: Here, one can no longer claim that potential political codeterminants of the union's choice of contract wage are, more or less, a serially independent random influence on the union's behavior. Instead, if political factors play a role, one may have to recognize that by its very nature a political process has memory and foresight and may therefore have a stronger influence on the union's collective behavior if unionists make their overall voting decisions under a multiperiod time-horizon.

It is noteworthy that most macroeconomic models, particularly of national economies, do either not attempt to clearly ground their formal

argument in the maximization behavior of individual economic principals or agents, or do so by pulling together the right assumptions to overcome economic aggregation problems. In addition, such macroeconomic models do usually not attempt to predict government behavior based on the predicted preferences of citizens as national voters. The former shortcoming is reason for further research; the latter shortcoming is more or less accepted because it would be almost preposterous to try to resolve it formally by trivializing all noneconomic concerns of citizens. In any case, such macroeconomic models are insightful and useful for many applications — for the real world, these models are not meant to be perfect, but essential for informed judgement.

Union memberships are likely to be less diverse than a nation's overall population, and it is very likely that both the number of issues and the complexity of the democratic process in many unions are lower than in national democratic life. One is therefore tempted to minimize the above-mentioned problems with the application of the straightforward utility maximization model and the majority voting model for the characterization of labor union behavior, particularly if one ignores the union's function as the collective voice for its members and centers one's analysis on the union's (possible) role as a monopolist in the labor market alone. The danger in doing so is twofold: On the one hand, one may end up with a formal model of union behavior with little or no empirical content. No great damage is done, as long as one does not convince oneself that the fact that the empirical testing of such a model brings, perhaps, a bit less shaky results than other models, is indicative

of the new model's capturing more of the real world union than these other models. On the other hand and more importantly, one may indeed be able to formulate a straightforward economic model which captures much of the actual decision making process of a real world union, particularly if it is a union with a relatively tranquil recent history operating in a more or less stable direct economic environment, acting according to well-defined and smooth internal procedures and bound by an enlightened, well-accepted overall legal framework. The potential danger here lies in the fact that such a union is, in a way, a collective which over time may appear to have lost its teeth; a social mass in a tranquil, settled state which waits to be awakened eventually by its history of successfully cornering itself into smooth, predictable, enlightened behavior atypical for a social mass. If such a union does indeed at some point in time experience an outburst of near-uncontrollable, unpredictable social energy, it is, in all likelihood, less prepared to deal with this explosive situation than a union which throughout its history has seen and dealt with a lot of internal political activities. Therefore, even if our economic model makes empirical sense for a tranquil union, it probably requires the caveat that such a union will not be unlikely to experience, eventually, a period of political instability which the economic model is unable to capture. So, in a sense, the model buys its applicability for a tranquil period in a union's history by ignoring the likelihood of a consequential period of time where it loses its empirical content.

The pragmatic way to understand the economic treatment of union behavior in the main part of this paper is this: If one is able to identify and characterize a set of straightforward economic incentives for union members at a higher level of the overall system than that of the axioms of the individual utility maximization model alone, then one can argue that whatever the other determinants of a union's behavior are, the union has to deal with these incentives as well, and may even shape some of the behavioral determinants not covered by the economic model so as to deal with the incentive structure created by the modelled economic circumstances. So, the contribution in this paper is understood to be primarily the analysis of one set of determinants of union behavior among others. Its direct usefulness for the prediction of union behavior depends then on how complex an overall process guides the union, both at any given point in time and, connected by memory and anticipation, over time.

12. Concluding Remarks

The principal contribution of this paper is the extension of available single-period models of union majority preferences over contract wages for the two-period and in some instances n -period case. Motivated by some unlikely predictions of single-period models, this extension yields predictions (in some cases) which seem to be more in tune with observed union behavior, and it allows us to sketch a likely time path for the development of union rules regarding the allocation of employment and voting rights among union members. A well-informed, democratic union facing a stable and nonstochastic demand for labor schedule, powerful enough to impose its choice of contract wage on the industry and able to exclude workers not employed in the union sector from its ranks, has been shown to change its rules in a step-by-step process from an (assumed) initial set, where layoffs are by random draw and laid-off workers retain their union membership, to a final set where layoffs are by reverse seniority and laid-off workers retain their membership, but not their union voting rights. With this final set of union rules, the union has been predicted to choose, in general, an ever-rising series of contract wages, for as long as workers consider only earnings benefits or do not enjoy counterbalancing benefits from union size. The wage increase in each contract period is such that after a possible, but not very likely initial large adjustment, union employment will decline with each contract by twice the number of workers due to retire in the coming contract period.

The results for a union facing a demand for labor schedule with a stochastic component are much more limited: For a union allocating employment by seniority, it has been shown for two cases that workers who consider the consequences of their present wage choice on the union's next period voter pool will choose, in general, a lower wage than if they had not had such foresight. In the general case, it is likely that a stable majority voting process will not always be possible when demand has a random component, and it has been shown to be questionable whether employment allocation among union members by seniority is always preferable to employment by random draw under stochastic demand for labor conditions.

If the analysis in this paper has empirical merit, and if one accepts the arguments raised in section 10.1 for the empirical validity of the decision process implied in this paper's models, one can, in closing, consider the following informal argument regarding the ethics of unionism:

Two opposing points of view in the general discussion of the merits of the labor movement as a whole are, on the one hand, the view of unions as socially undesirable collectives interfering with the market mechanism and limiting the freedom of economic agents in favor of a few and at a cost for many or society as a whole; and, on the other hand, the view of unions as interest groups representing one large part of society in favor of which it is socially desirable to redistribute income and political influence. The actual behavior of real-world unions (and the overall real-world economy) then provides arguments in favor of either one of these points of view.

