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THE INFLUENCE OF THE UNION ON WORKING HOURS, WAGES AND EMPLOYMENT

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ABSTRACT

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The presence of a trade union has been recognized to have a notable impact on the determination of wages and employment. More recently economists have began to study the influence of unions on hours of work. The purpose of this thesis is to study theoretically and empirically union influence on bargaining outcomes, and particularly on hours of work. I explore these ideas using an establishment level survey data within the UK electrical engineering industry from 1979 to 1984, which covers a recessionary period.

Chapter 1 of this thesis provides a brief introduction and how the thesis has been organized. Chapter 2 is a survey study of unionism and hours of work. The main difference of this survey to others is that, rather than generally exploring all the union bargaining models, the focus here is on modelling a union's influence on working hours, and providing a summary of the empirical finding in the literature.

Chapter 3 studies the effect of union bargaining on working hours in different union-management bargaining frameworks. Three kinds of bargaining scenario are presented: two Right-to-Manage models and one Efficient Bargaining Model. The comparative statics show that higher union bargaining power leads to lower working hours and a higher wage rate in all the models. The employment effect is ambiguous, and depends on the bargaining framework and the value of other variables. Also a comparison of this paper with other literature has been provided. Chapter 4 is an empirical study of union's influence on hours using the survey data.

Chapter 5 studies the union and firm size effects on wage rates. The firm size effect on the wage rate is found to differ in the union and non-union sectors. In the union sector, the influence of size on wages is negligible or even negative. However in the non-union sector, wages increase with firm size for manual workers. The union wage differential is larger during the recessionary phase of our sample. By decomposing the union wage differential, various factors have been found to contribute differently to it, and unemployment is one of the most significant factors.

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Chapter One: Introduction

This thesis has been organized around a theme of trade unions, how unions affect working hours, employment and wage rate. The presence of unions has been recognized to have a notable impact on the determinations of wages, employment and hours of work. In the past there has been a large amount of work addressing the economics of trade unions, i.e. Oswald (1985), Pencavel (1985), Ulph and Ulph (1990). However few of them have special focus on hours of work, especially the rising issue of work sharing - reducing each employee's hours could increase employment by spreading the work to other people, this makes it worthwhile to contribute. The initial motivation of this work is to study the union's impact in hours setting. Among the hours literature, most are empirical finding, i.e. Freeman & Medoff (1984), Pencavel (1990), that unions have negative effects on hours. While very few of them have theoretically shown these effects in hours setting. Therefore I included the first three chapters.

Chapter Two is a survey of unionism and hours of work. The main difference of this survey to others is that, rather than generally exploring all the union bargaining models, the focus here is on the modelling of how unions influence working hours as well as the relationships among hours, employment and wage rates. Two broad bargaining models: the Right-to-Manage model and the Efficient Bargaining model and one integration of these two - the Sequential Bargaining model have been presented. Then different kinds of modelling of hours have been analysed in detail - the approach, the method and the comparison. Also the empirical evidence has shown that the union hours gap, in most cases, is negative and not negligible in size. It varies considerably by type of worker, by industry and by occupation.

Chapter Three studies the effect of union bargaining on working hours in three kinds of union - management bargaining frameworks. The three frameworks differ in terms of what variables both parties have been bargaining with. The first has been defined as the strong Right-to-Manage model in which firms and unions only bargain over wage rate. The second is the weak Right-to-Manage model in which both parties bargain over not only wage rate but also working hours. The third is the Efficient Bargaining model which all three variables - wage, hours and employment have been bargained over. Then I find that higher union bargaining power leads to lower working hours and higher wage rate. The employment effect is ambiguous. That depends on the bargaining framework and the value of the other variables. Also it has been found that external shocks, i.e. technology and price, will not affect hours of work and wage rate, it only has major effect on employment. Furthermore, comparing with other hours models in the literature shows the emphasis of this paper, and to what extent this paper is or is not consistent with other work.

Chapter Four provides the empirical evidence for chapter three. In this section firm level survey data has been used to examine the union's effect on working hours. In the literature, most of the papers have used individual data sets to test the unions' hours effect. However the individual data set has not been able to examine how the firm's characteristics affect the hours setting. This survey data is within the electrical engineering industry from 1979 to 1984 across the U.K. It is found that the union has a negative effect on working hours. In general unions reduce about 4% of total hours of work for the semi-skilled, and about 2% of work for the craftsman. Furthermore in different firm sizes the union may play a different role for different kinds of workers in terms of hours setting, for semi-skilled workers in middle sized firms, employees in union sector work about 3.8% less than their counterpart in the nonunion sector, however in large size firms the difference in hours between these two parts is 5%; whilst for the craftsman the effect of middle and large sized firms are nearly same.

The work of Chapter Four leads to a idea of analyzing the union and firm size effect in wage setting. This is what has been explored in Chapter Five. It has been found in the literature that both unions and firm size have influence on wage rates, however, if firm size is included as an explanatory variable in the wage regression, the union effect is reduced. Using the same data set as in chapter four, especially it covers a recession period within UK, the evidence shows that the size effect differs in the union and non-union sectors. In the union sector, the influence of size on wages is negligible or even negative, while in the non-union sector, wages increase with firm size for manual workers. The union wage differential is also found to be larger during the recessionary phase of our sample. Decomposing union and non-union wage differentials, I find that various factors have contributed differently; unemployment is one of the most significant factors. This wage differential is mainly caused by the "price difference", which denotes that there exist different wage rates in union and non-union sector given same firm characteristics.

Chapter Two: A Survey of Unionism and Hours of Work

1 Introduction

There are a large number of papers that study the union-firm bargaining behaviour. Moreover two survey papers by Oswald (1985) and Ulph (1990) have given a clear description of modelling trade union objectives. However few of these models consider hours of work, and particularly recently more and more economists have been concerned with the issue of working hours. They discuss whether work sharing can increase the employment by spreading the work to other people. The purpose of this paper is to explore various models of union behaviour in the literature, however rather than generally to discuss all bargaining variables and other economic effects, the focus here is on the modelling of how unions influence working hours as well as the relationship among working hours, employment and wage rate.

The paper has been organized as follows. Section 2 describes the union's objective function and the firm's profit function under different assumptions. Section 3 explores the bargaining procedure and the outcome. There are two general types of model: the Right to Manage model and the Efficient Bargain model have been analyzed; also, an integration of these two models; the Sequential Bargaining model has been provided. We will see that many models are just a special case of these models. Section 4 presents the bargaining effect on the wage, employment and working hours. In particular, much of it is devoted to summarizing various model on hours determination and the relationship among working hours, wage and employment. In section 5, I briefly evaluate the influence of union on productivity and efficiency. The concluding segment is presented in section 6.

2 Models of Union Behaviour

Union bargaining parties always concern two sides: firm and union. Despite there being quite a lot of studies about the modelling of these two sides, there is still no universally accepted model. I will start from a firm and union objective function in a general case.

2.1 Firm Profit Function

For the firm profit function, the simplest traditional model is

$$\pi = R(K, L, H) - WHL \tag{2.1.1}$$

where R is the gross revenue; K denotes the capital invested in the firm; L denotes the number of workers employed; H presents the hours of work of each employee; W, the wage rate per hour for the employee. If we consider the short run, so that the capital does not vary, we may write the model as

$$\pi = R(L, H) - WHL \tag{2.1.1'}$$

If hours of work is a exogenous variable, then the firm profit function can be written as

$$\pi = R(L) - WL \tag{2.1.1''}$$

but here W is the salary of each employee. This is what McDonald & Solow (1981) use in their well known paper: Wage Bargaining and Employment. The function (2.1.1), (2.1.1′), or (2.1.1″) are the simple way of modelling the firm profit, although they ignore some other inputs or factors of general case. For instance the fixed cost of each employee, such as training cost, fringe benefit, etc.... If we study how the fixed cost of each employee affects the employment, hours and wage, it would be necessary to add it in the firm profit function as

$$\pi = R(K, L, H) - WHL - cL \tag{2.1.2}$$

where c is the fixed cost of each employee.

In some recent studies, economists study look at how the over time hours affect the bargaining behaviour; in this case, we can build up the model as

$$\pi = R(K, L, H) - \left[W\overline{H} + W(1+b)(H - \overline{H})\right] L - cL \tag{2.1.3}$$

where $\overline{H}$ is standard hours of work, and H is total hours of work. Thus $H - \overline{H}$ is overtime hours, which have been paid with the overtime premium b. As we can see, compared with the (2.1.1), this function is getting complicated, especially when we want to get comparative statics. Therefore, normally in the literature we can find that the profit function takes the formula as in (2.1.1) or (2.1.2).

We formally assume that the firm is selling its product at the price p. The firm is a price taker, and has production function F(K,L,H).

$$R = pF(K, L, H)$$

Furthermore we would assume that F is a concave function, $F' > 0, F'' < 0$, the marginal product is positive and decreasing. Also some economists may define a firm's production function as

$$Y = f(eL, K)$$

where e is effort, it is conventionally defined in terms of efficiency of units of labor, and L is the labor input. Thus eL is efficient labor services.

Following McDonald & Solow(1981), this iso-profit curve of the firm would be as in Figure 2.1.

[Figure 2.1 insert here]

The curve is approximately an inverse-U shape. The profit of the firm is increasing in the direction shown on the Figure 2.1. The lower the wage rate, the higher the profit of the firm, given the number of the employees L. For any L, the iso-profit curve would be a positive slope until the marginal product of labor reaches the wage rate w; then it becomes negative with more employment. A line through the peak of each indifference curve gives a downward sloping line D-D which is the labor demand curve. It denotes the profit-maximizing employment levels of different wages.

2.2 Union's Objective Function

There are several ways to specify the union's preference. Oswald (1985) defines them as two approaches:

i. a general quasi-concave union utility function, usually of a specific form

ii. an expected-utility, or utilitarian, function .

Quite a few economists follow the first approach. The most natural way to characterize the union objective is with the social welfare utility. The way of defining union objective function can be either with the Benthamite Social Welfare Function

$$\Gamma(x_1,,,x_m,h_1,,,h_m,M) = \sum_{i=1}^{M} u_i\left(x_i,h_i\right) \tag{2.1.4}$$

or the Bernoulli-Nash Social Welfare Function

$$\Gamma(x_1,,,x_m,h_1,,,h_m,M) = \prod_{i=1}^{M} u_i\left(x_i,h_i\right) \tag{2.1.5}$$

where M is the union membership; x_i and h_i are the consumption and hours of work respectively. The individual utility function of each member is $u_i(x_i, h_i)$. the assumption is that $u_x > 0, u_h < 0$. Utility is increasing with consumption goods, and decreasing with hours of working.

We would also address the particularly influential form which Dertouzos & Pencavel (1981) adopt in the Stone – Geary objective function for the union:

$$\Gamma(W, M) = (W - \gamma)^{\theta}(M - \delta)^{1-\theta} \tag{2.1.6}$$

where W denotes the negotiated hourly wage rate and M, the local union membership; Because the emphasis is here placed on closed shop employment, M actually represent employment. γ can represent the alternative wage rate if they do not draw negotiation, or unemployment benefit. And δ could be the reference levels of employment. Parameter θ is the weight to show the relative importance between wage and employment. So if we let θ vary from 0 to 1, we could have different union objective functions. $\theta = 1/2$, for example,

$$\Gamma(W, M) = (W - \gamma)^{1/2}(M - \delta)^{1/2}$$

could be interpreted as the wage bill maximization; $\theta = 1$ could be the union concern about the wage only. Formulation (2.1.6) could be rationalized in terms of an approximation to the Bernoulli-Nash Social Welfare function. However as Oswald (1982) comments about this form, it has some advantages, especially it nests other objective function as the special case we have shown, and it leads to convenient reduced form equations; but the disadvantage is that it does not show explicitly worker's preference.

Following the second approach, assuming the workers choose to be employed as the random from all of the members, then each individual has the expected utility as

$$U(n, M, r, W) = \frac{N}{M}u(W) + \frac{M - N}{M}u(r) \tag{2.1.7}$$

where M is the union membership number, N is the number of members that have been employed. W and r represents the wage rate of those who have been employed and the alternative wage rate of those not employed. Therefore u(W) and u(r) denotes the utility of workers who have been employed and not employed respectively. The assumption here is that every individual worker has the identical utility function u. We would assume $u' > 0, u'' \leq 0$. The worker is either risk neutral $u'' = 0$, or risk averse $u'' < 0$. If M is an exogenous number, we could lead the utilitarian function

$$U = Nu(W) + (M - N)u(r) \tag{2.1.8}$$

which has the same properties as (2.1.7). Alternatively we could just write it as

$$U = N\left[u(W) - u(r)\right]$$

The union's objective is to maximize the gain from getting N numbers of members being employed at the wage rate W.

Some economists such as Costa(1998) specify the individual utility function as $u(WH, T - H)$ rather then $u(W)$. As we can see from Costa's utility function, the worker not only cares about the wage rate, the total earning, but also the leisure. We would assume $u_1 > 0, u_2 < 0$. Some may define per-worker utility as $u(w, e)$, where e is effort spent on the work, which is disliked by workers, so $u_e < 0$.

The advantage of the second approach, compared with the first approach, is the individual worker's preference and the size of the membership appearing explicitly. In the Figure 2.2, we show the union's indifference curve between wage rate and employment holding hours of work fixed. Given the number of workers employed, the higher wage rate the higher the union's utility. The union's utility is increasing with the direction showed in the Figure. The curve is downward sloping, and a higher wage rate compensate for lower employment.

[Figure 2.2 insert here]

3 Union Bargaining Goals and Outcomes

After we set up the union and firm objective function, I will now present the bargaining process and the outcome. Booth (1995) considers the bargaining behaviour in two broad approaches: the axiomatic approach and the game-theoretic approach. The former approach is to assume under certain principles or axioms that a unique outcome can be found. It focuses on the outcome of the bargaining process. However, the later approach involves the bargaining process in order to determine the actual outcome. While Hirsch & Addison (1986) define them as bargaining on the demand curve and off the demand curve. In general, the economists, (including Oswald, Ulph, Pencavel, McDonald & Solow), assign the bargaining models to two categories: the Right-to-manage model and the Efficient bargain model. This approach has also been followed in this paper. In the end I present the Sequential Bargaining model as an integration of the Right to Manage model and the Efficient Bargain model.

3.1 Right to Manage model

The assumption of this bargaining model - the Right to manage model - is that the union can either bargain over the wage with the firm or set the wage independently; then the firm can set employment unilaterally to maximize its profit. Given this assumption, after the wage has been set up, the firm will subsequently pick the relating point on the demand curve in Figure 2.3, as this is the point of the profit-maximization level. Given a higher wage, the firm will choose lower employment. It is a trade-off between wage and employment.

[Figure 2.3 insert here]

Figure 2.3 shows the wage-employment outcome of such a model as the tangency of the union's indifference curve U_0, and the firm's labor demand curve D_L. After the wage has been set up as W*, the firm adjusts its employment level to L*. Any outward shift of D_L will increase the union's utility as well as the wage and employment. Any slope reduction of the demand curve would lower the wage, and increase the employment.

A special example of this bargaining model is the Monopoly Union Model. In this model, the union chooses the wage unilaterally to maximize the utility, subject to the constraint that the employment is on the demand curve. Let's suppose the union's utility function to be (2.1.8).

$$U = Nu(W) + (M - N)u(r)$$

Here we treat the union membership number M as fixed. And for simplicity's sake, we take the (2.1.1″) as the firm profit function.

$$\pi = R(L) - WL$$

Given the wage rate set by the union, the firm will maximize its profit

$$Max\pi = MaxR(L) - WL$$

by choosing

$$R'(L) - W = 0$$

which means the marginal product of labor equals the wage. We could have the solution

$$L = \Phi(W) \tag{2.2.1}$$

The union tries to maximize its utility subject to the employment chosen by the firm.

$$\underset{w}{Max}\, U = Lu(W) + (M - L)u(r) \tag{2.2.2}$$

Substitute (2.2.1) back to the equation (2.2.2), and we can get

$$\underset{W}{Max}\, U = \Phi(W)\left[u(W) - u(r)\right] + Mu(r)$$

At an interior maximum, then

$$U_W = \Phi'(W)\left[u(W) - u(r)\right] + \Phi(W)u'(W) = 0$$

This equation tells us the marginal benefit of increasing the wage is equal to the marginal cost.

A more general version is the wage rate being set by the bargaining instead of by the union unilaterally. The firm's bargaining power β is less than 1, compared with $\beta = 1$ in the monopoly union model. In this case I can get another equation with almost the same implications but which is slightly complicated, where both the wage rate and the employment would also depend on the bargaining strength of the union. The comparative statics show wages rise with the union bargaining strength. If the alternative wage, r, is reduced, this will extend the gap between the utility of employed member u(W) and unemployed u(r), and eventually increase the employment. Booth (1995) explicitly shows the bargaining outcome when β is facing different value in Figure 2.4.

[Figure 2.4 insert here]

Oswald(1982) shows that in general unions' desired wage rates will increase by increasing the unemployment benefit, the employment subsidy to the firm; and will decrease with the rise of the worker's income subsidy. However a rise in the price of the product and the change of membership has no effect on union's desired wage rate.

3.2 Efficient Bargaining model

In the previous model I have assumed that the firm adjusts the employment level after the wage has been set up by bargaining or by the union alone. The wage rate and employment outcome will be on the demand curve. But if the assumption changed to the firm, and the union is bargaining over the wage and employment simultaneously, the firm, not like in the Monopoly union Model, could not freely choose the employment level to maximize its profit. We can see that the point on the demand curve in this case is not Pareto Optimal. In other words, we can always find some other wage and employment level that could be better off than the combination on the demand curve, which we call the curve combined by those points "contract curve".

Coming back to the same firm and union objective function as we showed in Monopoly Union Model, we can now describe the problem as

$$\underset{L,W}{Max}\,\Gamma = \underset{L,W}{Max}\; R(L) - WL + \theta\left[Lu(W) + (M-L)u(r)\right]$$

where θ is union bargaining power. The solution of this maximization problem is

$$\frac{[u(W) - u(r)]}{u'(W)} = W - R'(L) \tag{2.2.3}$$

It means the slope of the union's indifference curve equals the slope of the iso-profit curve. In other words, the marginal rate of substitution between wages and employment for the firm should equal the corresponding marginal rate of substitution for the union. The locus of points is called "contract curve". By differentiation (2.2.3), we could get the slope of contract curve as

$$\frac{dW}{dL} = -\frac{u'(W)R''(L)}{u''(W)\left[R'(L) - W\right]} \tag{2.2.4}$$

We assume $W \geq r$, else there is no reason for unions to exist. From (2.3) we can yield $W \geq R'(L)$. Combine the assumption that the worker is either risk neutral $u'' = 0$ or risk averse $u'' < 0$, if it is risk neutral, the contract curve would be a straight vertical line; if it is risk averse, the contract curve would be a positive slope. As shown in the Figure 2.5, the contract curve would start from L, which is corresponding with the alternative rate r, as there is no bargaining lower than r, end by the fixed membership M. In fact the contract curve might end earlier than M when the firm's profit become small enough to cause it to shut down.

[Figure 2.5 insert here]

Also in the Figure 2.5 we can see that any point on the demand curve is not Pareto Optimal. Take the point A as an example; any point to the southeast of A would be better than A, as both sides would prefer the combination off the demand curve with the lower wage and higher employment. If the union has the ability to achieve the point A, it would choose any point above c'', as it can achieve higher utility. On the other hand, the firm will choose any point lower than A, as it can get higher profit. The tangency point c'' represents efficient bargaining.

Oswald (1982) and Ulph(1990) present some properties of the model, thus this is not the place to represent them again. Also Oswald(1984) shows that the efficient contract does not necessarily imply that settlements should be off the demand curve in some cases.

By contrast, Pencavel (1991) provides a slightly different efficient contract figure yielded from a different form of the objective functions

$$\begin{aligned} \pi &= R(H, L, K) - WHL - rK \\ U &= [y - \varphi(H) - \overline{y}]^u L \end{aligned}$$

where r is the fixed cost of capital, $\varphi(H)$ can be interpreted as the disutility of work, and $\overline{y}$ is earning in a nonunion job. Therefore $\varphi(H) + \overline{y}$ is the opportunity cost of the employee who took the union job, u is the weight on the gain of the union job, and $y = WH$. By holding hours of work constant, the slope of the contract curve is

$$\frac{dy}{dL} = \left(\frac{u}{u-1}\right) R_L''$$

Assuming $R'' < 0$, the contract curve would be like that in Figure 2.6. It will be positively sloped if $u < 1$; it will be negatively sloped if $u > 1$; and it will be vertical if $u = 1$. Suppose L* is the employment level in the event of not being unionized, then employment would rise if the efficient contract was negotiated along $u < 1$, and would fall along $u > 1$, and would not change along $u = 1$.

[Figure 2.6 insert here]

There are a small number of studies about the testing of these two theories; Brown and Ashenfelter (1986) use the pooled cross-section time-series data collected by Dertouzos(1979) to test the efficient contracts employment in the two arguments. Firstly they show that the contracts may be efficient even if the marginal revenue product of employment is uncorrelated with alternative earning; secondly a partial correlation between employment and alternative earning is compatible with a first-order condition corresponding to an employer being on his labor demand curve. In reality there are difficulties in testing the theories to determine which is better, as the test may be implicitly joint hypotheses about the profit function as well as the union behavior.

Also there are some limitations about these two theories. Ulph(1990) and Oswald (1987) argue that there is a need to model more closely to unions bargaining, for instance, the hours of work, capital per worker and union membership are not included in the modelling, which have been important to unions. In fact, Clark and Oswald (1992) report that 86% of 57 UK trade unions, the firm decides the level of employment, and yet for 91% the firm negotiates with the union over 'working practices'.

3.3 Sequential Bargaining Model

There is an integration of those two models, the Sequential Bargaining model, in which the union has separate abilities to influence wages and employment. In the monopoly model the union has no influence over employment, but some influence over the wage. In the efficient bargaining model, to some extent, the union has the same influence over wage and employment. In a sequential bargaining model there is first a bargain over wage(or employment), then a bargain about employment (or the wage). The union's influence on the bargaining may be different in these two stages. Manning (1987) has addressed the framework of sequential bargaining: the wage-employment sequential bargain and the employment-wage bargain. In the former model the wage is determined before employment. In the second stage of bargaining when W has already been determined, employment will be chosen to solve the following problem:

$$\underset{L}{Max}\; q \ln U(W, L) + (1-q) \ln V(W, L)$$

where q is the union's power over employment, and $U(W, L), V(W, L)$ are the union and firm's utility function. This will yield a solution $L(W, q)$. In the first stage, when the wage is determined, w will be set to solve:

$$\underset{w}{Max}\; p \ln U\left[W, L(W, q)\right] + (1-p) \ln V\left[W, L(W, q)\right]$$

where p is the union's power over the wage. P may or may not equal to q.

In the latter sequential bargaining model, the employment was determined before the wage. Therefore the roles of W and L are reversed as above.

In reality unions may have different emphasis in different bargain cases. So it is reasonable to assume $p \fallingdotseq q$. However p and q can not be seen as totally independent of each other. Binmore et al. (1986) study how differences in risk aversion and time preference can explain bargaining power. If we assume time preference and risk aversion to be the same in bargains about wage and employment, both p and q would be affected by changes in the discount rates of the parties to the bargain. Manning (1987) proves for both wage-employment and employment-wage sequential bargains, that the sufficient condition for efficiency is $p = q$. If $p \leq 1, q = 0$, then we have right to manage model.

Pencavel (1991) and Nickell & Andrews (1983) offer some explanations as to why sequential bargaining may constitute the actual bargaining process. It may be because (i) efficient contract might be too costly to effect due to the significant transaction cost for each party to full evaluate other's objective function. (ii) Contracts may be efficient at the initial negotiation stage, a subsequent unforeseen change may necessitate recontracting. However it may be too expensive to recontract a new efficient contract, and this may allow some unilateral adjustment.

4 The Union Effect on Wages, Employment and Hours

4.1 Union Relative Wage Effect

There are numbers of papers about the union relative wage effects. And it has been shown hundreds of times that unionized workers tend to earn more than non-unionized workers. Lewis (1986) summarizes how to estimate the union and nonunion wage gap in his well-known survey. He concludes that during 1967 -1979 the mean wage gap was approximately 15% in US. In the survey, he also distinguishes the gap differences by gender, color, marital status, major industry, major occupation, region, education, age, etc, and the adjustment to the data problem. Blanchflower (1996) confirms that the wage effect in US by 1983 data is about 15.5%, and UK is about 11.2% in the same year. Freeman & Medoff (1984) use the National Longitudinal Survey of men aged 14-24 in 1966 in US, and he finds that, compared worker from nonunion joining union with worker remaining nonunion, it is about a 15.7% increase in his wage; it is approximately a 10.5% change by comparing workers remaining in union vs. workers leaving unions; and about 20.3% increase in workers joining unions vs. workers leaving unions. Blanchflower and Freeman (1990) show that unions are consistent with low wage dispersion compared with its counterpart.

Meanwhile Driffill & Meschi (1996) use the across establishment data in UK and find that the union mark-up in competitive establishment has increased for unskilled worker, but for the same workers in establishments with market power, the mark-up has disappeared. For skilled workers, there has been little evidence of markups. Lemieux(1998) estimate that in Canada, that on average union increase the wages, and reduce the wage inequality among workers, but union reduce the returns to both observed and unobserved skills.

Some studies focus on how the union density affects the wage. Reilly (1996) finds that union membership does matter in the 1% to 25% range . For the establishment union density ranges above the 25% level, union membership matters only in terms of the number of individuals whose age are set by the collective bargaining process, and the gains are captured by all employees in the establishment. Barth & Raaum (1998), using Norwegian data, find that a 10% increase in union density at the establishment leads to an increase in the wage of about 2%. Furthermore they find that individual union membership affects the wage gap only in the absence of controls for workplace union density. If the establishment level union density is included, the individual membership has no significant effect on the wage.

4.2 Hours of work

One reason that economists are attracted by the concept of reducing working hours of each employee, is that it offers the possibility of spreading work to others, and increasing employment by the way of work sharing. The worker may be concerned about the number of hours as they care about the earning as well as their leisure. The firms care about the hours as they presume that the labors input and hours are not perfect substitute for one another: firms adjust the fixed cost of employment by changing hours of work per employee rather than by hiring and firing workers. Hart (1995) believes that if the union bargains over the per-period length of working hours, along with wages, it is implicitly concerned with the level of employment too, as the trade off between hours and workers should be aware that labor utilization on the firm's intensive margin will influence the employment level on the extensive margin. In this section I will provide theoretical model and empiricial evidence in hours literature.

4.2.1 Theoretic Model

Attempting to test work sharing, Calmfors (1985) uses the expected utility function of the worker

$$u = \frac{N}{M}v(WH, H) + \frac{M-N}{M}v(b, 0)$$

where $v(Y, H)$ is the utility function of the worker, if he is employed, his utility is $v(WH, H)$. If he is unemployed, his utility is $v(b, 0)$, b is unemployment benefit. M, N, H are the membership numbers, employed workers and hours of working respectively. For the firm, its profit function is

$$\pi = F(N, H, K) - WHN$$

where F is the production function, K is the capital investment. By holding the capital constant and taking the working time and the wage as exogenous given to the firm, the first order condition for profit maximization gives the labor demand function for workers as

$$\begin{aligned} N &= N(W, H) \\ N_W &< 0,\ N_H \text{ ambiguous} \end{aligned}$$

Thus it is not obvious that a reduction in working time will increase employment even at an unchanged wage.

Assume working hours are given as exogenous for the union and firm, in order to obtain the effect on the wage of a reduction in working time, in a monopoly model (the union decides the wage rate to maximize its utility function subject to the labor demand, and suppose $M = 1$), which yields

$$\frac{\partial u}{\partial W} = \Phi = NHv_Y + N_W(v - \overline{v}) = 0 \tag{2.3.1}$$

differentiate (2.3.1) with respect to W and H gives

$$\Phi_H dH + \Phi_W dW = 0 \tag{2.3.2}$$

Consequently

$$\frac{dW}{dh} = -\frac{\Phi_H}{\Phi_W}$$

where

$$\Phi_H = N_W W v_Y + N_{WH}(v - \overline{v}) + N_W v_H + NHWv_{YY} + NHv_{YH} + Nv_Y + N_H H v_Y \tag{2.3.3}$$

From (2.3.2) and combine the assumption $\Phi_W < 0$, it can be obtained

$$\frac{dW}{dH} \leq\geq 0 \Longleftrightarrow \Phi_H \leq\geq 0 \tag{2.3.4}$$

As it can be seen $\frac{dW}{dH}$ is ambiguous, but by interpreting each term of (3.3), he showed how the reduction of hours affects wage rate.

Further, in the case when employment and working time are perfect substitutes, $N_H = -\frac{N}{H}$, by comparing initial working time with optimal working of trade union, it can be concluded:

i) If initial working time is optimal or smaller than optimal for the trade union, an exogenously imposed reduction in working time will then always increase the wage

ii) If initial working time is larger than optimal for the trade union,

$$\frac{\partial u}{\partial H} < 0$$
$$\frac{\partial W}{\partial H} \leq\ \geq 0 \Longleftrightarrow \Phi_H \leq\geq 0$$

The wage may then increase or fall in response to an exogenously imposed reduction in working time.

The main contribution of this paper is that it is the first paper which theoretically studies work sharing; how employment is affected by hours setting. However there is a significant weakness in this paper. The conclusion of the ambiguous effect of hours cut on employment is drawn from an assumption that hours and wage are exogenous. Given the exogenous working hours and wage rate, the firm intends to maximize its profit by choosing its employment level unilaterally. This excludes the situation where hours or wage rate are endogenous to the bargaining.

Earle and Pencavel (1990) have an influential paper that summarizes the various ways in which economists might model the determination of hours of work in different bargaining situations. This paper includes the situations that exists when hours are exogenous as well as endogenous to the bargaining. However it neglects the distinction between overtime hours (wage) and standard hours (wage), and specifies the firm profit maximization function as

$$\pi = R(L, H) - WHL - cL$$

where c is per-worker fixed costs of employment, such as hiring and training costs and certain fringe expenditures; union well-behaved objective function is expressed as

$$\Gamma = g(Y, L, H)$$

where $Y = WH, g_Y > 0, g_H < 0$, and $g_L > 0$.

The first model he showed is efficient contract model, which could be described as

$$\max\ \Omega_1 = \Gamma + B\Pi$$

where B>0 represents the management's bargaining strength relative to the union. From the first-order condition of profit maximization we can get

$$-\frac{\partial g}{\partial H} = B\frac{\partial \Pi}{\partial H}$$

It shows that an efficient contract requires hours to be set so that the marginal disutility of hours in the union's objective function is proportional to the firm's marginal revenue of hours; the factor of proportionality is the bargaining power parameter B.

Thereafter he moved to models of the principal-agent general form. In these models at least one of the parties is able to determine one or other of the variables unilaterally. The second model is the union and firm bargains over wage rate as well as working hours, firm sets the employment unilaterally afterwards. So the model can be presented as

$$\max\ \Omega_2 = \Gamma + B\Pi + \lambda\left(R_1 - WH - c\right)$$

where λ is a Lagrange multiplier, and $\lambda_1 = \frac{\partial R}{\partial L}$. If it bargains only over the wage rate, then the firm is going to adjust the employment and the working hours according to its own interest, the model is

$$\max\ \Omega_3 = \Gamma + B\Pi + \lambda(R_1 - WH - c) + \psi(R_2 - WL)$$

where ψ is another Lagrange multiplier, and $R_2 = \frac{\partial R}{\partial H}$.

A slight modification of previous models is that the union decides the wage rate according to its own interest rather than bargaining with the firm. The firm follows by setting employment and working hours unilaterally. In this event, the maximization problem can be wrote as

$$\max\ \Omega_4 = \Gamma + \lambda(R_1 - WH - c) + \psi(R_2 - WL)$$

If the union can not only set the wage rate, but also the working hours, firms choose the employment, then the maximization problem can be written as

$$\max\ \Omega_5 = \Gamma + \lambda\left(R_1 - WH - c\right)$$

Earle and Pencavel have described a whole scenario of union-firm bargaining. This is the main contribution of this paper, however they fail to offer more detailed comparative statics for the bargaining procedure. Also it can not distinguish between standard working hours and over time hours, which should affect the bargaining as well.

Hart (1987) distinguishes overtime hours from standard hours, and explores the relationship between standard hours, overtime hours with employment in terms of cost minimization. He considers the case that a firm minimizes its cost when it employs positive overtime hours. Thus total hours $H > H_s$, the standard hours. Hence

$$W(H) = W_s H_s + aW_s(H - H_s), a \geq 1, H > H_s \tag{2.4.1}$$

Following Ehrenberg (1971), the labor services function can be defined as

$$\begin{aligned} L &= F(H, N), F_H > 0, F_N > 0 \\ &= g(H)N^{1-\alpha}, 0 \leq \alpha < 1 \end{aligned}$$

where $g'(H) > 0, g''(H) < 0$. It implies that L increase at a diminishing rate when H increases. By specifying

$$g(H) = (H - s)^{\varepsilon}, \varepsilon < 1 \tag{2.4.2}$$

where s is the minimum set-up time per worker.

Assume total labor cost C_L:

$$C_L = (pW(H) + T)N$$

where p is the payroll tax, $p > 1$, and T is other fixed cost per worker. The firm intends to minimize its total labor cost, thus the problem can be described as

$$\underset{L, H, N}{Min} R = C_L + \lambda(L - g(H)N^{1-\alpha})$$

where λ is the Lagrangian multiplier. We should notice that this is from the point of cost minimization in stead of the point of union bargaining in Pencavel's paper. From the first-order conditions $R_H = R_N = R_\lambda = 0$, have

$$(1 - \alpha)GW'(H) = W(H) + \varsigma \tag{2.4.3}$$

where $G = g(H)/g\prime(H)$ and $\varsigma = T/p$. Substituting (4.1) and (4.2) into (4.3) gives

$$H = \left\{ \frac{-H_s \varepsilon W_s (a-1) + \varepsilon\varsigma + (1-\alpha) saW_s}{(1-\alpha-\varepsilon)aW_s} \right\}$$

On the assumption $1 - \alpha - \varepsilon > 0$ we have

$$\frac{\partial H}{\partial H_s} < 0$$
$$\frac{\partial N}{\partial H_s} > 0$$

which means a fall in standard hours will lead the firm to substitute more overtime hours for less workers.

[Figure 2.7 insert here]

In figure 2.7, we can see initially that the firm is in equilibrium at point X with working hours $H_1$and employment N_1. If standard hours reduce from H_s to $H_s^{'}$, the isocost curve will move to $C_L^{'}C_L^{'}$, and the new equilibrium will be at point y, where working hours will be increased to H_2 and employment will be reduced to N_2.

Hart (1984) studies about work sharing from another point of view in terms of the effect of relative factor prices on worksharing within a model structure. The factor prices include standard wages, premium wages, obligatory social welfare contributions, other non-wage labor costs, as well as the price of capital goods. The firm's production Q takes the form as

$$Q = F(N, H, K, I), \qquad F_i > 0, F_{ii} < 0, F_{ij} > 0, i \neq j, i, j = 1, ...4$$

where N is the number of workers, h is the average hours worked per worker, K is the capital stock and I is an index of productivity per person employed. Also it is assumed that an increase in labor productivity applies to all hours of labor. Thus the labor services function L

$$L = IG(N, H), \;\; G_N, G_H > 0, G_{NN,} G_{HH} < 0$$

Average hours are composed of two parts

$$H = H_s + (H - H_s)$$

The firm faces fixed labor costs, z, which has been divided into endogenous z_e,and exogenous z_x elements; Further subdivision of fixed worker costs

$$z = \tilde{z} + (q + r)\bar{z} = \tilde{z}_e + \tilde{z}_x + (q + r)(\bar{z}_e + \bar{z}_x)$$

where $\tilde{z}$ is the recurring component (e.g., recreation facilities, social welfare payments, holidays) and $\bar{z}$ is the 'once-over' component (e.g., hiring, training and redundancy costs). q is the quit rate and r is the interest rate. And variable cost, v, are comprised of three elements,

$$v = W_s + W_p + W_n$$

where W_s is the standard wage rate, W_p and W_n are the premium wage rate and non-wages (social welfare, unemployment insurance , etc.). Specifying

$$I = I(z_e/p), I' > 0, I'' < 0$$

P is the general price index.

Therefore, the firm's total cost function C is expressed as

$$C = (\tilde{z}_e + \tilde{z}_x)\, N + (q + r)\, (\bar{z}_e + \bar{z}_x) N + W_s\, (1 + \beta)\, NH_s + \alpha W_s\, (1 + \beta)\, N\, (H - H_s) + sH + cK$$

The costs are minimized subject to the production constraint, given by

$$Q = F\left[I(z_e/p)G(N, H), K\right]$$

Two implicit equilibrium functions for workers and hours per worker N^* and h^* can be given from the first order conditions to the cost minimizing problem

$$\begin{aligned} N^* &= N^*(\tilde{z}_x, \bar{z}_x, q, r, H_s, W_s, \alpha, \beta, Q), N_i^* < 0, i = 1, ...4, N_j^* > 0, j = 5, ...8. N_9^* > 0 \\ h^* &= h^*(\tilde{z}_x, \bar{z}_x, q, r, H_s, W_s, \alpha, \beta, Q),\ h_i^* > 0, i = 1, ...4. h_j^* < 0, j = 5, ...8, N_9^* \gtrsim 0 \end{aligned}$$

The signs of the partial derivatives indicate that a rise of per worker costs $(\tilde{z}_x, \bar{z}_x, q, r)$ increases the marginal cost of new employment relative to longer hours by existing employees and thus induces substitution of H for N. On the other hand, a rise in standard hours or the standard wage or the overtime premium or the social security contribution rate reverses the relative marginal cost increases, thereby encouraging substitution in the opposite direction.

More attention on how subsidy affects the employment and hours has been given in Hart (1989). Consider a cost-minimizing firm with per-period total labor costs,

$$C_L = [Pw(h) + Z + T]\, N$$

where $W(H)$ is the wage cost for H hours of work, $P \geq 1$ is a payroll tax, Z is once-over hiring and training costs, T is fixed per-period payroll taxes and N is the total workforce. The wage function is assumed as

$$\begin{aligned} W(H) &= W_s H_s + aW_s(H - H_s) \ , \text{for } H > H_s \\ &= W_s H \qquad\qquad\qquad \text{for } H \leq H_s \end{aligned}$$

$a > 1$ is the overtime premium. And output Q is related to labor services L

$$Q = f(L), \qquad f' > 0, f'' < 0$$

The labor services function is given by

$$L = (H - s)^{\varepsilon} N^{1-\alpha} \qquad \varepsilon < 1, 0 \leq \alpha < 1$$

where s is the set-up time. Thus

$$\begin{aligned} C_L &= [P(W_s H_s + aW_s(H - H_s)\ ) + Z + T]\ N, \qquad \text{for } H > H_s \\ &= (PW_s H + Z + T)\, N \qquad\qquad\qquad \text{for } H \leq H_s \end{aligned}$$

1. Consider the firm receives a subsidy φ with respect to the variable labor costs of each additional employee while the firm is in equilibrium $H_{0,}\bar{N}_0$. This

can be represented by the cost function:

$$C_L = [PW(H) + Z + T]\, N - \varphi PW(H) \left[\max\left(0, N - \bar{N}_0\right)\right] \qquad 0 < \varphi < 1$$

It can be shown that

$$\frac{\partial}{\partial \varphi}\left(\frac{dN}{dH}\right) = \frac{-W'W\bar{N}_0}{\left[\tau + (1-\varphi)\, W\right]^2} < 0$$

An increase in φ " steepens" the isocost curve at the point $\bar{N}_0$.Furthermore it can be proved that employment is increased and average hours are reduced as a result of the subsidy.

2. Consider the case of marginal employment subsidy with respect to quasi-fixed labor costs. For example the government may offer to subsidize a part of the firm's initial training costs in order to encourage the recruitment of young unemployed persons.

$$C_L = [PW(H) + Z + T]\, N - \varphi\, (Z + T) \left[\max\left(0, N - \bar{N}_0\right)\right]; \qquad 0 < \varphi < 1$$

As might be expected, all the results with a subsidy on variable costs hold in the case of a subsidy on quasi-fixed costs.

It also can be proved that:

(i) a fall in standard hours is opposite to that of an increase in Marginal Employment Subsidy;

(ii) a reduction in W_s or P through a general subsidy to a firm working equilibrium overtime will produce adverse substitution effects; it will substitute longer average hours for fewer workers.

Hart (1984, 1987, 1989) has studied work sharing in terms of the effect of changing standard hours, input prices and subsidies (i.e. subsidies to training investment, lumpsum payments to each employee), on hours of work and employment. He goes in more detail about the determination of hours of work, which is beyond Calmfors and Earle, Pencavel. However they are not standing on the point of union-firm bargaining, but on the point of firm's cost minimization.

Recently Andrews, Schank & Simmons (2000, EEEG Conference Paper) also develop two kinds of model regarding the issue of work sharing in terms of the distinction between the standard hours and over-time hours: between-firm variations model and within-firm variations model. In the former model, given variations in exogenous parameters, some firms offer only standard hours, whereas some offer overtime. However, within each type of firm, all workers are identical. In the latter, there are two types of worker, some work exactly the workweek whereas others work overtime. The firm optimally chooses the numbers of both types worker and the number of overtime hours.

1. Between-firm variations model. The firm is free to choose both the level of employment N and weekly hours H per employee, the standard workweek is $\bar{H}$. All workers are identical within each firm. Thus the profit-maximizing firm's problem is written

$$\underset{H,N}{Max}\ L = \theta R(H,N) - N\left[W\bar{H} + \gamma W\left(H - \bar{H}\right) + z\right] + \lambda\left(H - \bar{H}\right)$$

where θ is a demand shock, $\theta R(H,N)$ is revenue function, γ is overtime premium, and z represents quasi-fixed labor costs, λ is a Lagrange Multiplier. From the first order conditions for the Interior solution with positive overtime hours and Corner solution with zero overtime, they conclude when the firm faces a low workweek is likely to be unconstrained in its choice of hours and so the relationship between employment and the workweek is positive. As the workweek increases, the firm eventually becomes constrained and the relationship is negative.

2. Within-firm variations model. There are two types of worker, some work exactly the standard hours whereas others work overtime. The firm optimally choose the numbers of both types and the number of hours for the overtime workers. The contribution of hours worked for overtime workers to the revenue function as

$$G = (1-\delta)\,\bar{H} + \delta\tilde{H} \equiv \bar{H} + \delta V$$

where $\tilde{H} > \bar{H}$, $V = \tilde{H} - \bar{H}$, and if $\delta > 1$, assumes an overtime hour is more productive. Using the Cobb-Douglas revenue function, the firm's problem is written as

$$\underset{\bar{N},\hat{N},\tilde{H}}{Max}\ \pi = \bar{N}^{\beta_1}\hat{N}^{\beta_2}\bar{H}^{\alpha_1}\left[(1-\delta)\bar{H}+\delta\tilde{H}\right]^{\alpha_2} - \bar{N}\left(\overline{W}\bar{H}+\bar{z}\right) - \hat{N}\left[\widetilde{W}\bar{H}+\gamma\widetilde{W}\left(\tilde{H}-\bar{H}\right)+\hat{z}\right]$$

where $\bar{N}$ is the number of worker with standard hours, and $\hat{N}$ is the number of workers with overtime hours.