One point for one's value judgement about the social desirability of unionism and about the social agreeableness of a labor union's behavior in this context may be this: A particular union may cause relatively high unemployment even among its members for a considerable period of time, a fact which will usually do harm to unionism's reputation of social agreeableness. At the same time, this does not necessarily mean that unionism transforms workers from more or less agreeable, caring human beings into brutally self-interested economic beasts¹, and it does not necessarily mean that the union as a social institution strives (and cares for, as far as a collective can approach this human emotion) solely for the betterment of relatively few at a cost to many even among the union's own members. Rather, the analysis in this paper suggests that a union may more or less consciously slide towards circumstances where the powerful incentive effects of rather simple union rules (such as a seniority system) may be strong enough to overcome even significant original union-internal feelings of altruism, at least among members of the same union. But at the same time, the union may reach a stage where the same strong union-internal incentive mechanism causes the union's ongoing demands to moderate and eventually to stabilize, and it may well be that the more informed union members are and the more democratic the decision process within the special-interest group labor union, the sooner such stabilization will occur.

¹ This proposition may appear odd, since the archetypical foe of unionism will usually favour unfettered markets, where, of course, individuals are supposed to act as self-interested economic beasts. But when social agreeableness is judged in such debates, unions are often argued to have to live up to an image of altruism among workers.

Bibliography

- Blair, Douglas H., and Crawford, David L. "Labor Union Objectives and Collective Bargaining." Quarterly Journal of Economics 99 (August 1984): 547-66.
- Booth, Alison. "A Public Choice Model of Trade Union Behaviour and Membership." Economic Journal 94 (December 1984): 883 - 98.
- Brown, James, and Ashenfelter, Orley. "Testing the Efficiency of Employment Contracts." Journal of Political Economy 94 (July 1986): S40-S87.
- Carmichael, Lorne. "Does Rising Productivity Explain Seniority Rules for Layoffs?" American Economic Review 73 (December 1983): 1127 - 1131.
- Dertouzos, J. N., and Pencavel, J. H. "Wage and Employment Determination under Trade Unionism: The International Typographical Union." Journal of Political Economy 81 (December 1981): 1162 - 81.
- Dunlop, John T. Wage Determination under Trade Unions. New York: Macmillan, 1944.
- Eberts, Randall W., and Stone, Joe A. "On the Contract Curve: A Test of Alternative Models of Collective Bargaining." Journal of Labor Economics 4 (January 1986): 66-81.
- Edwards, Joseph. A Treatise On The Integral Calculus. 2 vols. London: Macmillan, 1922.
- Farber, Henry S. "Individual Preferences and Union Wage Determination: The Case of the United Mine Workers." Journal of Political Economy 86 (October 1978): 923-42.
- _____. "The Analysis of Union Behaviour." Working Paper 1502, National Bureau of Economic Research, November 1984.

- Freeman, Richard B. "The Exit-Voice Tradeoff in the Labor Market: Unionism, Job Tenure, Quits and Separations." Quarterly Journal of Economics 94 (June 1980): 643 - 674.
- Freeman, Richard B., and Medoff, James L. "The Two Faces of Unionism." The Public Interest 57 (Fall 1979): 69-93.
- Freeman, Richard B., and Medoff, James L. What Do Unions Do? New York: Basic Books, 1984.
- Grossman, Gene M. "Union Wages, Temporary Layoffs, and Seniority." American Economic Review 73 (June 1983): 277 - 90.
- Hirsch, Barry T., and Addison, John T. The Economic Analysis of Unions. Boston: Allen and Unwin, 1986
- Hirschman, Albert O. Exit, Voice and Loyalty. Cambridge: Harvard University Press, 1971.
- Johnson, George E. "Economic Analysis of Trade Unionism." American Economic Review 65 (May 1975): 23-28.
- Kramer, Gerald H. "On a Class of Equilibrium Conditions for Majority Rule." Econometrica 41 (March 1973): 285-97.
- Leibenstein, Harvey. Beyond Economic Man. Cambridge: Harvard University Press, 1980.
- MaCurdy, Thomas, and Pencavel, John. "Testing between Competing Models of Wage and Employment Determination in Unionized Markets.," Journal of Political Economy 94 (July 1986): S3-S39.
- Martinello, Felice. "Wage and Employment Determination in a Unionized Industry: The IWA in the B.C. Wood Products Industry." Carleton Economics Papers 84-09, March 1984.
- Oswald, Andrew J. "The Microeconomic Theory of the Trade Union." Economic Journal 92 (September 1982): 576-95.

- _____. "On Union Preferences and Labour Market Models: Neglected Corners." Seminar Paper 296, Institute for International Economic Studies, University of Stockholm, October 1984.
- _____. "The Economic Theory of Trade Unions: An Introductory Survey." Scandinavian Journal of Economics 87 no. 2 (1985): 160-93.
- Oswald, Andrew J., and Carruth, Alan A. "Miners' Wages in Post-War Britain: An Application of a Model of Trade Union Behaviour." Working Paper 175, Industrial Relations Section, Princeton University, July 1984.
- Pencavel, John H. "The Tradeoff Between Wages and Employment in Trade Union Objectives." Quarterly Journal of Economics 99 (May 1984): 215-216.
- Phillips, Gerald E. Labour Relations and the Collective Bargaining Cycle. 2d ed. Toronto: Butterworths, 1981.
- Rees, Albert. The Economics of Trade Unions. 2d ed., rev. Chicago: University of Chicago Press, 1977.
- Rosen, S. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." Journal of Political Economy 82 (February 1974): 34 - 55.
- Ross, Arthur M. Trade Union Wage Policy. Berkely: University of California Press, 1948.
- Simons, Henry C. "Some Reflections on Syndicalism." Journal of Political Economy 52 (March 1944): 1 - 25.