They conclude that a cut in the workweek influences the demand for both types of worker through four distinct channels:via the marginal cost of standard time workers $\overline{W}\bar{H}+\bar{z}$, via the marginal cost of overtime workers $\widetilde{W}\bar{H}+\gamma\widetilde{W}\left(\tilde{H}-\bar{H}\right)+\hat{z}$, via G, and via $\bar{H}^{\alpha_1}$ in the revenue function negatively. In these four channels, the first and the third deliver a worksharing effect, and the other two do not.

Compared with Hart, the main difference of Andrews *et al.(2000)* is from the view of profit maximization rather than cost minimization. The distinction of the Between-firm variations model and the Within-firm variations model separates firms who offer overtime and those who do not, and enables study as to how work sharing behaves in different firm.

In a two stage procedure, Hoel and Vale (1985) analyse the effects of an exogenous cut in working hours on a profit maximizing firm in a competitive market. In the first stage, the firm set the wage rate to the minimum effective wage rate W, where

$$W = W(W, W*, H, \eta)$$

$W*$ is the alternative wage rate, η is the probability of finding a job. In the second stage, given the wage rate from the first stage, the firm maximize its profit

$$\pi = F(L, K) - WHN - cK$$

Holding the capital fixed in the short run, and the unemployment rate is defined as

$$U_r = \frac{M-N}{M}$$

$$= U_r(\eta)$$

$U_r' < 0$, M is the labor supply. It is easy to show that

$$\frac{\partial U_r}{\partial H} < 0$$

It indicates that a cut in the working hours will increase the unemployment rate. The authors show that this also suits the long run when the K is variable.

To study the relationship among hours, wage and employment under the framework of efficient bargain, Oswald and Walker (1996, Discussion Paper) formulate a problem as that of choosing $W(\theta), N(\theta), H(\theta)$ to maximize union utility

$$\int [u(y, H)N + u(b)(m - N)]\, g(\theta)d(\theta)$$

subject to firm's revenue

$$\int v(\theta f(NH) - WHN)g(\theta)d(\theta) \geq \bar{v}$$

where $\bar{v}$ is an arbitrary constant, the minimum level of firm's profit. θ is the output price, and is distributed according to density $g(\theta)$. $u(y, H)$ is the individual's utility if he is employed, otherwise his utility is $u(b)$.

Some results about the hours issue emerge from this model:

1. Unions ration hours so that individuals are to the left of their privately rational labor supply curves.

2. If the firm is risk-neutral, and leisure is a normal good, wages and hours are inversely related.

3. If workers are risk-neutral with respect to income, and utility is separable, hours are independent of the wage.

4.If the firm is risk-neutral, and utility is additively separable in income and hours, the shocks to θ affect only employment. Wages and hours are not affected.

Obviously this paper is from the efficient bargaining point of view rather than cost minimization or profit maximization, which is the main difference between

Hart and Andrews, *et al.* This paper believes that it should be analyzed as a contract model to analyze the unionized sector, while it should be treated as a canonical model for the non-unionized sector. Compared with Earle and Pencavel (1990), it shows some stylized facts with more specific firm and union utility function. However this paper does not shed any light on (i) how union bargaining power affects hours, wage and employment determination. (ii) the semi-efficient bargaining case, as in real world, it more likely happens with that firm has some more control on one or two specific variable, i.e. employment, rather than bargain all three variables with union.

Similarly, Marimon & Zilibotti (Discussion paper 1999) examine the employment effect of reducing working time from the Nash bargaining solution

$$\max_{w,L}\,(Y-U)^{\beta}\,(J-V)^{1-\beta}$$

where Y and U are the value of being employed or unemployed respectively; J is the value of the marginal position filled by the firm, and V is the value of vacancy. V has been assumed as zero in equilibrium.

Assume firm expected profits function

$$\begin{aligned}\pi_i &= \int_0^{\infty} e^{-rt}(A(N_iH_i)^{\alpha} - WN_i - cV_i)dt \\ &= \int_0^{\infty} e^{-rt}(A(N_iH_i)^{\alpha} - WN_i - c\theta^{\varsigma}(\widehat{N_i} + sN_i))dt\end{aligned}$$

where A is a parameter, N_i is the number of firm i's employee, and h_i is the hours of working, V_i denotes the number of vacancies in firm i, and $\theta \equiv \frac{v}{u}$ is the tightness of the labor market, $\theta^{-\varsigma} = \frac{m}{v}$, where m denotes matches, v denotes vacancies ($\theta^{-\alpha}$ is the rate that firms fill vacancies), $\widehat{N_i}$ is the net flow of employment into firm i, s is the exogenous quit rate. In a steady-state equilibrium, the optimal labor demand condition for N_i can be drawn as

$$pH - W - c(r+s)\theta^{\varsigma} = 0$$

where p is marginal product of labor , $p = \alpha A(nH)^{\alpha-1}$. In the mean time, J , the value of the marginal position filled by the firm, must be subject to

$$(r+s)J = pH - W$$

Combining the above two equations

$$\theta^{-\varsigma} J = c$$

which denotes the firm will open vacancies until the cost of holding a vacant position, c, equals the expected value of a filled vacancy.

The utility of an employed worker is

$$(r+s)Y = u(W, 1-H) + sU$$

and the utility of an unemployed worker is

$$rU = u(0,1) + \theta^{1-\varsigma}(Y-U)$$

Using the above equations and parameterize

$$u(w, 1-H) = \nu(W - \frac{H^{\psi}}{\psi})^{\frac{1}{\nu}}$$

In two kinds of economies: (i) laissez-faire economies, where workers freely negotiate wages and hours with firm. Then given the bargaining outcome, firms decide the number of vacancies to post; (ii) hours of work have been set by exogenous regulation, union and firm only bargain for wages. Two main results have been found:

(i) The employees prefer to restrict statutory hours below the laissez-faire solution, even if they anticipate earning to be cut. Firm will suffer losses from regulations reducing working hours.

(ii) The employment effect of regulation are ambiguous, and depends on the response of wages. If the earning keeps constant, employment will fall unambiguously. However if the change of hours cause endogenous wage adjustments, then the total employment effect will be decided by both technology and worker preference for consumption and leisure. The employment gains from reducing working time are rather restrictive.

The first result of Oswald and Walker (1996) is similar to Marimon & Zilibotti (Discussion paper 1999); that unions will ration hours of work. But this conclusion is drawn from a very different model: the former is a full efficient bargaining model; the latter is principally a semi-efficient bargaining model, no matter whether the economy is laissez-faire or with regulated hours, the firm will set the vacancies afterwards. Another difference of these two papers is the emphasis of the former on the relationship of wage and hours. It does not focus on the hours effect on employment, while the latter does.

There is another view which argues that hours of work will influence employee's productivity. The reason is that workers will be more productive after a cut in hours as they will be more healthy and less tired, and thus absenteeism and accidents will decline. In the work which has been addressed above, this argument has not been captured. Booth & Ravallion (1993) study the relationship between employment and the length of the working week in a unionized economy conditioned on the assumption that hours of work influence productivity. In this paper the firm's output depends on the number of 'efficiency hours' of labor input, rather than the total number of clock hours.

$$F = F(\Phi(H)HN), \qquad f' > 0, f'' < 0$$

$\Phi(H)$ represents the efficiency hours index.

The model has a two stage-decision process (where employment is determined after wages and hours have been set.). Thus the competitive firm's profit from employing unionized workers at given W and H is

$$\pi(W, H) = \underset{N}{Max}\ [f(\Phi(H)HN) - (s + WH)N]$$

where $s > 0$ is the fixed cost associated with employing each worker. The first order condition gives

$$f'(\Phi(H)HN)\Phi(H)H = (s + WH)N$$

Suppose there are some exogenous cuts in hours, the effect on employment would be

$$\frac{\partial \ln N}{\partial \ln H} = \frac{\partial \ln N}{\partial \ln W}\left[1 + \frac{\partial \ln W}{\partial \ln H}\right] - (1 + \frac{\partial \ln N}{\partial \ln W}\frac{s + WH}{WH})\left[1 + \frac{\partial \ln \Phi}{\partial \ln H}\right]$$

Therefore the conditions sufficient for a cut in hours to increase employment are that:

(i) the cut in hours does not increase unit labor cost ($\partial \ln W/\partial \ln H \geq -1$)

(ii) the cut in hours reduces output at given employment ($\partial \ln \Phi/\partial \ln H > -1$), and

(iii) the absolute wage elasticity of demand for labor is less than the share of variable labor cost in the wage bill ($-\frac{\partial \ln N}{\partial \ln W} < \frac{WH}{s+WH}$).

It should be noticed that, given the two stage process model, both firm and union would anticipate that the employment will be conditioned by the wage and hours outcome, if these two parties are rational. Whereas the weakness of this paper is the employment N has been assumed as exogenous. In other words, N is being treated as unconditional to wage and hours when they differentiate W and H in the first order conditions of the following Efficient bargaining and Monopoly bargaining model.

In the case of an efficiently bargained contract that maximizes the representative worker's utility subject to the firm achieving at least its reservation profits. This problem can be described as to maximize

$$\frac{N}{M}\left[v(WH, H) - v_0\right] + v_0 + \lambda\left\{\left[f(\Phi(H)HN\right] - (s + WH)N - \pi_0\right\}$$

with respect to W,H and the Lagrange multiplier $\lambda > 0$. The first two sufficient conditions hold when a cut in hours is imposed in a neighbourhood of an efficient bargain over wages and hours. The third condition is not implied by any obviously plausible theoretical assumptions. Therefore the hours effect in the efficient bargaining model is ambiguous.

However in the case of the monopoly union model, the union's choice problem is to maximize the following function with respect to W and H, for some $\lambda > 0$:

$$\frac{N}{M}\left[v(WH,H)-v_0\right]+v_0+\lambda\left\{f'\left[\Phi(H)HN\right]\Phi(H)H-(s+WH)\right\}$$

When holding the unit labor cost constant, the first order conditions yields $\frac{\partial \ln N}{\partial \ln H} > 0$. Thus the proposed reduction in hours must lead to a reduction in employment. Whereas, the comparative static effect on employment is ambiguous if unit labor cost is also allowed to fall with demands for a cut in hours.

As I pointed out in the previous paragraph, all conclusions are drawn from the assumption that N is unconditioned on W and H, which I think it is a big weakness of this paper. Apart from that, the main contribution of this paper is that, based on the assumption that hours of work have an influence on productivity, the hours effect on employment has been analysed under the circumstance of the efficient bargaining and the monopoly bargaining model.

4.2.2 Empirical Evidence

There are also various studies which show the empirical results about how unions affect the hours of work. Earle and Pencavel (1990) find the hours of work vary considerably by type of worker, by industry, and by occupation. For white men in 1978 outside of the construction industry, the union-nonunion hours differential is -2.8% for craftsworkers, +2.1% for operatives, +14.3% for laborers, and +3.3% for all other occupations: and in the construction industry, the differentials are -9% for craftsworkers, -0.7% for operatives, +27.6% for laborers, and +6.8% for all other occupations. Furthermore the dispersion among individuals in hours and weeks worked is invariably smaller in the union sector. As Perloff(1987) indicates in the construction industry, union wage markups are positive, but for most demographic groups the union hours markups are negative. Lewis (1986) reports that the union hours gap, in most cases, was negative and not negligible in size; the hours differential average is -1.8%. Blanchflower (1996) shows that unions reduce the total hours of work. They tend to reduce standard hours and unpaid overtime hours but increase the number of paid overtime hours. By the full longitudinal sample, Raisian(1983) found that wages, hours and weeks exhibit significant procyclical patterns. A 1% increase in the unemployment rate is associated with a 1.1% decline in weeks worked, a 0.6% decline in weekly wages, and a 0.3% decline in weekly hours worked. Also he showed that the white-collar workers exhibit less procyclical variability in wages and hours, and weeks than blue-collar. Oswald & Walker (1996, Discussion Paper) find that union and non-union exhibit quite different labor supply behaviour. The former should be analyzed as a contract model, and the latter should be treated as a canonical model. In the non-union sector, the wage elasticity of total hours is approximately 0.6 and the wage elasticity of overtime hours is 1.2. In the union sector, there appears to be a vertical or negatively sloped relationship between wages and hours, although there is a relatively well-determined positive overtime hours elasticity so that the overall elasticity of hours is about 0.2. Andres (2000) derives a model that the firm has two types of worker. One works with overtime, the other works only with standard hours. The standard hours have a positive effect on the proportion of overtime workers in the plant. It substitutes between overtime workers and standard time workers. Followed by empirical test with the Establishment Panel Data set in Germany from 1993 to 1999, he found that a 10% cut in standard hours leads to a 4.67% employment increase in the plants where every worker works zero overtime; however, in the plant where a proportion of workers work with positive overtime, the effect is negative, falling by about same amount; in the firm where every worker works with overtime, the effect is very small. Booth & Ravallion (1993) found from a UK aggregate data set that employment will increase unambiguously after a cut in hours if the conditions of the efficient bargaining model prevail.

As an extension, there are also some papers about the standard hours or maximum hours legislation issue, such as Stewart & Swaffield (1997), Goldin (1988) and Costa (1998). Hunt(1998) declares that in Germany the actual and desired hours was narrowed by reductions in standard hours. In fact, a reduction in standard hours did not lead to higher employment. The real hourly wage rose enough to offset reduced hours. A by-product of the reduction in standard hours of full-time male workers was a small reduction in the hours of their wives. Hart & Wilson (1988) find that a one hour decrease in the standard work week reduced work hours by 0.77 hours. On another aspect, some papers, i.e. Fuest and Huber (2000), study how tax affect employment with endogenous hours of work.

5 Union with Economic Performance

In previous section I have assessed the impact of unions on the labor market. In this section I briefly and selectively evaluate the union effect on economic performance and efficiency in other dimensions.

5.1 Productivity and Efficiency

Will union be good for productivity? The Monopoly model has suggested that unionism will cause the high wage premium. Firms thus respond by altering the capital per worker and hiring higher quality labor, and it leads to higher productivity. On the other hand, orthodox theory suggests that the monopoly wage increase in productivity is socially harmful, as it causes a misallocation of resources, and labour and capital are directed from higher to lower marginal product uses: workers who would have been employed in the union sector have to work in the nonunion sector for low productivity; machines which would have been used in the nonunion sector now have to be used in the union sector for raising the productivity of the union labor. However, in the perfect competition market, it requires that the input to be used in a way which causes the marginal product to be equalized.

Leibenstein (1966) argues the X-inefficiency situation, in which least-cost combinations of labor and capital are not utilized in a technically efficient manner. Neither firm nor the employees work as hard or search the information as hard as they can, as it has been influenced by the unionism.

While there is also another kind of view–collective voice response. The unionism could increase the productivity, as this result not only from the inefficient resources allocation, but also from improved efficiency within the firm. Many economists have proved that unionism could increase the management effectiveness. For example, it will reduce the quit rate and turnover rate, and therefore reduce the training cost and hiring cost. Freeman(1976) shows that since workers have some control over their own activities and can affect the productivity of others, their attitudes and morale become potentially important inputs into the production process.

Freeman and Medoff (1984) concludes that monopoly analysis allows for the possibility that restrictive work rules reduce productivity, the voice/response analysis allows for possibilities such as seniority or rules restricting managerial flexibility can reduce productivity. In short, if industrial relations are good, with the management and union working together, productivity is likely to be increased. Otherwise, can be reduced.

Booth & Ravallion (1993) believes that the union's influence on hours setting is associated with worker productivity. A cut in hours will make employees more healthy and less tired, thus would be more productive. Similarly Andrews & Simmons (2000) have argued that union have power in effort bargaining, apart from employment and wages. They suggest that wages and effort are positively associated, with both increasing at a time of weakening union power, worsening outside opportunities for workers and increased competetiviness.

5.2 Union Influence on Profitability

We have known that the union increases the wage, so the further question is how it could be? It comes from nonunion labor in the form of lower wage, or through the higher product price which is transferrable to the consumer, or the firm's low profit rate. Intuitively if the union has more power in the bargaining with the firm, it would either get more rent from the firm's side, make the firm less profitable, or increase the union member's utility by cutting hours of working, and having more leisure. However each side may face the force of competition.

Freeman & Medoff (1984) and Clark (1983) provide a table to show the impact of unionism on profitability in three industries.

Table 2.1 The Impact of Unionism on Profitability in Three Industries

	approximate percentage difference in profitability due to unionism	
sample	price-cost margin	*quasi−rents* divided by capital
industries		[1]
1. 139 manufacturing industries, 1958-76	-17	-12
2. Major Internal Revenue Service 1965−76	−37	−32
3.State Industry 1972	4	−27
3.State Industry 1977	−14	−9

Source: Freeman & Medoff (1984) "What do unions do?"

All the figures in the table are the effect of unionism on profitability by comparing profits in industries that are heavily unionized with those less unionized. It clearly shows that the impact of unionism is negative to the profitability no matter in which measure of profitability.

Clark (1983) explains why there is so large reduction in profitability. It is because that profits are a relative small component of an industry's income flows. So

[1]Price-Cost Margin defined as the excess of prices over variable costs

Quasi-Rent return on capital defined as business receipts less variable cost that percentage changes in costs or in productivity would become larger changes in profit. He provided a detailed example to show how it works.

5.3 Influence on Union Membership

Unions increase wage mark-up for their members, and reduce the profitability of the firm, so what kind of firm and worker are likely to be unionized? Blanchflower (1996) concludes by comparing the data in US and UK, that men are more likely to be union members than women; full timers have a higher probability than part timers; overall schooling and qualifications are related negatively to membership. The probability of being a union member rises with age, and reaches a maximum at age 44.7 in 1983 and 46.6 in 1993. While Duncan & Stafford (1980) and Hirsch & Berger (1984) find a more interesting result, there is a concave relationship between union membership and length of worker experience: a positive coefficient on experience and a negative coefficient on experience squared. Production or blue-collar workers are more likely to be union members. The controversial issue is education. Union membership is significantly less likely among those with high school education. Most studies do not find education to be a significant determinant of union membership after controlling for other characteristics.

Other than personal characteristics, industry characteristics also show the relationship with union membership. There are not too many studies about this, but it is commonly believed that worker in highly concentrated industries are more likely to be unionized, and greater capital intensity also leads to greater unionization.

Most of the work concern how unions operate in the case of closed shop, which means that if the firm continues to deal with the union it must only employ union members. Because of the closed shop, workers outside the union will have to work in the alternative sector at the reservation wage r. A large number of papers have contributed to how the introduction of seniority, insider/outsider model address the issue of membership.

Compared to the literature of closed shop, there are relatively few papers about the membership within an open shop framework, where the membership is not compulsory. Booth & Chatterji (1995) study when the membership is voluntary, the union set wage is a public good applying to all workers in the sector regardless of their union status. But the union also supplies excludable incentive goods available only to members, i.e. legal and pension advice, grievance and promotion procedures.... The union members pay subscription cost,while non union members do not. They found that an increase in union power or alternative opportunities causes wages and membership to increase, and employment to decline. An increase in union costs causes wages to rise, employment to fall, but has an ambiguous impact on membership.

6 Conclusion: Unions and Hours

This survey chapter has summarized various kinds of union bargaining models, and the effect of bargining on economic performance. It primarily aims at the issue of modelling of working hours determination and its relationship to wages and employment. In summary, three types of theoretical hours models have been studied in the literature:

1. Models in which hours are set exogenously, it might be by the regulation or legislation, etc. In these models, a change of working hours is used to explore the influence of hours change on employment. One example is Calmfors (1985) which shows that it is not obvious that a reduction of working time will increase employment.

2. Models in which hours is endogenously set by the firm within the model, but is not bargained over by the union. For example, Hart (1984, 1987, 1989) separates hours into standard hours and overtime hours, and shows that a fall in standard hours will lead the firm to substitute more overtime hours for less

workers; a rise of per worker cost increases the marginal cost of new employment ralative to hours, and induces substitution of hours for employment, a rise of standard wage or overtime premium would encourage substitution in the opposite direction. Using a similar framework, Andrews, *et al.* (2000) conclude that the employment effect of a cut in weekly hours may be positive or negative, depends on the situation. Some parameter values may deliver a worksharing effect, some may not.

3. In the third type of models, hours is not only endogenously set within the model, but also is bargained over by the union. A leading example is Oswald & Walker (1996), who conclude that unions ration hours so that individuals are to the left of their rational labor supply curve.

Some papers study models of both type 2 & 3. For example Earle & Pencavel (1990), Marimon & Zilibotti (1999) and Booth & Ravallion (1993). None of these papers provide a comprehensive assessment of how exogenous influence on the bargaining process affect hours.

In contrast, the empirical study of union and hours have shown that the union hours gap, in most cases, is negative and not negligible in size. It varies considerably by type of worker, by industry and by occupation.

My intention is to develop the third type of models in which bargaining over hours is allowed. We shall explore how unions bargaining, the change of union bargaining power or the employment preference in union's utility function, affect hours determination. In different bargaining scenarios, we might exepect the union effect will be different in hours setting as well as wages and employment. The following chapter will comapartively study the influence of union bargaining on hours in both strong and weak Right-to Manage model, and Full Efficient Bargaining Model.

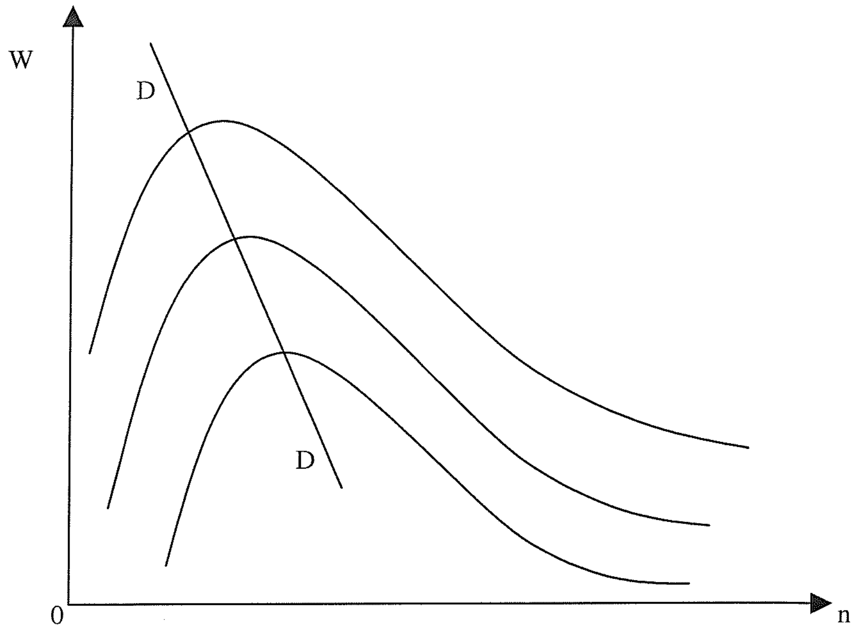

Figure 2.1 Iso-profit Curve of the firm

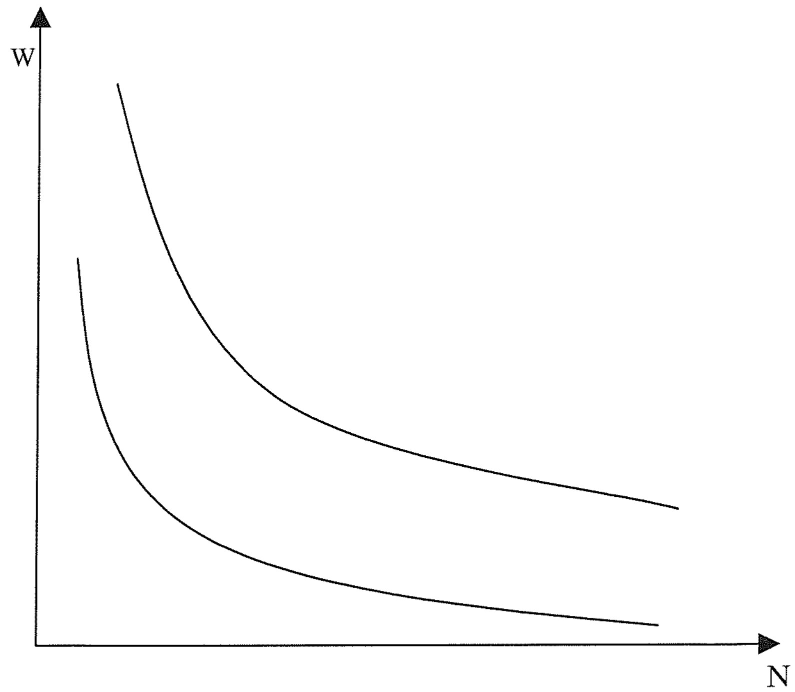

Figure 2.2 Union Indifference Curves

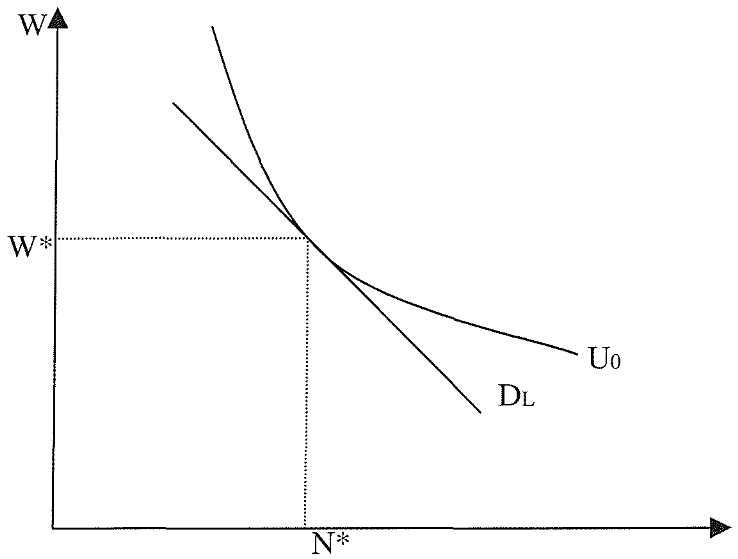

Figure 2.3 Wage and Employment Outcome: On the demand curve

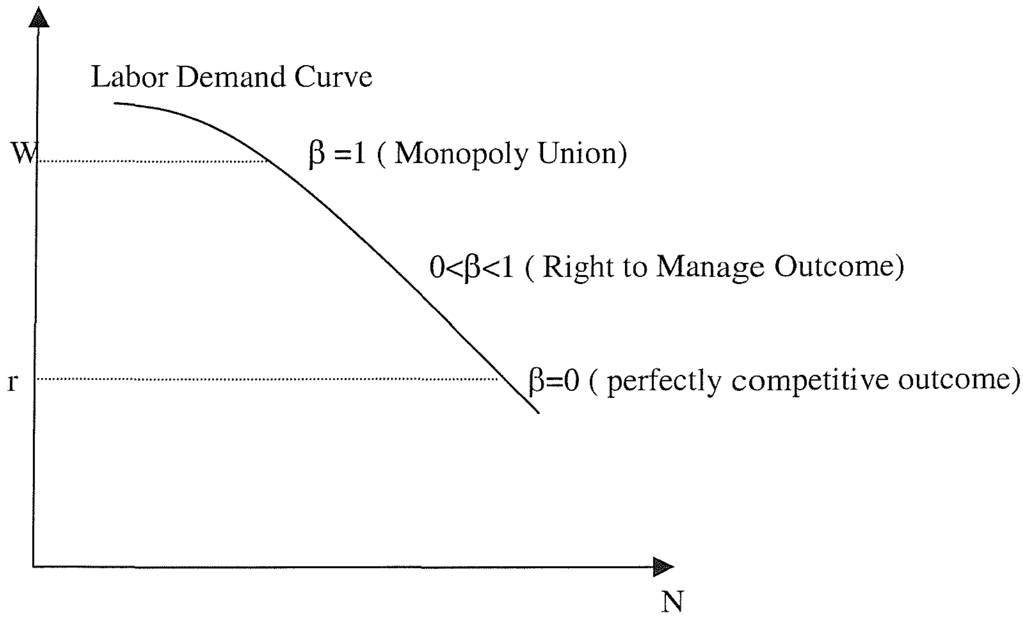

Figure 2.4 Bargaining on the demand curve with different β

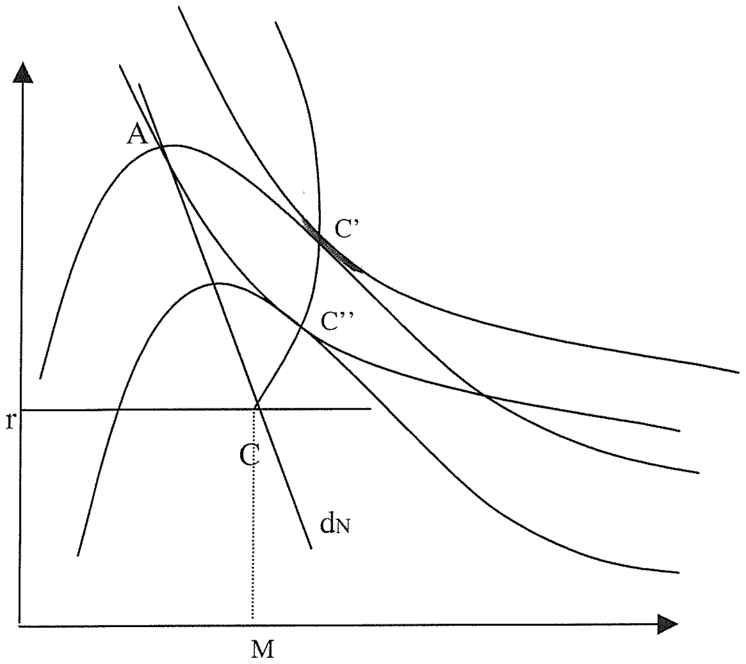

Figure 2.5: Wage and Employment: off the demand curve

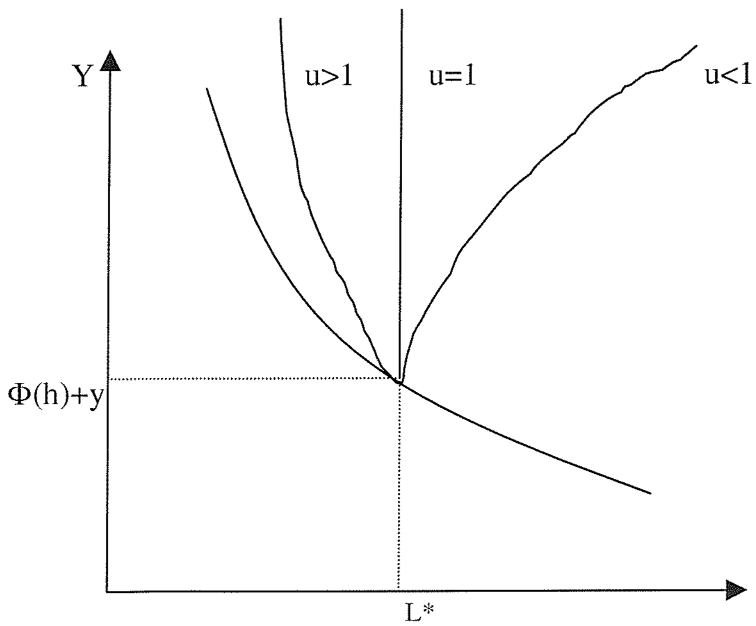

Figure 2.6 Contract Curve with different u

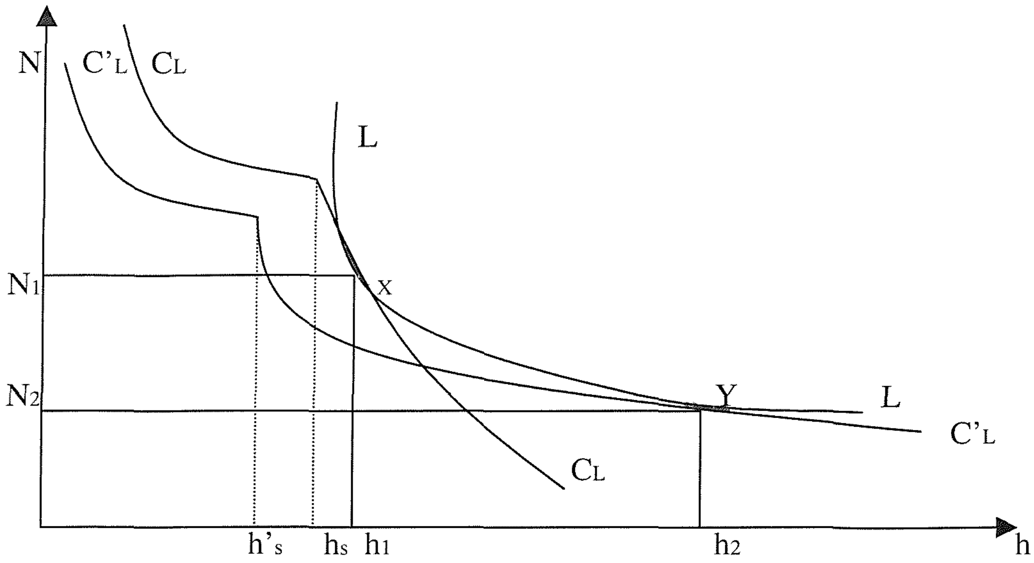

Figure 2.7: Reaction of working hours to a change of standard works

Chapter Three: The Influence of Union on Working Hours

1 Abstract

This paper studies the effect of union bargaining on working hours in different union-management bargaining frameworks. Three frameworks regarding how bargaining influences hours have been considered. In framework 1, the union bargain over the wage rate with the firm only, then the firm sets the employment and working hours unilaterally; in framework 2 the union and firm jointly determine the wage rate as well as the working hours. The firm will choose the employment afterwards; in framework 3 both parties bargain over all the three variables: employment, working hours and wage rates. Then I find that higher union bargaining power leads to lower working hours and higher wage rates. The employment effect is ambiguous, and depends on both the bargaining framework and the value of the other variables. Furthermore, by comparing with other union bargaining models, it shows to what extent this paper is or is not consistent with the literature.

2 Introduction

Many studies have found that the union bargaining will increase the wage markup. However, recently economists are increasingly concerned about the union's role in setting working hours, and the relationship among the working hours, wages and employment. Nevertheless little work has been done on how union affect hours. Pencavel (1990) discusses various bargaining models in terms of the determination of working hours in different bargaining situations. However he can not offer more detailed comparative statics of the bargaining procedure, how hours, employment and wage rate are affected by the bargaining. He indicates from his empirical finding that there is a negative effect of unionism on annual full-time hours worked. While Freeman & Medoff (1984), Lewis(1986), Blanchflower(1996), Perloff(1987) and Raisian (1983) find that for most demographic groups the union hours markup are negative. Working hour differences vary considerably by type of worker, the average is -1.8%

More recently there is a view of work-sharing spreading in the literature. They argue that if working hours have been reduced by the effect of bargaining or legislation, the employment might be increased by way of spreading the work to other people. For example, Calmfors (1985) and Marimon & Zilibotti (1999) prove there is an ambiguous or rather restrictive relation between working hours and employment. Booth & Ravallion (1993) have two stage decision models for the efficient bargaining model and the monopoly union model, (employment is decided by the firm after the wage and hours have been set by the bargaining or unilaterally by the union.), on the assumption that hours has the effect on the labor's productivity, namely that workers will be more productive after a cut in hours. And they conclude that a cut in hours will increase employment if the absolute wage elasticity of labor demand is less than the share of variable labor costs in the wage bill. But this is not true for monopoly union model. More details regarding hours literature have been described in Chapter Two.

The purpose of this paper is to study the bargaining effect on working hours as well as the employment and wages. In this paper, I begin from the firm's profit function and union objective function in a general framework and nest other objective functions as special cases by specifying the function parameter. My concern is to examine how the bargaining outcome is influenced by the different bargaining situation and different bargaining power, or different union preference. The assumptions that have been made are that the model is based on closed shop employment, and the elasticity of utility with respect to earning and the leisure of individual worker is constant. By maximizing both bargaining party's utilities subject to different constraint, I derive the comparative statics for different models.

Three models have been defined in this work in terms of what variables they are bargaining over. Model 1 and 2 belong to the right to manage model, and model 3 is the full efficient bargaining model.

The main findings of this paper are as follows:

1. An increase in the union bargaining power will reduce hours of work and increase wage rate in each of the bargaining scenario studied here. The effect on employment varies according to the framework. The effect is negative in right to manage models, but is ambiguous in the full efficient bargaining model.

2. An increase in the fixed cost of each worker does not change the hours set in all three bargaining models.

3. Optimal bargaining hours are the same in all three bargaining models. It only depends on (i) the external price (technology) parameter, (ii) the union's bargaining power, and (iii) the union's preference.

4. Hours of work are negatively related to the wage rate. Moreover, in the right to manage model, total earnings are a fixed amount. However in the other *two models, they increase with union preference over employment.*

5. An increase of union's preference for employment will increase hours of working, and reduce wage rate. Whereas the employment effect varies with the bargaining framework. It increases employment in the right to manage models, but is ambiguous in full efficient bargaining model.

6. Price (technology) shocks will not affect the hours of work and wage rates. They only have major effects on employment regardless of the bargaining framework.

7. Union workers may be rationed in their hours of working, or may be required to work for more hours than they wish. This is true for all three bargaining frameworks. The outcome is determined by the value of the parameters.

8.*Provided with same bargaining power* $1-\beta$ *and weight* θ *on employment in the union utility function as well as other parameters, the wage rate and working hours would be set equal in Model 2 & 3, the employment level would be higher in Model 3 than it in Model 2. Individual utility would be maintained at the same level, while the union's total utility would be higher in Efficient Bargaining Model, firm's profit would be higher in the (weak) Right to Manage Model. However Model 1 is not comparable with Model 2 or 3.*

Overall the comparative statics show that the union tends to reduce the working hours, although the employment effect may or may not be ambiguous. In the following Section II I will present the theoretical models and analyse the union bargaining effect on the working hours , employment and wage rate by their power. Section III is a comparison work with union bargaining literature, i.e. McDonald & Solow, Oswald & Walker and Ulph& Ulph. The conclusion is in section IV.

3 Theoretical Model

There are different kinds of union-management bargaining models. The crucial issue among these models is whether the bargaining parties, union and firm, share the bargaining power over all or part of the variables, or set the variables unilaterally. The economists would normally distinguish them as the Recursive contract model, the Right to Manage model and the Efficient contract model[2]. In this section I will set up models for different bargaining situations in terms of the union's presence or absence as well as bargaining variables. My concern is, in different cases, to assess unions in light of how they affect the worker's wage and working hours, or labor employment.

3.1 Firm's Profit Function and Union Utility Function

3.1.1 Firm's Profit Function

Here the firm's profit function is defined as

$$\pi = R(H, L, K) - WHL - cL \qquad {}^{3}$$

where R is gross revenue; W is the wage rate per hour per employee; H is the working hours of each employee; L is the number of workers hired by the firm; K is the capital endowed by the firm; c is the fixed cost of each employee, such as hiring cost, training cost and certain fringe expenditures, etc. If c is written as $c = c' - s$, then s can be interpreted as government subsidy for training, or employment.

Consider the production function of the firm as

$$Y = A'(H^{\alpha_1} L^{\alpha_2}) K^{1-\alpha_1-\alpha_2}$$

[2] The definition of these models see Earle and Pencavel 1990.

where $A^{'}$ is a parameter, and $0 < \alpha_{1,}\alpha_2 < 1$. Thus labor services are produced in a Cobb-Douglas relationship between hours of work and the number of employees. In this model these two factors, hours and employees, are perfectly substitutable inputs of labor services. Total efficient labor services can be achieved either by less labor more hours from each employee, or by more labor and less hours. And supposing the firm only produce a unique product, it is a price taker. The price of this product is P which is exogenous. Furthermore we assume K, the capital endowed by the firm to be a fixed factor. Therefore we can write

$$\begin{aligned} R(H,L,K) &= PA^{'}(H^{\alpha_1}L^{\alpha_2})K^{1-\alpha_1-\alpha_2} \\ &= A(H^{\alpha_1}L^{\alpha_2}) \end{aligned}$$

where $A = PA^{'}K^{1-\alpha_1-\alpha_2}$, here we can interpret A as an indicator of price and technology. Thus firm's profit function can be described as,

$$\pi = A(H^{\alpha_1}L^{\alpha_2}) - WHL - cL \tag{3.1.1}$$

3.1.2 Union Objective Function

In fact, the union is concerned with how many members it has, as well as each individual worker's utility. We assume that each worker has an identical utility function $u(WH, T-H)$. The definition of W, H are the same with the firm's profit function, and T is the total hours available from each worker. The first term in the bracket WH, represents the total earning of the worker, and $T-H$ denotes how much leisure the worker can enjoy. So $u_1 = \partial u/\partial(WH) > 0$, and $u_2 = \partial u/\partial(T-H) > 0$.

We construct the union's objective function Γ as argument :

$$\Gamma = L^{\theta}u(WH, T-H), \theta > 0 \tag{3.1.2}$$

where L is the number of workers in the union. θ measures the union's preference over employment concerning how much weight the union puts on labor in its objective function. If θ equals 1, it would simply be interpreted as that union's objective is to maximize total utility of its members. If θ equals 0, it would be interpreted as to maximize the representative worker's utility. The model has been assumed as a closed shop case, which means if the worker wants to work, he has to join the union. Therefore we have the L in union objective function is identical to L in firm's profit function.

3.2 Model 1:The (Strong) Right To Manage Model

Now let's consider the first case, given the firm's profit function and union's objective function. The both parties are going to bargain over wage rate only, then firm would set employment and hours of work unilaterally to maximize its profit. In other words, after the wage rate has been jointly determined, the firm will choose its employment level and hours of work subject to the profit-maximization condition $\partial\pi/\partial H = 0$, and $\partial\pi/\partial L = 0$. Thus the bargaining problem can be described by the maximization problem of the following function G subject to two constraints:

$$\underset{s.t.\partial\pi/\partial H=0,\partial\pi/\partial L=0}{Max} \quad G_1' = (\pi - \pi_0)^{\beta}(\Gamma - \Gamma_0)^{1-\beta}$$

where β is the bargaining power parameter, π_0, Γ_0 is the alternative payoff if they do not have agreement. Here I assume $\pi_0 = \Gamma_0 = 0$. So the function can be simplified as

$$\underset{s.t.\partial\pi/\partial H=0,\partial\pi/\partial L=0}{Max} \quad G_1' = \pi^{\beta}\Gamma^{1-\beta}$$

From $\frac{\partial\pi}{\partial H} = A\alpha_1 H^{\alpha_1-1}L^{\alpha_2} - WL = 0$, I can have

$$A\alpha_1 H^{\alpha_1-1}L^{\alpha_2-1} = W$$

From $\frac{\partial \pi}{\partial L} = A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - WH - c = 0$, it can be yielded

$$A\alpha_2 H^{\alpha_1} L^{\alpha_2-1} = WH + c$$

From these two equations, I have the solution for H and L as a function of W

$H = \frac{\alpha_1}{\alpha_2 - \alpha_1}\frac{c}{W}$ and $L = A^{\frac{1}{1-\alpha_2}} \alpha_1^{\frac{1}{1-\alpha_2}} (\alpha_2 - \alpha_1)^{\frac{1-\alpha_1}{1-\alpha_2}} c^{\frac{1-\alpha_1}{\alpha_2 - 1}} W^{\frac{\alpha_1}{\alpha_2-1}}$

The implicit assumption here is $\alpha_2 > \alpha_1$, which assumes in the production function, that a unit of labor is more productive than a unit of working hours. To simplify the solution of H and L, let $A_1 = \frac{\alpha_1}{\alpha_2 - \alpha_1}$, and $A_2 = A^{\frac{1}{1-\alpha_2}} \alpha_1^{\frac{1}{1-\alpha_2}} (\alpha_2 - \alpha_1)^{\frac{1-\alpha_1}{1-\alpha_2}}$, the above two equations can be rewritten as

$$\begin{aligned} H &= A_1 \frac{c}{W} \\ L &= A_2 c^{\frac{1-\alpha_1}{\alpha_2-1}} W^{\frac{\alpha_1}{\alpha_2-1}} \end{aligned} \tag{3.1.3}$$

In order to derive the wage bargaining, substitute (3.1.3) back to the firm's profit function π,

$$\begin{aligned} \pi &= A(A_1 \frac{c}{W})^{\alpha_1} \left[A_2 c^{\frac{1-\alpha_1}{\alpha_2-1}} W^{\frac{\alpha_1}{\alpha_2-1}}\right]^{\alpha_2} - A_1 c A_2 c^{\frac{1-\alpha_1}{\alpha_2-1}} W^{\frac{\alpha_1}{\alpha_2-1}} - cA_2 c^{\frac{1-\alpha_1}{\alpha_2-1}} W^{\frac{\alpha_1}{\alpha_2-1}} \\ &= D_1 W^{\frac{\alpha_1}{\alpha_2-1}} c^{\frac{\alpha_2-\alpha_1}{\alpha_2-1}} - D_2 W^{\frac{\alpha_1}{\alpha_2-1}} c^{\frac{1-\alpha_1}{\alpha_2-1}}, \end{aligned} \tag{3.1.4}$$

where$D_1 = AA_1^{\alpha_1} A_2^{\alpha_2}, D_2 = A_1 A_2 - A_2$

Since the maximization problem $\underset{s.t. \partial\pi/\partial H = 0, \partial\pi/\partial L = 0}{Max} \quad G_1' = \pi^{\beta}\Gamma^{1-\beta}$ is same with $\underset{s.t. \partial\pi/\partial H = 0, \partial\pi/\partial L = 0}{Max} \quad G_1 = \beta \ln \pi + (1-\beta)\ln \Gamma$.

Using (3.1.1),(3.1.2),(3.1.3) and (3.1.4)

$$\begin{aligned} G_1 &= \beta \ln \left(D_1 c^{\frac{\alpha_2-\alpha_1}{\alpha_2-1}} - D_2 c^{\frac{1-\alpha_1}{\alpha_2-1}} \right) + \beta \frac{\alpha_1}{\alpha_2 - 1} \ln W + (1-\beta)\theta \ln(A_2 c^{\frac{1-\alpha_1}{\alpha_2-1}}) \\ &+ (1-\beta)\theta \frac{\alpha_1}{\alpha_2-1} \ln W + (1-\beta)\ln u(WH, T-H) \end{aligned}$$

From the first order condition $\partial G_1/\partial W = 0$, I can have

$$\frac{\alpha_1\beta}{\alpha_2 - 1} + \frac{\alpha_1(1-\beta)\theta}{\alpha_2 - 1} + (1-\beta)\frac{u_2}{u}A_1 c\frac{1}{W} = 0$$

where u_2 is the differentiation of u with respect to $T - H$. Assume $\eta_2 = \frac{\partial u}{\partial(T-H)}\frac{T-H}{u}$, the elasticity of utility with respect to leisure is constant, than I can have

$$\begin{aligned} W &= \left[\frac{(1-\beta)\eta_2}{D} + 1\right]\frac{A_1 c}{T} \\ H &= \frac{T}{\frac{(1-\beta)\eta_2}{D} + 1} \\ L &= A_1^{\frac{\alpha_1}{\alpha_2 - 1}} A_2 T^{\frac{\alpha_1}{\alpha_2-1}} \left[\frac{(1-\beta)\eta_2}{D} + 1\right]^{\frac{\alpha_1}{\alpha_2-1}} c^{\frac{\alpha_1}{\alpha_2-1}} \end{aligned} \qquad (3.1.5)$$

where $D = \frac{\alpha_1\beta}{1-\alpha_2} + \frac{\alpha_1(1-\beta)\theta}{1-\alpha_2}$.

Thus the comparative statics are as follows:

$$\begin{aligned} \frac{dW}{d\beta} &< 0, \frac{dH}{d\beta} > 0, \frac{dL}{d\beta} > 0 \\ \frac{dW}{d\theta} &< 0, \frac{dH}{d\theta} > 0, \frac{dL}{d\theta} > 0 \\ \frac{dW}{dc} &> 0, \frac{dH}{dc} = 0, \frac{dL}{dc} < 0 \end{aligned}$$

Some stylized features turn up as:

(1) If a union has more bargaining power, or β is reduced, the individual's working hours as well as total employment would be reduced. However, it will increase the wage rate. From (3.1.3) we can see that the total earning of workers has been fixed as $A_1 c$, which is constant given any fixed cost per unit of labor.

The intuition behind this is, considering the union's objective function $\Gamma = L^\theta u(WH, T-H)$, leisure is always a normal good to the worker. The individual worker always prefer high wage rate and more leisure. Given the union has more power in the bargaining, the wage rate would be increased as a result. Since the firm will set the working hours and employment after the wage rate has been determined jointly, as the cost of labor services is increased, the firm will reduce H and L. The outcome shows that the worker's total earning has been maintained at the same level.

Furthermore, it also can be easily proved from (3.1.2) and (3.1.4) that

$$\frac{d\pi}{d\beta} > 0, \frac{du}{d\beta} < 0, \frac{d\Gamma}{d\beta} < 0 \qquad 4$$

Union and individual worker utility would be increased with bargaining power, while firm's profit would be decreased. Individual utility rises, and also total union utility rises, because individual utility rises sufficiently enough to outweigh the effect of lost employment. In other words, the firm's profit would be transferred from the firm's side to increase the representative worker's utility and union's total utility due to more bargaining power of the union.

(2) If the union is more concerned about the employment effect, and puts more weight θ on labor in its objective function, the bargaining outcome will show working hours and employment to be increased , whereas the workers have to sacrifice the high wage rate as the compensation. Moreover, it can also be shown from (3.1.2) and (3.1.4) that $\frac{d\pi}{d\theta} > 0, \frac{du}{d\theta} < 0$[5]. It indicates that the firm's profit is positively related with θ, but that each worker's utility is negatively related to θ. The intuition is that, as union's more interest on employment, it has to give up its strength on wage bargaining. With relativly cheap labor input, and more workers, the firm is increasing its profit, while each individual worker's utility are reduced.

(3) If the fixed cost of each unit of labor, c, is increased, it can be expected that employment would be reduced, as each worker would be more costly to

[5]The proof is very similar with Footnote 3.

the firm. If it is possible, the firm would prefer to increase the total number of working hours to substitute for the reduced number of employees. However given a more expensive fixed cost c, the union would anticipate that the employment would be reduced, thus it might insist on a higher wage rate in the bargaining process as compensation.

To some extent we may be surprised that $\frac{dH}{dc} = 0$, which denotes that the fixed cost will not affect the working hours at all. It might be expected that the firm will ask every employee to work more hours and cut employment, if c is more expensive, since the assumption has been made that hours and labor are perfectly substitutable for each other in the product function. To understand this, one possible explanation is that, as the wage rate has been raised due to the union's anticipation of reduced employment, the cost of labor service is increased, and the firm, therefore, can not afford to increase the working hours as it would wish. Another point which should be beared in mind is the assumption that the fixed cost c has been assumed to be exogenous, as it does not affect each worker's productivity even if the firm offers more training to each worker. If the assumption is changed to c is endogenous, it is possible to have a different situation.

(4) Technology and price shocks will not affect the hours of work and wage rate, but only affect employment, as in (3.1.5) A only enter with a positive relation in the expression of L, and does not appear at all in the expression of H and W .

We may expect that when productivity rises, the worker can either produce the same amount of output in less time or produce more output in the same time, which may tell us that the worker would either have more leisure time or have more money. It may have similar effect to the output price. The employment may have some adjustment to booms and slumps. However the surprising thing is that when the firm has more productive technology, or the price level of output rises, it will only hire more people to work with the same wage and the working hours.

Few studies have also realized that the fluctuations in aggregate demand have their major effect on employment and little or none on the wage and hours, i.e. McDonald & Solow (1981), Oswald & Walker (1996 Discussion Paper) . Whereas Ulph & Ulph (1990) indicate that hours of working is increasing with the output price. In the following section I address in detail whether their finding is consistent with this work.

Furthermore, I also can prove from (3.1.5) that $\frac{d^2L}{dAd\beta} > 0$, which means that if the union has less power in the bargaining, the employment effect would be more significant than when the union has more power.

(5) Union members may be rationed for their hours of working, or involuntarily work for some hours more than they wish. The outcome is determined by the value of parameters. So individuals may be to the left or to the right of their privately rational labor supply curves. Union hours are more likely to exceed the individual optimum when it does not have too much influence in the bargaining.

The individual worker's utility is $u(WH, T-H)$, the optimal hours individual would like to work are given from

$$u_1 W - u_2 = 0 \tag{3.1.6}$$

where $u_1 = \frac{\partial u}{\partial(WH)}, u_2 = \frac{\partial u}{\partial(T-H)}$. Divided by u on both sides of equation (3.1.6)

$$\frac{u_1}{u}W - \frac{u_2}{u} = 0$$

Assume that η_1, η_2, the elasticity of utility with respect to earning and leisure respectively, which is defined as

$\eta_1 = \frac{\partial u}{\partial(WH)}\frac{WH}{u}$, and $\eta_2 = \frac{\partial u}{\partial(T-H)}\frac{T-H}{u}$ are constant. Therefore we can have

$$\frac{\eta_1}{H^*} = \frac{\eta_2}{T-H^*}$$

and

$$H^* = \frac{T}{\frac{\eta_2}{\eta_1} + 1} \tag{3.1.7}$$

From (3.1.5) we know that hours set by the firm are $H = \frac{T}{\frac{(1-\alpha_2)(1-\beta)\eta_2}{\alpha_1[\beta+(1-\beta)\theta]}+1}$. Compare H with H^*, if

$$\frac{(1-\alpha_2)(1-\beta)}{\alpha_1[\beta+(1-\beta)\theta]} > \frac{1}{\eta_1}, \text{ then } H < H^*$$

This implies that bargaining hours are less than that at the individual optimum. In other words, given the bargaining wage rate, individuals would like to work more hours than they have been offered, however they have been rationed.

If

$$\frac{(1-\alpha_2)(1-\beta)}{\alpha_1[\beta+(1-\beta)\theta]} < \frac{1}{\eta_1}, \text{ then } H > H^*$$

This implies that the bargaining hours are more than at the individual optimum. In other words, individuals involuntarily work more hours than they wish to do.

When β is sufficiently close to 1, in other words, if the firm has sufficient bargaining power, it is more likely that $\frac{(1-\alpha_2)(1-\beta)}{\alpha_1[\beta+(1-\beta)\theta]} < \frac{1}{\eta_1}$, and hence actual hours will exceed individual optimal hours ($H > H^*$), employees have to work for more hours than they wish; When β is sufficiently close to 0, in other words, the union has sufficient bargaining power, and assuming that the elasticity of utility with respect to earning, η_1, is equal to 1, and θ is close to 1 in the mean time, $\frac{(1-\alpha_2)(1-\beta)}{\alpha_1[\beta+(1-\beta)\theta]} > \frac{1}{\eta_1}$ will hold, and so actual hours will be less than individual optimal hours ($H < H^*$), union hours would be rationed. If the union's preference over employment θ increases, it is also likely that individuals will work involuntarily for more hours.

[Figure 3.1 insert here]

In Figure 3.1, H_0H_1 is the hours curve where union members have exactly their optimal hours. On the left of H_0H_1, $H < H^*$, union members have been rationed for their hours of working; on the right of H_0H_1, $H > H^*$, union members involuntarily work for more hours than they wish.

To understand intuitively about this diagram, pick point A from H_0H_1, where employees have exactly optimal hours they want, and then move to horizontal left point B, where they have the same bargaining power β, but the value of θ, the union's employment preference, is less. At a lower level of θ, the employment level would be lower, therefore, the union would insist upon a higher level of individual utility. This can be achieved by a higher wage rate W . Given the same or a higher level of utility, unions would be indifferent to hours changes. On the firm's side, a higher wage rate would lead to a lower demand of hours from each worker, a unchanged fixed cost c would make the worker relatively cheaper. Thus union hours would be rationed if θ is decreased. If the movement is from A to C, with the same value of θ and a lower level of β (firm's bargaining power), it can also be expected that higher union's bargaining power leads to a higher wage rate for union members, and union hours would be rationed.

3.2.1 Two Special cases of the Model

Two variations of the preceding models will be considered in this section, "Representative" Individual Bargaining and Monopoly Unionism compared with the collective bargaining, and an examination of how the union behaves in the bargaining process.

"Representative" Individual Bargaining The firm may be thought of bargaining individually with as many workers as it chooses, in each case setting hours of work conditional on the wage bargaining outcome. There is no union. However this would be a complicated procedure to model. Furthermore substantial resources may be required to bargain with every worker. Hence we imagine that a firm bargains over wage with a representative worker, and then sets the wage rate for all employees. The firm is free to choose H and L afterwards. Assume $\theta = 0$ in the objective function, then it becomes $\Gamma = u(WH, T - H)$, which manifests representative worker's utility, or it could be interpreted as a representative individual bargaining, each worker has the same utility function. From (1.5) we can have

$$
\begin{aligned}
W_I &= \left[\frac{(1-\alpha_2)(1-\beta)\eta_2}{\alpha_1\beta}+1\right]\frac{A_1 c}{T} \\
H_I &= \frac{T}{\frac{(1-\alpha_2)(1-\beta)\eta_2}{\alpha_1\beta}+1} \\
L_I &= A_1^{\frac{\alpha_1}{\alpha_2-1}} A_2 T^{\frac{\alpha_1}{\alpha_2-1}} \left[\frac{(1-\alpha_2)(1-\beta)\eta_2}{\alpha_1\beta}+1\right]^{\frac{\alpha_1}{\alpha_2-1}} c^{\frac{\alpha_1}{\alpha_2-1}}
\end{aligned}
$$

which shows that the individual worker's wage is higher than in collective bargaining, and working hours is less. The earnings have been maintained at the same level. So the worker has more leisure to enjoy with the same amount of income. The individual worker's utility is higher than that of collective bargaining. This is because that bargaining outcome is equal to a union that maximizes individual utility without any concern on employment.

Monopoly Unionism Monopoly unionism is, once the wage rate are determined by the unions unilaterally, the firm is free to set employment and hours adjusting to its new profit-maximizing level. The settlement would occur on the labors demand curve.

Now let's come back to the model, and set $\beta = 0$ in the argument $\underset{s.t.\partial\pi/\partial H=0,\partial\pi/\partial L=0}{Max} G_1' = (\pi-\pi_0)^{\beta}(\Gamma-\Gamma_0)^{1-\beta}$. From (3.1.5) I have

$$
\begin{aligned}
W_M &= \left[\frac{(1-\alpha_2)\eta_2}{\alpha_1\theta}+1\right]\frac{A_1 c}{T} \\
H_M &= \frac{T}{\frac{(1-\alpha_2)\eta_2}{\alpha_1\theta}+1} \\
L_M &= A_1^{\frac{\alpha_1}{\alpha_2-1}} A_2 T^{\frac{\alpha_1}{\alpha_2-1}} \left[\frac{(1-\alpha_2)\eta_2}{\alpha_1\theta}+1\right]^{\frac{\alpha_1}{\alpha_2-1}} c^{\frac{\alpha_1}{\alpha_2-1}}
\end{aligned}
$$

It would be expected that it would lead to a higher wage rate, and lower employment compared with collective bargaining. And individuals would work less hours with the same amount of income. Each worker's utility has been increased as it is in the individual bargaining.

Compare hours of work in "Representative" Individual Bargaining and Monopoly Unionism, if

$$\theta > \frac{\beta}{1-\beta}, \qquad \text{then} \qquad H_M > H_I$$
$$\theta < \frac{\beta}{1-\beta}, \qquad \text{then} \qquad H_M < H_I$$

So if the employment weight θ is greater than the ratio of the firm's bargaining power to the union (individual)'s bargaining power, hours of work in the "Representative" Individual Bargaining would be less than it is in Monopoly Unionism. Otherwise it would be greater than the hours of work in Monopoly Unionism. In the circumstance when the union (individual) and the firm have equal bargaining power, $\beta = 1/2$, then when $\theta = 1$, the union's objective is to maximize the total utility of its members, H_I would equal to H_M; when $\theta < 1$, then $H_M < H_I$, any Monopoly Bargaining hours would be less than "Representative" Individual Bargaining hours when $\beta = 1/2$. The relationship can be seen in the following figure 3.2.

[Figure 3.2 Insert here]

The working hours increas with β and θ. Monopoly Unionism hours are along the Y axis where $\beta = 0$ in bargaining model 1. Hence monopoly unionism hours is less than hours in model 1. When $\beta = 0, \theta = 1$, Monopoly Unionism hours H_{M0} equals to H_{I_1}, Representative Individual Bargaining when $\beta = 1/2, \theta = 0$.

3.3 Model 2: The (Weak) Right To Manage Model

The previous model characterizes the both bargaining parties only jointly determine over wage rate, and the firm will fix hours of work and the number of employees according to its own interest. However, if there is a slight modification of the model 1, which the firm and union jointly determine not only the wage rate but also working hours, afterwards the firm would set the number of employees regarding the bargaining result. This problem can be described as to maximize the function G_2' subject to $\partial\pi/\partial L = 0$:

$$\underset{s.t.\partial\pi/\partial L=0}{Max} \quad G_2' = (\pi - \pi_0)^{\beta}(\Gamma - \Gamma_0)^{1-\beta}$$

instead of two constraints in model 1. It can be also described as

$$\underset{s.t.\partial\pi/\partial L=0}{Max} \quad G_2 = \beta \ln \pi + (1-\beta)\ln \Gamma \tag{3.2.1}$$

From the maximization constraint $\partial\pi/\partial L = 0$, I can have

$$\partial\pi/\partial L = A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - WH - c = 0$$

then

$$L = \left[\frac{1}{A\alpha_2} H^{-\alpha_1}(WH + c)\right]^{\frac{1}{\alpha_2 - 1}} \tag{3.2.2}$$

Combine (3.2.2) and (3.1.1),

$$\begin{aligned} \pi &= A^{\frac{1}{1-\alpha_2}}(\alpha_2^{\frac{\alpha_2}{1-\alpha_2}} - \alpha_2^{\frac{1}{1-\alpha_2}})H^{\frac{\alpha_1}{1-\alpha_2}}(WH + c)^{\frac{\alpha_2}{\alpha_2 - 1}} \\ &= \lambda H^{\frac{\alpha_1}{1-\alpha_2}}(WH + c)^{\frac{\alpha_2}{\alpha_2 - 1}} \end{aligned} \tag{3.2.3}$$

where $\lambda = A^{\frac{1}{1-\alpha_2}}(\alpha_2^{\frac{\alpha_2}{1-\alpha_2}} - \alpha_2^{\frac{1}{1-\alpha_2}})$ is a constant .

Substitute (3.2.2) back to (3.2.1),

$$\begin{aligned} G_2 &= \beta \ln \lambda + \beta \frac{\alpha_1}{1-\alpha_2} \ln H + \frac{\alpha_2 \beta}{\alpha_2 - 1} \ln(WH + c) + \frac{(1-\beta)\theta}{1-\alpha_2} \ln A\alpha_2 \\ &+ \frac{(1-\beta)\theta\alpha_1}{1-\alpha_2} \ln H + \frac{(1-\beta)\theta}{\alpha_2 - 1} \ln(WH + c) + (1-\beta)\ln u(WH, T - H) \end{aligned}$$

The first order condition for optimisation are

$$\frac{\partial G}{\partial H} = \frac{D}{H} - \frac{D_3 W}{WH + c} + (1-\beta)\left[\frac{\eta_1}{H} - \frac{\eta_2}{T - H}\right] = 0, \tag{3.2.4}$$

$$\frac{\partial G}{\partial W} = -\frac{A_2 H}{WH + c} + \frac{1-\beta}{WH}\eta_1 H = 0 \tag{3.2.5}$$

where $D = \frac{\alpha_1[\beta+(1-\beta)\theta]}{1-\alpha_2}$, and $D_3 = \frac{\alpha_2\beta+(1-\beta)\theta}{1-\alpha_2}$, η_1, η_2 are the elasticity of utility with respect to earning and leisure respectively, which are defined as

$\eta_1 = \frac{\partial u}{\partial(WH)}\frac{WH}{u}$, and $\eta_2 = \frac{\partial u}{\partial(T-H)}\frac{T-H}{u}$. Here I assume η_1, η_2 are constant.

Simplify (3.2.5) as

$$W = \frac{c}{D_4 H} \tag{3.2.6}$$

where $D_4 = \frac{D_3}{\eta_1(1-\beta)} - 1$. The implicit assumption here is $\frac{D_3}{\eta_1(1-\beta)} \geq 1$, in order to guarantee $W \geq 0$.

Combine (3.2.2), (3.2.4) and (3.2.6),

$$\begin{aligned} W &= \frac{c}{D_4}\frac{\frac{(1-\beta)\eta_2}{D}+1}{T} \\ H &= \frac{T}{\frac{(1-\beta)\eta_2}{D}+1} \\ L &= \left[\frac{1}{A\alpha_1}\left(\frac{\frac{(1-\beta)\eta_2}{D}+1}{T}\right)^{\alpha_1}\left(\frac{c}{D_4}+c\right)\right]^{\frac{1}{\alpha_2-1}} \end{aligned} \tag{3.2.7}$$

The comparative statics are as the following:

$$\begin{aligned} \frac{dW}{d\beta} &< 0, \frac{dH}{d\beta} > 0, \frac{dL}{d\beta} > 0 \\ \frac{dW}{d\theta} &< 0, \frac{dH}{d\theta} > 0, \frac{dL}{d\theta} > 0 \\ \frac{dW}{dc} &> 0, \frac{dH}{dc} = 0, \frac{dL}{dc} < 0 \end{aligned}$$

The comparative statics are exactly the same as model 1. Therefore features (1)-(5) can also be derived from this model. However there are some slight differences between these two models.

(1) In model 1, the total earning of workers is a fixed amount as long as α_1, α_2 are fixed, which equals to $\frac{\alpha_1}{\alpha_2-\alpha_1}c$. Whereas in model 2, the total earning

of workers equals to $\frac{c}{D_4}$, which is affected by the firm bargaining power β, and the employment weight θ in union objective function. We can show from (3.2.6) that $\frac{d(WH)}{d\beta} < 0, \frac{d(WH)}{d\theta} < 0$, which indicates that total earning has a positive relationship with union bargaining power, and a negative relationship with the employment weight θ.

(2) The implicit assumption in model 1 is $\alpha_2 > \alpha_1$, however in model 2 it is $\frac{D_3}{\eta_1(1-\beta)} \geq 1$. Another interesting point is that the hours of working in these two models are exactly the same, but the wage rate W and Employment L are different. Especially in Model 2, W and L are not only affected by η_2, the elasticity of utility with respect to leisure, but also affected by η_1, the elasticity of utility with respect to earning. However in model 1 they are only concerned with the η_2.

It indicates that no matter whatever the union and firm bargain over the working hours or the firm chooses it according to its own interests, in the end the bargaining outcome for the working hours will be the same . But the difference only comes to the W and L.

(3) " Increasing working hours" seems to be "job creating", as it increases the employment while the working hours rises. The popular confidence of some economists is "work sharing". If unions cut the working hours of each worker, the firm may hire more people to work, based on the idea that the amounts of work has to be done is fixed (Hunt, 1998). However from this model, we find if hours has been reduced no matter because of more union bargaining power or the bigger employment weight θ, it follows with a lower employment and higher wage rate, not the higher employment as the popular confidence expect.

One possible reason for this is that the marginal cost of production has been increased if the firm reduces the working hours. It may be because of the higher wage rate or because the firm has to pay more training costs if it hires more people to substitute for lower working hours,...etc. Thus the optimal output may fall, or the firm may move away from the labor to other substitution inputs, and this leads to lower employment.

3.3.1 Diagrammatic Expression

In order to show more clearly about the union effects, in this section, some diagrams will be drawn to explain when β or θ changes, how the both bargaining parties utility changes. McDonald & Solow (1981) has given a well known diagram in terms of the trade off between wage and employment. He predicts there would be greater employment and a lower wage if the union comes into the bargaining. It is showed in the diagram,

[Figure 3.3 insert here]

The model 1, the strong Right to Manage model is the case where settlement is on the demand curve. However model 2, the weak Right to Manage model is the case where settlement is off demand curve. And with endogenous hours this shall be different with McDonald & Solow's figure.

As the union's objective function is $\Gamma = L^{\theta}u(WH, T-H)$, let's start from the individual utility function $\Gamma = u(WH, T-H)$ when $\theta = 0$. Given any constant Γ,

$$\frac{dW}{dH} = -\frac{u_H}{u_W} = -\frac{u_1 W - u_2}{u_1 H} = \frac{\frac{\eta_2}{T-H} - \frac{\eta_1}{H}}{\frac{\eta_1}{W}}$$

So

$$\frac{dW}{dH} \lesseqgtr 0 \Longleftrightarrow \frac{\eta_2}{T-H} - \frac{\eta_1}{H} \lesseqgtr 0 \Longleftrightarrow (\eta_1 + \eta_2)H - \eta_1 T \lesseqgtr 0$$

The slope of worker's indifference curve would be negative until $H = \frac{\eta_1 T}{\eta_1 + \eta_2}$, then it is going to be positive. Thus the indifference curve will look like Figure 3.4. The higher wage rate W would be better off for the worker.

[Figure 3.4 insert here]

Consider if $\theta > 0$, from (3.2.2), $L = \left[\frac{1}{A\alpha_2} H^{-\alpha_1}(WH + c)\right]^{\frac{1}{\alpha_2 - 1}}$, and $Ln\Gamma$ can be written as

$$\begin{aligned}\ln\Gamma &= \frac{\theta}{1-\alpha_2}\ln A\alpha_2 + \frac{\theta\alpha_1}{1-\alpha_2}\ln H + \frac{\theta}{\alpha_2 - 1}\ln(WH + c) + \ln u(WH, T - H) \\ &= f(W, H)\end{aligned}$$

where $f(W, H)$ is a function of W and H.

Given any constant Γ,

$$\begin{aligned}\frac{dW}{dH} &= -\frac{f_W}{f_H} = -\frac{\frac{\alpha_1\theta}{1-\alpha_2}\frac{1}{H} + \frac{\theta}{\alpha_2-1}\frac{1}{WH+c} + \frac{u_1W-u_2}{u}}{\frac{\theta}{\alpha_2-1}\frac{H}{WH+c} + \frac{u_1H}{u}} \\ &= \frac{\frac{\eta_2}{T-H} - \frac{\eta_1}{H} + \frac{\theta}{1-\alpha_2}\frac{(1-\alpha_1)WH-\alpha_2 c}{(WH+c)H}}{\frac{\eta_1}{W} - \frac{\theta}{1-\alpha_2}\frac{H}{WH+c}}\end{aligned}$$

It would be very difficult to sign the $\frac{dW}{dH}$. In order to draw the diagram, a very special case will only be considered here, which assumes when

$$\begin{aligned}H &\geq \overline{H_1} \\ \frac{WH}{c} &\geq \varphi = Max\left[\frac{\alpha_2}{1-\alpha_1}, \frac{2\alpha_1}{\alpha_2 - \alpha_1}\right]\end{aligned}$$

where $\overline{H_1}$ is a positive number, and $\eta_1 > \frac{\theta}{1-\alpha_2}$. It means that when the worker works more than some fixed hours $\overline{H_1}$, the total earning of each worker will be greater than φ times of the fixed cost c . The assumption $\eta_1 > \frac{\theta}{1-\alpha_2}$ is to guarantee that the denominator is always positive.

When $\theta = 0$, I have shown that $\frac{dW}{dH}$ is from negative to positive when H is getting bigger. Now $\theta > 0$, combine the assumption above, when H is smaller than $\overline{H_1}$, $\frac{\theta}{1-\alpha_2}\frac{(1-\alpha_1)WH-\alpha_2 c}{(WH+c)H} < 0$, in the mean time, the denominator $\frac{\eta_1}{W} - \frac{\theta}{1-\alpha_2}\frac{H}{WH+c}$ is also getting small, which means the slope of the utility indifference curve would be more negative when H is small. When H is getting bigger than $\overline{H_1}$,

$\frac{\theta}{1-\alpha_2}\frac{(1-\alpha_1)WH-\alpha_2 c}{(WH+c)H} > 0$, which means the slope would be more positive. Thus the indifference utility curve would be shown as Figure 3.5.

[Figure 3.5 insert here]

Consider the profit function $\pi = A(H^{\alpha_1}L^{\alpha_2}) - WHL - cL$, and

$$L = \left[\frac{1}{A\alpha_2}H^{-\alpha_1}(WH+c)\right]^{\frac{1}{\alpha_2-1}}$$

We would sign the slope of the isoprofit curve. From (2.3) : $\pi = \lambda H^{\frac{\alpha_1}{1-\alpha_2}}(WH+c)^{\frac{\alpha_2}{\alpha_2-1}}$, given any constant π,

$$\begin{aligned} \frac{dW}{dH} \mid_{\pi=\pi_0} &= -\frac{f_H}{f_W} \qquad (3.2.8) \\ &= -\frac{\lambda\frac{\alpha_1}{1-\alpha_2}H^{\frac{\alpha_1}{1-\alpha_2}-1}(WH+c)^{\frac{\alpha_2}{\alpha_2-1}} + \lambda H^{\frac{\alpha_1}{1-\alpha_2}}\frac{\alpha_2}{\alpha_2-1}(WH+c)^{\frac{\alpha_2}{\alpha_2-1}-1}W}{\lambda H^{\frac{\alpha_1}{1-\alpha_2}}\frac{\alpha_2}{\alpha_2-1}(WH+c)^{\frac{\alpha_2}{\alpha_2-1}-1}H} \\ &= \frac{(\alpha_1-\alpha_2)WH+\alpha_1 c}{\alpha_2 H^2} \end{aligned}$$

If $\alpha_1 \geq \alpha_2$, $\frac{dW}{dH}$ is positive, the isoprofit curve is upward sloping. If $\alpha_1 < \alpha_2$, combine the assumption $H \geq \overline{H_1}$, $\frac{WH}{c} \geq \varphi = Max\left[\frac{\alpha_2}{1-\alpha_1}, \frac{2\alpha_1}{\alpha_1-\alpha_2}\right]$, the isoprofit curve would be positive until H reaches $\overline{H_1}$, then negative afterwards.

$$\begin{aligned} \frac{d^2W}{dH^2} &= \frac{(\alpha_1-\alpha_2)W\alpha_2 H^2 - [(\alpha_1-\alpha_2)WH+\alpha_1 c]\,2\alpha_2 H}{\alpha_2^2 H^4} \qquad (3.2.9) \\ &= -\frac{(\alpha_1-\alpha_2)WH+2\alpha_1 c}{\alpha_2 H^3} \end{aligned}$$

So if $\alpha_1 \geq \alpha_2$, (3.2.9) would be negative. And because $\frac{dW}{dH} > 0$, the isoprofit curve would be as Figure 3.6. If $\alpha_1 < \alpha_2$, come back to the assumption, if $H \leq \overline{H_1}$,(3.2.9) would be negative; if $H \geq \overline{H_1}$,(3.2.9) would be positive. Then the isoprofit curve would be as Figure 3.7. The higher wage rate will make the firm worse off.

[Figure 3.6 insert here]

[Figure 3.7 insert here]

The following Figure 3.8 and Figure 3.9 show that if the union has less bargaining power (β is increasing), in the circumstance of $\alpha_1 \geq \alpha_2$ or $\alpha_1 < \alpha_2$, the firm's isoprofit curve moves to a higher level, and working hours changes from H_1 to H_2, the employee would work more hours with a lower wage rate W_2.

[Figure 3.8 insert here]

[Figure 3.9 insert here]

If θ, the union preference over employment in the union's objective function, is changing, it will be another case but a similar result to when the firm has more bargaining power. The following figure 3.10 and Figure 3.11 show that if θ is increasing, the bargaining will lead to a higher level of firm's Isoprofit Curve, and the individual worker will work more hours with lower wage rate. Whilst the employment, which we can not see from the figure, is increased as the union expects.

[Figure 3.10 insert here]

[Figure 3.11 insert here]

3.4 Model 3: Efficient Bargaining Model

The argument of this section is to consider the Full Efficient Bargaining model, in which both parties bargain over all the variables: employment , wage rate as well as the hours of working. The firm has no priority to set any variable according to its own interest. It seems to be just a slight modification of the last two models, but it offers a big change to the bargaining outcome. The problem can be described as

$$Max\ G_3' = (\pi - \pi_0)^{\beta}(\Gamma - \Gamma_0)^{1-\beta}$$

and rewrite it as

$$MaxG_3 = \beta \ln \pi + (1-\beta) \ln \Gamma$$

Combine (3.1.1) and (3.1.2),

$$G_3 = \beta \ln \left[A(H^{\alpha_1} L^{\alpha_2}) - WHL - cL\right] + (1-\beta)\,\theta \ln L + (1-\beta) \ln u(WH, T-H) \tag{3.3.1}$$

The First Order condition gives

$$\frac{\partial G_3}{\partial L} = \frac{\beta\,(A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - WH - c)}{A\,(H^{\alpha_1} L^{\alpha_2}) - WHL - cL} + \frac{(1-\beta)\,\theta}{L} = 0 \tag{3.3.2}$$

$$\frac{\partial G_3}{\partial W} = \frac{\beta\,(-HL)}{A\,(H^{\alpha_1} L^{\alpha_2}) - WHL - cL} + \frac{(1-\beta)\,u_1 H}{u} = 0 \tag{3.3.3}$$

$$\frac{\partial G_3}{\partial H} = \frac{\beta\,[A\alpha_1 H^{\alpha_1 - 1} L^{\alpha_2} - WL]}{A\,(H^{\alpha_1} L^{\alpha_2}) - WHL - cL} + \frac{(1-\beta)\,(u_1 W - u_2)}{u} = 0 \tag{3.3.4}$$

Solve this equation system:

$$W = \frac{c}{\left(\frac{\theta}{\eta_1} - 1\right) H + \frac{\alpha_2 \eta_2}{\alpha_1 \eta_1} \frac{H^2}{T-H}} \tag{3.3.5}$$

$$L = \left[\frac{\eta_2}{\eta_1} \frac{H^{2-\alpha_1}}{A\alpha_1} \frac{c}{\left(\frac{\theta}{\eta_1} - 1\right) H\,(T-H) + \frac{\alpha_2 \eta_2}{\alpha_1 \eta_1} H^2}\right]^{\frac{1}{\alpha_2 - 1}} \tag{3.3.6}$$

$$H = \frac{[\beta + (1-\beta)\,\theta]\,T}{\beta + (1-\beta)\lambda_1} \tag{3.3.7}$$

where $\lambda_1 = \frac{(1-\alpha_2)\eta_2}{\alpha_1} + \theta$, all the definition of the variables are the same with last two models. As wage is non-negative, the implicit assumption of (3.3.5) is

$$\frac{\theta}{\eta_1} - 1 + \frac{\alpha_2 \eta_2}{\alpha_1 \eta_1} \frac{H}{T-H} \geq 0$$

and (3.3.7) yields that $\frac{H}{T-H} = \frac{\alpha_1}{(1-\alpha_2)\eta_2} \frac{(1-\beta)\theta + \beta}{1-\beta}$. So the assumption is equivalent to .

$$1 - \frac{\theta}{\eta_1} \leq \frac{\alpha_2}{(1-\alpha_2)\eta_1} \frac{(1-\beta)\,\theta + \beta}{1-\beta} \tag{3.3.8}$$

Easily from (3.3.7) it can also be yielded

$$H = \frac{T}{\frac{(1-\alpha_2)\eta_2}{\alpha_1}\frac{1-\beta}{(1-\beta)\theta+\beta}+1}$$

$$\frac{dH}{d\beta} > 0, \frac{dH}{d\theta} > 0$$

It is the same as Model 1 & Model 2. If the union has more bargaining power, it will reduce the working hours; if the union is more concerned about employment in its objective function, it will increase working hours.

Rearrange (3.3.5) as

$$WH = \frac{c}{\left(\frac{\theta}{\eta_1}-1\right)+\frac{\alpha_2\eta_2}{\alpha_1\eta_1}\frac{H}{T-H}} \tag{3.3.5'}$$

thus

$$\frac{d(WH)}{dH} < 0$$

As $\frac{d(WH)}{dH} = W + H\frac{dW}{dH}$, and I have assumed $W \geq 0$ from the implicit assumption $1 - \frac{\theta}{\eta_1} < \frac{\alpha_2}{(1-\alpha_2)\eta_1}\frac{(1-\beta)\theta+\beta}{1-\beta}$. Thus

$$\frac{dW}{dH} < 0$$

Since

$$\frac{dW}{d\beta} = \frac{dW}{dH}\frac{dH}{d\beta}$$

we have known $\frac{dW}{dH} < 0$, and $\frac{dH}{d\beta} > 0$, thus

$$\frac{dW}{d\beta} < 0 \tag{3.3.9}$$

However it is not like what is in the Right to Manage models, $\frac{dL}{d\beta}$ can not be signed, it is ambiguous. Let

$$\phi = \left(\frac{\theta}{\eta_1}-1\right)H^{\alpha_1}\left(\frac{T}{H}-1\right)+\frac{\alpha_2\eta_2}{\alpha_1\eta_1}H^{\alpha_1}$$

in (3.3.6), so $L = \left[\frac{\eta_2}{\eta_1}\frac{c}{A\alpha_1}\frac{1}{\phi}\right]^{\frac{1}{\alpha_2-1}}$ and ϕ is a function of H.

$$\begin{aligned}\frac{d\phi}{dH} &= \left(\frac{\theta}{\eta_1}-1\right)\left(-\frac{T}{H^2}\right)H^{\alpha_1}+\alpha_1\left(\frac{\theta}{\eta_1}-1\right)\left(\frac{T}{H}-1\right)H^{\alpha_1-1}+\frac{\alpha_2\eta_2}{\eta_1}H^{\alpha_1-1}\\ &= (1-\alpha_1)\left(1-\frac{\theta}{\eta_1}\right)TH^{\alpha_1-2}+\alpha_1\left(\frac{\alpha_2\eta_2}{\alpha_1\eta_1}+1-\frac{\theta}{\eta_1}\right)H^{\alpha_1-1}\end{aligned}$$

If $1-\frac{\theta}{\eta_1}>0$, equivalent to $\theta<\eta_1, \frac{d\phi}{dH}>0$; If $\frac{\alpha_2\eta_2}{\alpha_1\eta_1}+1-\frac{\theta}{\eta_1}<0$, equivalent to $\theta>\eta_1+\frac{\alpha_2\eta_2}{\alpha_1}, \frac{d\phi}{dH}<0$; If $\eta_1+\frac{\alpha_2\eta_2}{\alpha_1}>\theta>\eta_1$, the sign of $\frac{d\phi}{dH}$ would be ambiguous. As

$$\frac{dL}{d\beta}=\frac{dL}{d\phi}\frac{d\phi}{dH}\frac{dH}{d\beta}$$

and it is known that $\frac{dL}{d\phi}>0$, and $\frac{dH}{d\beta}>0$, thus the sign of $\frac{dL}{d\beta}$ would be the same with $\frac{d\phi}{dH}$. Combine (3.3.8), the sign of $\frac{dL}{d\beta}$ would be as following:

$$\begin{aligned} \frac{dL}{d\beta} &< 0, \text{ if } 0< \eta_1<\theta-\frac{\alpha_2\eta_2}{\alpha_1} \\ \frac{dL}{d\beta}\text{ may} &< \mathit{or} >0 \text{ , if } \theta-\frac{\alpha_2\eta_2}{\alpha_1}<\eta_1<\theta \\ \frac{dL}{d\beta} &> 0, \text{ if } \theta<\eta_1<\theta+\frac{\alpha_2}{1-\alpha_2}\frac{(1-\beta)\,\theta+\beta}{1-\beta} \end{aligned} \tag{3.3.10}$$

For the same reason,

$$\begin{aligned} \frac{dW}{d\theta} &= \frac{dW}{dH}\frac{dH}{d\theta} \\ \frac{dL}{d\theta} &= \frac{dL}{d\phi}\frac{d\phi}{dH}\frac{dH}{d\theta} \end{aligned}$$

combine $\frac{dH}{d\theta}>0$, $\frac{dW}{d\theta}$ and $\frac{dL}{d\theta}$ can be signed exactly the same as (3.3.9) and (3.3.10),

$$\frac{dW}{d\theta}<0 \tag{3.3.11}$$

$$\begin{aligned} \frac{dL}{d\theta} &< 0, \text{ if } 0< \eta_1<\theta-\frac{\alpha_2\eta_2}{\alpha_1} \\ \frac{dL}{d\theta}\text{ may} &< \mathit{or} >0 \text{ , if } \theta-\frac{\alpha_2\eta_2}{\alpha_1}<\eta_1<\theta \\ \frac{dL}{d\theta} &> 0, \text{ if } \theta<\eta_1<\theta+\frac{\alpha_2}{1-\alpha_2}\frac{(1-\beta)\,\theta+\beta}{1-\beta} \end{aligned} \tag{3.3.12}$$

The comparative statics are still the same with respect to the fixed cost c,

$$\frac{dW}{dc}>0, \frac{dH}{dc}=0, \frac{dL}{dc}<0$$

Some new features emerge:

(1) If the union gets more bargaining power, what can be expected for sure is that it will reduce working hours and increase wage rate, the wage rate and working hours are inversely related, which is the same as in previous models, but we do not know what would happen to the employment level. It is ambiguous, may go up, or may fall given the same value of θ [6]. It depends on the relationship between θ and η_1, η_2, the elasticity of utility with respect to earning or leisure.

We have known

$$\frac{d(WH)}{dH} < 0 \text{ and } \frac{dH}{d\beta} > 0$$

therefore

$$\frac{d(WH)}{d\beta} < 0$$

which is inversely related with β . In other words, if the firm has more bargaining power, which will make each employee work for more hours with a lower level of income due to the reduced wage rate . It seems the same as Model 2 , but actually the total of earning in (3.5') is not only concerned about α_2, β, θ and η_1, but also concerned about α_1 and the negative relation with η_2, the elasticity of utility with respect to leisure. Also we know form individual utility function $u(WH, T-H)$, $u_1 > 0, u_2 > 0$, every individual worker's utility has been decreased.

(2) When θ changes, the change of hours and wage rate are the same as in Model 1&2, while the change in employment is ambiguous.

(3) , (4) and (5) of model 1 still hold in Model 3.

(6) Workers will still obtain the same working hours as in Model 1&2 even when they have one more right to bargain over employment. Simply rearrange $H_1 = \frac{T}{\frac{(1-\beta)\eta_2}{D}+1}$, $H_2 = \frac{T}{\frac{(1-\beta)\eta_2}{D}+1}$ and $H_3 = \frac{[\beta+(1-\beta)\theta]T}{\beta+(1-\beta)\lambda_1}$, we can find

$$H_1 = H_2 = H_3 = \frac{T}{\frac{(1-\alpha_2)(1-\beta)\eta_2}{\alpha_1[\beta+(1-\beta)\theta]} + 1} \qquad (3.3.13)$$

[6]It is different with Model 1&2, as it will reduce employment without any doubt

Hours of working is regardless to whatever kind of bargaining scenario, whether the union has influence over employment or hours itself, it is only affected by η_2, the elasticity of utility with respect to leisure, and bargaining power β and union preference over employment weight θ.

(7) "Job creating" disappeared, if hours is increased due to the change of β or θ, the movement of employment L is ambiguous since $\frac{dL}{d\beta}$ and $\frac{dL}{d\theta}$ are ambiguous. The firm may hire more workers or less which depends on the relationship of the parameters in (3.3.10) and (3.3.12).

4 A Summary of Model 1, 2 & 3

It has been demonstrated that an increase in the union bargaining power will reduce hours of working and increase the wage rate in every bargaining scenario studied here. The effect on employment varies according to the framework. This effect would be negative in the Right to Manage models, and ambiguous in the Full Efficient bargaining model. Union hours will be set to

$$H_1 = H_2 = H_3 = H = \frac{T}{\frac{(1-\alpha_2)(1-\beta)\eta_2}{\alpha_1[\beta+(1-\beta)\theta]} + 1}$$

in all three bargaining frameworks.

So the next question would be that in which scenario, will the union achieves the highest wage rate, largest employment, or utility?

From (3.2.7) and (3.3.5),

$$\begin{aligned} W_2 &= \frac{c}{D_4 H} \\ W_3 &= \frac{c}{\left(\frac{\theta}{\eta_1} - 1\right) H + \frac{\alpha_2\eta_2}{\alpha_1\eta_1}\frac{H^2}{T-H}} \end{aligned}$$

$$\begin{aligned} L_2 &= [\frac{1}{A\alpha_1} H^{-\alpha_1}(\frac{1}{D_4} + 1)c]^{\frac{1}{\alpha_2 - 1}} \\ L_3 &= [\frac{\eta_2}{\eta_1}\frac{H^{-\alpha_1}}{A\alpha_1}\frac{c}{\left(\frac{\theta}{\eta_1} - 1\right)\frac{T-H}{H} + \frac{\alpha_2\eta_2}{\alpha_1\eta_1}}]^{\frac{1}{\alpha_2 - 1}} \end{aligned}$$

Consequently

$$\frac{W_3}{W_2} = \frac{D_4}{\left(\frac{\theta}{\eta_1}-1\right)+\frac{\alpha_2\eta_2}{\alpha_1\eta_1}\frac{H}{T-H}} \tag{3.4.1}$$

$$= \frac{\frac{\frac{\alpha_2\beta+(1-\beta)\theta}{1-\alpha_2}}{\eta_1(1-\beta)}-1}{\left(\frac{\theta}{\eta_1}-1\right)+\frac{\alpha_2\eta_2}{\alpha_1\eta_1}\frac{[\beta+(1-\beta)\theta]\alpha_1}{(1-\beta)(1-\alpha_2)\eta_2}}$$

$$= \frac{\alpha_2\beta+(1-\beta)[\theta-\eta_1(1-\alpha_2)]}{\alpha_2\beta+(1-\beta)[(\theta-\eta_1)(1-\alpha_2)+\alpha_2\theta]}$$

$$= 1$$

and

$$\frac{L_3}{L_2} = \left[\frac{\frac{\eta_2}{\eta_1}\frac{H^{-\alpha_1}}{A\alpha_1}\frac{c}{\left(\frac{\theta}{\eta_1}-1\right)\frac{T-H}{H}+\frac{\alpha_2\eta_2}{\alpha_1\eta_1}}}{\frac{1}{A\alpha_1}H^{-\alpha_1}(\frac{1}{D_4}+1)c}\right]^{\frac{1}{\alpha_2-1}}$$

$$= \left[\frac{\frac{\eta_2}{\eta_1}\frac{W_3H^2}{T-H}}{W_2H+c}\right]^{\frac{1}{\alpha_2-1}}$$

$$= \left[\frac{\eta_2}{\eta_1}\frac{H}{T-H}\frac{\eta_1(1-\beta)(1-\alpha_2)}{\alpha_2\beta+(1-\beta)\,\theta}\right]^{\frac{1}{\alpha_2-1}}$$

$$= \left\{\frac{\eta_2}{\eta_1}\frac{\alpha_1[\beta+(1-\beta)\theta]}{\eta_2(1-\beta)(1-\alpha_2)}\frac{\eta_1(1-\beta)(1-\alpha_2)}{\alpha_2\beta+(1-\beta)\,\theta}\right\}^{\frac{1}{\alpha_2-1}}$$

$$= \left[\frac{\alpha_1\beta+\alpha_1(1-\beta)\theta}{\alpha_2\beta+(1-\beta)\,\theta}\right]^{\frac{1}{\alpha_2-1}}$$

If the assumption in Model 1 $\alpha_2 > \alpha_1$ still hold,

$$L_3 > L_2 \tag{3.4.2}$$

Therefore

$$u_2 = u_3 \qquad\qquad \Gamma_2 < \Gamma_3$$

(3.3.13) and (3.4.1) state that in frameworks 2 & 3, a unionized individual has the same amount of income and working hours, hence with same value of individual utility. However the union's utility in the Efficient Bargaining model would be higher than it in Model 2 due to a higher employment level.

How about firm's profit level? Will it be increased or decreased? The difference between Model 2 & 3 is, that the former is not bargaining over employment, but the latter is. In model 2, after the wage rate and hours are bargained by union and firm, the firm will set employment unilaterally adjusting to its profit-maximizing level. So given the wage rate W and hours of working H, L_2 would be the employment level for the firm's profit maximization,

$$\alpha_2 A H^{\alpha_1} L_2^{\alpha_2} = WH + c$$

where the marginal product of labor would equal to marginal cost. Provided with the same value of W and H, any other employment level, i.e. L_3, would lead the profit level lower than π_2. Consequently

$$\pi_3 < \pi_2$$

While

$$\frac{W_1}{W_2} = \frac{\alpha_1}{\alpha_2 - \alpha_1}\left[\frac{\frac{\alpha_2\beta+(1-\beta)\theta}{1-\alpha_2}}{\eta_1(1-\beta)} - 1\right]$$

$$W_1 \gtreqless W_2 \qquad \Longleftrightarrow \qquad \frac{\alpha_2\beta + (1-\beta)\,\theta}{(1-\beta)(1-\alpha_2)}\frac{\alpha_1}{\alpha_2} \gtreqless \eta_1$$

The relationship of $L_1$and L_2 would be ambiguous and more complicated than the relation of wage rate. And the relationship between union and firm's utility is also ambiguous.

So far a brief summary of the main features in Models 1, 2 & 3 can be concluded as follows:

1. An increase in the union bargaining power (union's preference over employment weight) will reduce (increase) hours of working and increase (reduced) wage rate in every bargaining scenario. The effect on employment varies according to the framework. The effect is negative (positive) in Right to Manage models, but is ambiguous in the full efficient bargaining model.

2. Hours are the same in all three bargaining models. It depends on only (i) the external price (technology) parameter, (ii) the union's bargaining power $1-\beta$, *and (iii) the union's preference over employment* θ.

3. Price (technology) shock will not affect the hours of work and wage rate. It only has major effect on employment regardless of the bargaining framework.

4. Union workers may be rationed for their hours of working, or involuntary work for some hours which are more than they wish. The outcome is determined by the value of the parameters.

5. *Given same bargaining power* β, *and employment weight* θ, *as well as other parameters, the wage rate and working hours would be set equal in Models 2 & 3, and the employment level would be higher in Model 3 than in Model 2. Individual utility would be maintained at the same level in these two models, while total union utility would be higher in the Efficient Bargaining Model, firm's profit would be higher in (weak) Right to Manage Model. However only hours can be ranked between Model 1 and Model 2&3.*

5 The Comparison with Union Bargaining Literature

5.1 A Comparison with McDonald & Solow (1981)

McDonald & Solow (1981) predict that the fluctuations in aggregate demand have their major effect on employment and little or none on the wage. In this section we shall prove it also exists in our efficient bargaining model by setting hours to be constant.

By setting the firm's revenue function as

$$\pi = R(L, B) - WL$$

where L is employment, W is worker's income and B is a parameter to indicate the business cycle. And the union's utility function is being set as

$$\Gamma = L(U(W) - \overline{U})$$

$\overline{U}$ is the alternative worker utility if he is not being employed, McDonald & Solow (1981) have shown that fluctuations in aggregate demand might have their major effect on employment and little or none on the wage. This also can be proved in our efficient bargaining model. In equation (3.3.1), if we treat H, hours of working as an exogenous variable,

$$G_3 = \beta \ln \left[A(H^{\alpha_1} L^{\alpha_2}) - WHL - cL\right] + (1-\beta)\,\theta \ln L + (1-\beta) \ln u(WH, T-H)$$

to maximize G_3, from the first order condition, we can still have

$$\frac{\partial G_3}{\partial L} = \frac{\beta\,(A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - WH - c)}{A\,(H^{\alpha_1} L^{\alpha_2}) - WHL - cL} + \frac{(1-\beta)\,\theta}{L} = 0 \qquad (3.3.2)$$

$$\frac{\partial G_3}{\partial W} = \frac{\beta\,(-HL)}{A\,(H^{\alpha_1} L^{\alpha_2}) - WHL - cL} + \frac{(1-\beta)\,u_1 H}{u} = 0 \qquad (3.3.3)$$

however, the difference here H is an exogenous variable.

As we have assumed before, $\eta = \frac{\partial u}{\partial (WH)} \frac{WH}{u}$, the elasticity of utility with respect to earning, is constant. Combining (3.3.2) and (3.3.3), then we can get

$$W = \frac{A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - c}{(1 - \frac{\theta}{\eta})H} \qquad (3.3.13)$$

$$AH^{\alpha_1} L^{\alpha_2 - 1} \left[\eta(1-\beta)(1 - \frac{\theta}{\eta} - \alpha_2) - \alpha_2 \beta\right] + \theta(1-\beta)c + \beta c = 0 \qquad (3.3.14)$$

Equations (3.3.13) and (3.3.14) can be solved to give W, L as a function of some exogenous variables, which can be written as

$$\begin{aligned} L &= L(A, H, \eta, \beta, \theta, c, \alpha_1, \alpha_2) \\ W &= W(H, \eta, \beta, \theta, c, \alpha_1, \alpha_2) \end{aligned}$$

which is consistent with McDonald and Solow's finding that W is independent with A, the wage rate is sticky over business cycle. The fluctuations in aggregate demand only have their effect on employment.

5.2 A Comparison with Oswald and Walker (1996 Discussion Paper)

In this section, we will compare this work with Oswald and Walker (1996 Discussion Paper). We shall show that these two different approaches have analogous results. Furthermore, even by assuming a more general union utility function or production function, we find the result still persistent.

Oswald and Walker (1996, Discussion Paper) have found that, if firm is risk neutral, and individual worker's utility is additively separable in income and hours, other external shocks only affect employment. The wage and hours are constant. This finding is analogous with what has been found in this paper that technology and price shock will not affect hours of work and wage rate, but will only affect employment. However the conclusion we had in this paper is from a different approach. In Oswald and Walker's paper, the firm's utility function is given by v, which is a function of $\theta f(nh) - whn$, where θ is the firm's output price, and is distributed according to density $g(\theta)$. The union's utility function is defined as $u(y,h)n + u(b)(m-n)$ to maximize their total utility, where $u(b)$ is the alternative individual worker's utility if he is unemployed, m is the number of union members, and n is the number of employed workers. In the efficient bargaining model, Oswald and Walker formulate the problem as that of choosing $w(\theta), n(\theta), h(\theta)$ to maximize union's utility

$$\int [u(y,h)n + u(b)(m-n)]\, g(\theta) d(\theta)$$

subject to firm's profit is not worse off than a given level

$$\int v(\theta f(nh) - whn)g(\theta)d(\theta) \geq \bar{v}$$

where $\bar{v}$ is an arbitrary constant. In contrast, in our work, we have the individual worker's utility function as $u(WH, T - H)$, and basically they are in the same formulation. Whereas the union's utility function is different, we have it as $U = L^{\theta}u(WH, T-H)$, as well as the firm's profit function $\pi = A(H^{\alpha_1}L^{\alpha_2}) - WHL - cL$. In these utility functions the parameter for price (technology) is exogenous, which is not assumed with density $g(\theta)$. And the utility functions are more general with parameter θ, the employment weight , and c, the fixed cost of each employee. $u(b)$ is being assumed to zero in this model. In the case of efficient Nash bargaining model,

$$G_3 = \beta \ln\left[A(H^{\alpha_1}L^{\alpha_2}) - WHL - cL\right] + (1-\beta)\,\theta \ln L + (1-\beta)\ln u(WH, T - H)$$

by assuming that the elasticity of utility with respect to income and leisure are constants, we have the same finding with Oswald and Walker.

It should be noticed that apart from the difference of the appearance of two utility functions, the assumptions made for these two approaches are quit different. To understand why the external shocks only affect employment, while wage rate and hours of work are independent to it, we change the union utility function to more general form as

$$U = u(WH, T - H, L)$$

$U_y > 0, U_{T-H} >, U_L > 0$. Constructing the Nash bargaining model as

$$G_3' = \beta \ln\left[A(H^{\alpha_1}L^{\alpha_2}) - WHL - cL\right] + (1-\beta)\ln u(WH, T - H, L)$$

To maximize G_3', the first order conditions for W, H, and L are

$$\frac{\partial G_3'}{\partial W} = \frac{\beta(-HL)}{A(H^{\alpha_1}L^{\alpha_2}) - WHL - cL} + \frac{(1-\beta)u_1 H}{u} = 0 \qquad (3.B.1)$$

$$\frac{\partial G_3'}{\partial L} = \frac{\beta \left[A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - WH - c\right]}{A(H^{\alpha_1} L^{\alpha_2}) - WHL - cL} + \frac{(1-\beta)\, u_3}{u} = 0 \tag{3.B.2}$$

$$\frac{\partial G_3'}{\partial H} = \frac{\beta \left[A\alpha_1 H^{\alpha_1 - 1} L^{\alpha_2} - WL\right]}{A(H^{\alpha_1} L^{\alpha_2}) - WHL - cL} + \frac{(1-\beta)\left[u_1 W - u_2\right]}{u} = 0 \tag{3.B.3}$$

As we have assumed

$$\eta_1 = \frac{\partial u}{\partial (WH)} \frac{WH}{u}, \eta_2 = \frac{\partial u}{\partial (T-H)} \frac{T-H}{u}$$

the elasticity of utility with respect to income and leisure are constants. Furthermore we assume

$$\eta_3 = \frac{\partial u}{\partial L} \frac{L}{u}$$

the elasticity of utility with respect to labor is constant.

Consequently (3.B.2) / (3.B.1)

$$A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - c = (1 - \frac{\eta_3}{\eta_1}) WH \tag{3.B.4}$$

And (3.B.3) / (3.B.1)

$$WH = \frac{\eta_1}{\eta_2} A\alpha_1 H^{\alpha_1 - 1} L^{\alpha_2 - 1} (T - H) \tag{3.B.5}$$

Substitute (3.B.5) into (3.B.4), and rearrange,

$$\frac{A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - c}{AH^{\alpha_1 - 1} L^{\alpha_2 - 1} (T - H)} = \frac{(\eta_1 - \eta_3)\, \alpha_1}{\eta_2} \tag{3.B.6}$$

(3.B.2) can be rearranged as

$$\frac{A\alpha_2 H^{\alpha_1} L^{\alpha_2 - 1} - WH - c}{AH^{\alpha_1} L^{\alpha_2 - 1}} = \frac{-(1-\beta)\, \eta_3\, (1 - \alpha_2)}{\beta + (1-\beta)\, \eta_3} \tag{3.B.7}$$

(3.B.6)-(3.B.7), and combine (3.B.5),

$$\frac{T-H}{H} \frac{\alpha_1 \eta_3}{\eta_2} = \frac{-(1-\beta)\, \eta_3\, (1-\alpha_2)}{\beta + (1-\beta)\, \eta_3}$$

Hence

$$H = H(\beta, \eta_2, \eta_3, \alpha_1, \alpha_2)$$

Combine (3.B.4) and (3.B.5), this equations system can be solved to have the solutions for H,W,L as

$$\begin{aligned} H &= H(\beta, \eta_2, \eta_3, \alpha_1, \alpha_2) \\ W &= W(H, c, \beta, \eta_1, \eta_3, \alpha_2) \\ L &= L(A, H, c, \beta, \eta_1, \eta_3, \alpha_2) \end{aligned}$$

which have shown , even when L is not separable from the individual worker's utility function, we can still have hours of working and wage independent of A. The external shock A only affects the employment.

In stead of using general union's utility function, we have the more general production function for the firm as

$$\pi = AF(H, L) - WHL - cL$$

Equation (3.3.1) can be written as

$$G_3 = \beta \ln \left[AF(H, L) - WHL - cL\right] + (1-\beta)\,\theta \ln L + (1-\beta) \ln u(WH, T-H) \tag{3.B'.4}$$

To maximize G_3, the first order conditions for optimization are

$$\frac{\partial G_3}{\partial L} = \frac{\beta(AF_L - WH - c)}{AF(H, L) - WHL - cL} + \frac{(1-\beta)\,\theta}{L} = 0 \tag{3.B'.5}$$

$$\frac{\partial G_3}{\partial W} = \frac{\beta(-HL)}{AF(H, L) - WHL - cL} + \frac{(1-\beta)\,u_1 H}{u} = 0 \tag{3.B'.6}$$

$$\frac{\partial G_3}{\partial H} = \frac{\beta(AF_H - WL)}{AF(H, L) - WHL - cL} + \frac{(1-\beta)\,(u_1 W - u_2)}{u} = 0 \tag{3.B'.7}$$

Using the assumptions that the elasticity of utility with respect to income and leisure η_1, η_2 are constants, and $\eta_3 = \frac{\partial F}{\partial L}\frac{L}{F}, \eta_4 = \frac{\partial F}{\partial H}\frac{H}{F}$ are constants , to solve the equations (3.B'.5), (3.B'.6) and (3.B'.7), we get

$$(1-\beta)\,\eta_1 - \left[(1-\beta)\,\eta_1 + \beta\right] \frac{\eta_1 \eta_4}{\eta_2} \frac{T-H}{H} = \eta_3 + \frac{(\theta - \eta_1)\,\eta_4}{\eta_2} \frac{T-H}{H} \tag{3.B'.8}$$

$$W = \frac{A\eta_1\,(T-H)}{\eta_2 H} \frac{F}{L} \frac{\eta_4}{H} \tag{3.B'.9}$$

$$\frac{cL}{F} = A\eta_3 + \frac{A(\theta - \eta_1)\eta_4}{\eta_2}\frac{T - H}{H} \tag{3.B'.10}$$

From equation (3.B'.8) , we have

$$H = H(\beta, \eta_1, \eta_2, \eta_3, \eta_4) \tag{3.B'.11}$$

which indicates that the hours is sticky with the external shocks, i.e. the price shock. In contrast, equations (B.10) and (B.11) show that L is a function of A, $\theta, c, \eta_1, \eta_2, \eta_3, \eta_4$ and H, which can be written as

$$L = L(A, \theta, c, \eta_1, \eta_2, \eta_3, \eta_4, H)$$

The employment is affected by the external shocks. Furthermore, the effect of A is ambiguous to L. If $\frac{L}{F}$ is an increasing function of L, then the greater value of A, the higher employment. If $\frac{L}{F}$ is a decreasing function of L, then the greater value of A, the lower level of employment. However by rearranging (3.B.9) and (3.B.10),

$$W = \frac{\eta_1(T - H)}{\eta_2 H} \frac{c}{\left[\eta_3 + (\theta - \eta_1)\frac{\eta_4(T-H)}{\eta_2 H}\right]} \frac{\eta_4}{H}$$

where W is also independent to the parameter A.

To sum up, the external shocks only affect employment, while the wage rate and hours of working are sticky over the parameter A, for quite general production function or union's utility function.

5.3 A Comparison with Ulph & Ulph (1990)

Ulph & Ulph (1990) find that hours of work increase with the output price. By offering a example when individual worker's utility $u = c - Kh$, where c is consumption, *we will show what Ulph & Ulph(1990) predict is only regarding to the partial price effect on working hours by holding constant the employment effect. However hours may be independent of the total price effect.*

Ulph & Ulph(1990) define the individual utility function $u = u(c, h)$, where c is the consumption and h is hours of working, and production function as $F(n, h)$. From inverted function $u(.)$, he yields

$$c = \varphi(h, u)$$

as the total amount of compensation a worker would need to work h hours if his utility is to be maintained as u. Given the price of the output p, the firm's profit is

$$\pi(u, n, h; p) = pF(n, h) - n\varphi(h, u)$$

Conditional on same level of utility u, the union is indifferent about h, the hours are chosen alone by the firm to maximize the profits as specified by

$$G(u, n; p) = \underset{s.t. h \geq 0}{Max} \; \pi(u, n, h; p)$$

The first order condition for optimisation is

$$\begin{aligned} pF_h(n, h) &= n\varphi_h(h, u) \\ pF_h(n, h)/n &= \varphi_h(h, u) \end{aligned}$$

which means the per capital marginal revenue product of an additional hour's work equals to the individual marginal rate of substitution between work and consumption. And this can be solved to have h is a function of u, n, and p as

$$h = H(u, n, p) \tag{3.C.1}$$

Then he concludes that hours of work increase with the price, which seems a contradiction with our finding.

In fact, what Ulph & Ulph (1990) find that an increase in p will increase hours of work is the partial effect from price shock. Equation (C.1) has shown that h is also a function of n. Considered n might be affected by the price shock as well, if we take n into account, hours might be independent of the total price effect. To explore the price total effect on hours, we have the following example.

Let's assume the utility function is linear to consumption and hours of working as

$$u = c - Kh$$

where $K > 0$, and $u_c > 0, u_h < 0$. Therefore the firm's profit function can be written as

$$\pi = pAn^{\alpha}h^{1-\alpha} - n(u + Kh)$$

As Ulph & Ulph (1990) did, the firm is setting hours alone to maximize its profit,

$$\frac{\partial \pi}{\partial h} = pAn^{\alpha}(1-\alpha)h^{-\alpha} - nK = 0$$

or

$$h = \left(\frac{1-\alpha}{K}\right)^{\frac{1}{\alpha}} (pA)^{\frac{1}{\alpha}} n^{\frac{\alpha-1}{\alpha}} \tag{3.C.2}$$

In the efficient bargaining procedure, the firm maximizes the gain from the bargaining subject to achieving a given level of gain for the union. The problem can be described as

$$\begin{aligned} \max \pi &= pAn^{\alpha}h^{1-\alpha} - n(u + Kh) \\ s.t. n(u - \hat{u}) &\geq \nabla, \qquad h = \left(\frac{1-\alpha}{K}\right)^{\frac{1}{\alpha}} (pA)^{\frac{1}{\alpha}} n^{\frac{\alpha-1}{\alpha}} \end{aligned}$$

where ∇ is a minimum level of the union's expected utility, which is unconstrained. Substitute (C.2) into the firm's profit function, the problem can also be written as

$$\begin{aligned} \max \Psi &= pAn^{\alpha}h^{1-\alpha} - n\left(u + Kh\right) - \lambda\left[n\left(u - \hat{u}\right) - \nabla\right] \\ &= (pA)^{\frac{1}{\alpha}} g_1 n^{2-\frac{1}{\alpha}} - nu - \lambda\left[n\left(u - \hat{u}\right) - \nabla\right] \end{aligned} \tag{3.C.3}$$

where $g_1 = \left(\frac{1-\alpha}{K}\right)^{\frac{1-\alpha}{\alpha}} - K\left(\frac{1-\alpha}{K}\right)^{\frac{1}{\alpha}}$. The first order condition gives

$$\frac{\partial \Psi}{\partial n} = (pA)^{\frac{1}{\alpha}} g_1 \left(2 - \frac{1}{\alpha}\right) n^{1-\frac{1}{\alpha}} - u - \lambda\left(u - \hat{u}\right) = 0 \tag{3.C.4}$$

$$\frac{\partial \Psi}{\partial u} = -n - \lambda n = 0 \tag{3.C.5}$$

From (3.C.4), we can have

$$\lambda = -1$$

Substitute it into (3.C.3),

$$n^{\frac{\alpha-1}{\alpha}} = \frac{\hat{u}}{g_1 \left(2 - \frac{1}{\alpha}\right)} (pA)^{-\frac{1}{\alpha}} \tag{3.C.6}$$

Equation (3.C.2) and (3.C.5) give

$$h = \frac{\hat{u}}{g_1 \left(2 - \frac{1}{\alpha}\right)} \left(\frac{1-\alpha}{K}\right)^{\frac{1}{\alpha}} \tag{3.C.7}$$

The solutions for n and h indicate that hours of working are sticky over the business cycle. When the economy is booming, the price p is higher, the price total effect on hours is zero, while the effect on employment is positive. The firm's profit increase with the price.

In the case of Nash bargaining, (3.C.3) can be rewritten as

$$\begin{aligned} \max \Psi &= \beta In \left[pAn^{\alpha}h^{1-\alpha} - n(u + Kh)\right] + (1-\beta) In \left[n(u - \hat{u}) - \nabla\right] \quad (3.C.3') \\ &= \beta In \left[(pA)^{\frac{1}{\alpha}} g_1 n^{2-\frac{1}{\alpha}} - nu\right] + (1-\beta) In \left[n(u - \hat{u}) - \nabla\right] \end{aligned}$$

where $g_1 = \left(\frac{1-\alpha}{K}\right)^{\frac{1-\alpha}{\alpha}} - K\left(\frac{1-\alpha}{K}\right)^{\frac{1}{\alpha}}$. From the first order condition

$$\frac{\partial \Psi}{\partial n} = \frac{\beta\left[(pA)^{\frac{1}{\alpha}} g_1 \left(2 - \frac{1}{\alpha}\right) n^{1-\frac{1}{\alpha}} - u\right]}{(pA)^{\frac{1}{\alpha}} g_1 n^{2-\frac{1}{\alpha}} - nu} + \frac{(1-\beta)(u - \hat{u})}{n(u - \hat{u}) - \nabla} = 0 \tag{3.C.8}$$

$$\frac{\partial \Psi}{\partial u} = \frac{\beta(-n)}{(pA)^{\frac{1}{\alpha}} g_1 n^{2-\frac{1}{\alpha}} - nu} + \frac{(1-\beta) n}{n(u - \hat{u}) - \nabla} = 0 \tag{3.C.9}$$

To solve the equation (3.C.8) and (3.C.9), we can get

$$\begin{aligned} n &= \left[\frac{\hat{u}}{g_1\left(2 - \frac{1}{\alpha}\right)}\right]^{\frac{\alpha}{\alpha-1}} (pA)^{\frac{1}{1-\alpha}} \\ u &= (1-\beta)\frac{\hat{u}}{\left(2 - \frac{1}{\alpha}\right)} + \beta\hat{u} + \beta\nabla\left[\frac{\hat{u}}{g_1\left(2 - \frac{1}{\alpha}\right)}\right]^{\frac{\alpha}{1-\alpha}} (pA)^{\frac{1}{\alpha-1}} \end{aligned}$$

Combining (3.C.2),

$$h = \left(\frac{1-\alpha}{K}\right)^{\frac{1}{\alpha}} \frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}$$

Where we still can see the hours is sticky over the business cycle, and employment is positively related to the price. The higher price p, the higher level of employment, and the lower the level of the individual worker's utility.

The total union's utility

$$\begin{aligned} n(u-\hat{u}) &= \left[\frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\right]^{\frac{\alpha}{\alpha-1}} (pA)^{\frac{1}{1-\alpha}} \\ &\quad * \left[\frac{(1-\alpha)(1-\beta)}{2\alpha-1}\hat{u} + \beta\nabla\left[\frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\right]^{\frac{\alpha}{1-\alpha}} (pA)^{\frac{1}{\alpha-1}}\right] \\ &= \beta\nabla + \left[\frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\right]^{\frac{\alpha}{\alpha-1}} \left[\frac{(1-\alpha)(1-\beta)}{2\alpha-1}\hat{u}\right] (pA)^{\frac{1}{\alpha-1}} \end{aligned}$$

which, it can be easily shown that the total union's utility is increasing with the price, although the individual worker's utility is decreased. While the firm's profit

$$\begin{aligned} \pi &= pAn^{\alpha}h^{1-\alpha} - n(u+Kh) \\ &= pA\left[\frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\right]^{\frac{\alpha^2}{\alpha-1}} (pA)^{\frac{\alpha}{1-\alpha}} \left(\frac{1-\alpha}{K}\right)^{\frac{1-\alpha}{\alpha}} \left[\frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\right]^{1-\alpha} \\ &\quad - \left[\frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\right]^{\frac{\alpha}{\alpha-1}} (pA)^{\frac{1}{1-\alpha}} \{(1-\beta)\frac{\hat{u}}{2-\frac{1}{\alpha}} \\ &\quad + \beta\hat{u} + \beta\nabla\left[\frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\right]^{\frac{\alpha}{\alpha-1}} (pA)^{\frac{1}{\alpha-1}} + K\left(\frac{1-\alpha}{K}\right)^{\frac{1}{\alpha}} \frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\} \\ &= (pA)^{\frac{1}{1-\alpha}} \left[\frac{\hat{u}}{g_1\left(2-\frac{1}{\alpha}\right)}\right]^{\frac{\alpha}{\alpha-1}} \frac{(1-\alpha)\beta\hat{u}}{2\alpha-1} - \beta\nabla \end{aligned}$$

where we can see the firm's profit is positive related with the price. In other words, when the economy is booming, the firm and union have more surplus to share, and both of their utilities will be increased by the higher price. However the total price effect on hours is zero, it is sticky over the business cycle, although Ulph & Ulph (1990) conclude that the partial effect is positive. The employment is increasing in the boom and decreasing during the slump, and is flexible over the business cycle.

6 Conclusion

Despite the importance of the working hours attached to trade unions, economists have less attention to this subject than they have to the wage and employment. However there are lots of disagreements on which policies the government should follow to solve the employment problem. The proposal of reducing working time is one of the controversial policies.

In the early literature most of the studies have indicated that there is unionism negative hours markup by their empirical finding. A well known paper by Pencavel (1990) provides various ways of modelling the determination of hours of work in the bargaining situation with very a general objective function, and followed by his empirical finding that the effect of unionism on hours worked ranges from -6.7% to -14.7%, and it varies over time. In other sorts of papers like Calmfors (1985) and Zilibotti (1999), these studies focused on the individual worker's utility bargaining with the firm, without too much attention on the change of collective bargaining power. Calmfors (1985) concludes that the effect of a reduction of working time on employment is ambiguous; whilst Zilibotti (1999) proves that a small reduction in working time always increases employment, while larger reductions reduce employment.

This study attempts to verify theoretically the presence of the union power in the bargaining effect on hours, wage and employment. Distinguished by the bargaining variables, three kinds of semiefficient and full efficient bargaining model have been discussed in this paper. The union objective function has been defined as not only concerned about the worker's earning, but also the worker's leisure as well as the membership of the union, which is more realitical. By increasing the union bargaining power, all the three models have shown that it will raise the wage rate and reduce the working hours. The employment effect varies with the different bargaining model. In the Right-to Manage model it is negative with union bargaining power, in the Full Efficient Bargain model, however, it is ambiguous, which depends on the bargaining situation, the value of worker's elasticity of utility with respect to earning and leisure, and the employment weight of union objective function. Given the same value for the parameters in all the three models, regardless of whether the union have the power to bargain over the working hours, the bargaining hours for the worker would be the same. It is only concerned with the elasticity of utility with respect to leisure, bargaining power and employment weight θ in the union objective function.

On the other aspects I also proved that the technology and price shock will not affect the working hours, it will only affect the employment. Higher product price, more advanced technology will lead to higher employment without changing the wage rate and hours of working. Given the exogenous fixed cost of each unit of labor, the working hours are fixed as well. In other words, although it has been assumed the labor and hours working are perfectly substitutable for each other, even the fixed cost is more costly, it will not increase the working hours of each worker, but the wage rate would be increased due to the union's anticipation of lower employment caused by expensive fixed cost.

Union workers may be rationed for their hours of working, or involuntary work for some hours which are more than they wish. The outcome is determined by the value of the parameters. And provided with the same value of parameters, the wage rate and working hours would be set equal in Model 2 & 3, the employment level would be higher in Model 3 than it in Model 2. Individual utility would be maintained at same level, while total union's utility would be higher in Efficient Bargaining Model, firm's profit would be higher in (weak) Right to Manage Model. However only hours can be ranked between Model 1 and Model

2 & 3.

One shortcoming of this paper is that it can not be distinguished the standard working hours and overtime hours, to see how the overtime premium affect the working hours; another is that the exogenous fixed cost of each labor does not vary with the number of trainees, the trainee intensity, and then the productivity.

7 Appendix

This Appendix elaborates on the deviation of some results in the text. Substitute (1.5) into (1.4), which yields

$$\begin{aligned}\pi &= c^{\frac{1}{\alpha_2-1}}(D_1c-D_2)(\frac{A_1}{T})^{\frac{\alpha_1}{\alpha_2-1}}[\frac{(1-\beta)\eta_2}{D}+1]^{\frac{\alpha_1}{\alpha_2-1}} \\ &= \xi_1[\frac{(1-\beta)\eta_2}{D}+1]^{\frac{\alpha_1}{\alpha_2-1}}\end{aligned}$$

where $D=\frac{\alpha_1\beta}{1-\alpha_2}+\frac{\alpha_1(1-\beta)\theta}{1-\alpha_2}$, and $\xi_1=c^{\frac{1}{\alpha_2-1}}(D_1c-D_2)(\frac{A_1}{T})^{\frac{\alpha_1}{\alpha_2-1}}$.

Consequently

$$\begin{aligned}\frac{d\pi}{d\beta} &= \xi_1\frac{d[\frac{(1-\beta)\eta_2}{D}+1]^{\frac{\alpha_1}{\alpha_2-1}}}{d\beta} \\ &= \xi_1\frac{d[\frac{(1-\alpha_2)\eta_2}{\alpha_1}\frac{1}{\frac{1}{\frac{1}{\beta}-1}+\theta}+1]^{\frac{\alpha_1}{\alpha_2-1}}}{d\beta} > 0\end{aligned}$$

As

$$u=u(WH,T-H)$$

combine (1.5)

$$\begin{aligned}\frac{du}{d\beta} &= \frac{du(WH,T-H)}{d\beta} \\ &= \frac{du(A_1c,T-\frac{T}{\frac{(1-\beta)\eta_2}{D}+1})}{d\beta}\end{aligned}$$

Given the value of $\alpha_1,\alpha_2,$ and fixed cost c, the first term of utility function A_1c is a constant, thus

$$\frac{du}{d\beta}=\frac{du}{d(T-H)}\frac{d(T-H)}{d\beta}$$

$$= u_2 \frac{d(T - \frac{T}{\frac{(1-\beta)\eta_2}{D}+1})}{d\beta}$$

$u_2 > 0$, as individual's utility is increasing with leisure time, consequently

$$\frac{du}{d\beta} < 0$$

And as the sign of $\frac{d\Gamma}{d\beta}$ equals to the sign of $\frac{dLn\Gamma}{d\beta}$

$$\begin{aligned}
\frac{dLn\Gamma}{d\beta} &= \frac{\theta}{L}\frac{dL}{d\beta} + \frac{dLnu(WH, T-H)}{d\beta} \\
&= \frac{\theta}{L}\frac{dL}{d\beta} + \frac{\eta_2}{T-H}\frac{d(T-H)}{d\beta} \\
&= [\frac{\alpha_1\theta}{\alpha_2 - 1} + \frac{D}{1-\beta}]\frac{1}{\frac{(1-\beta)\eta_2}{D}+1}\frac{d[\frac{(1-\beta)\eta_2}{D}]}{d\beta} \\
&= \frac{\beta}{1-\beta}\frac{\alpha_1}{1-\alpha_2}\frac{1}{\frac{(1-\beta)\eta_2}{D}+1}\frac{d[\frac{(1-\beta)\eta_2}{D}]}{d\beta}
\end{aligned}$$

as

$$\frac{d[\frac{(1-\beta)\eta_2}{D}]}{d\beta} < 0$$

and every other terms are positive as I have assumed, hence

$$\begin{aligned}
\frac{dLn\Gamma}{d\beta} &< 0 \\
\frac{d\Gamma}{d\beta} &< 0
\end{aligned}$$

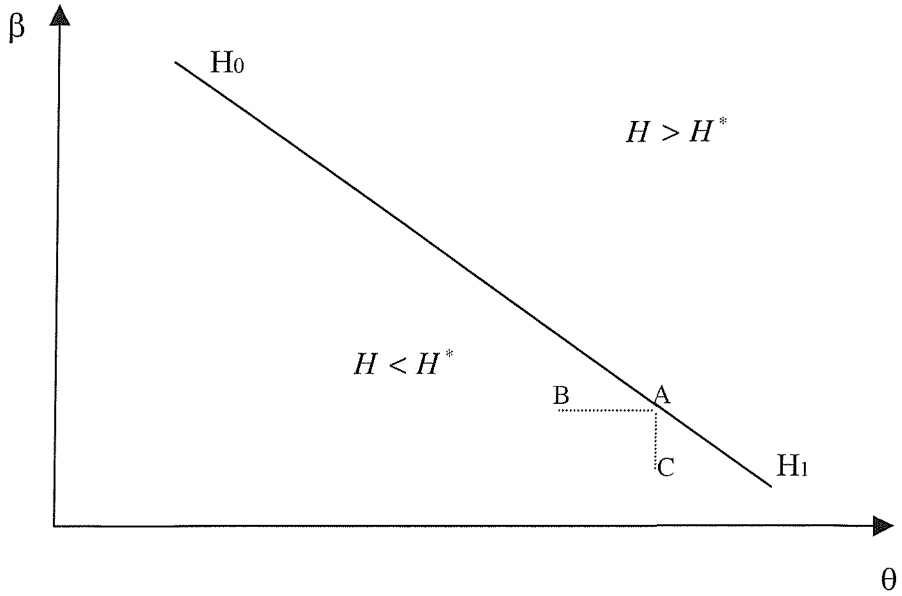

Figure 3.1 Hours Curve

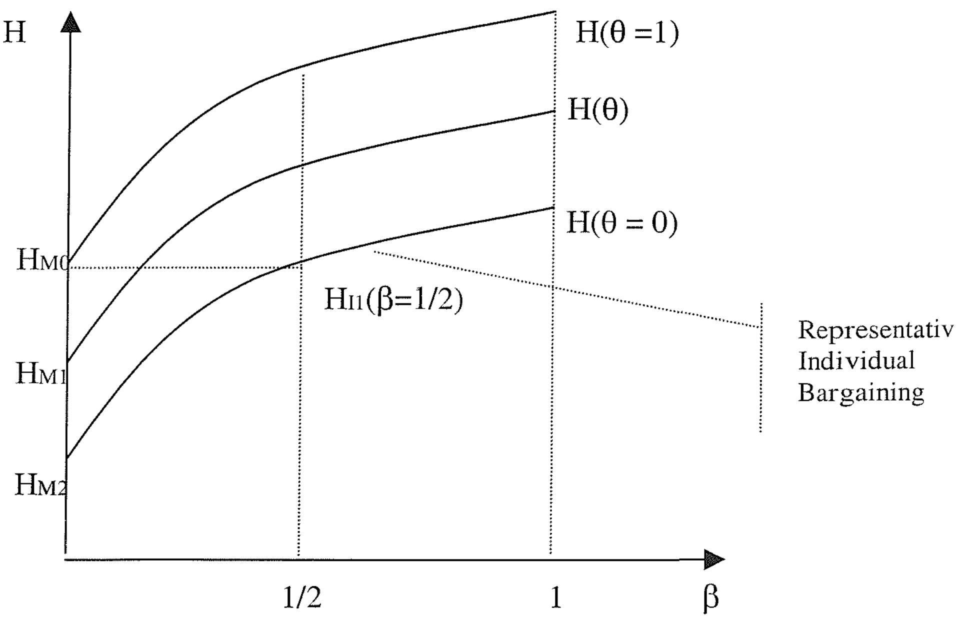

Figure 3.2: The relationship of Hours with β and θ

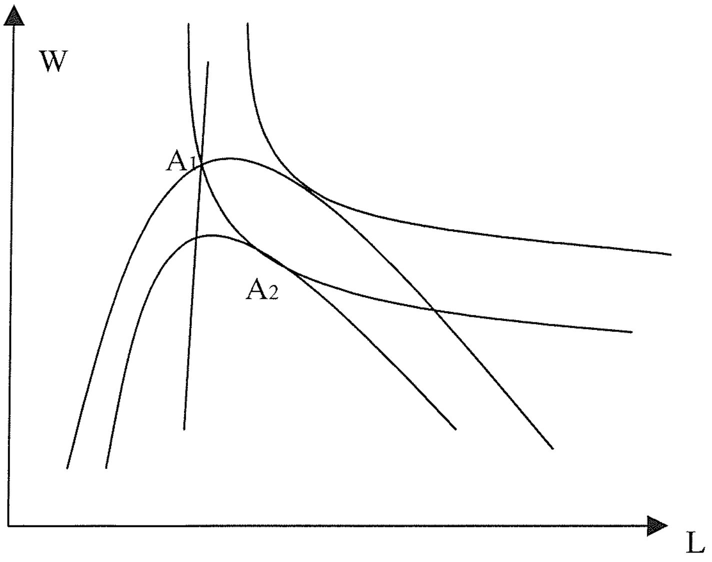

Figure 3.3 Contract Curve

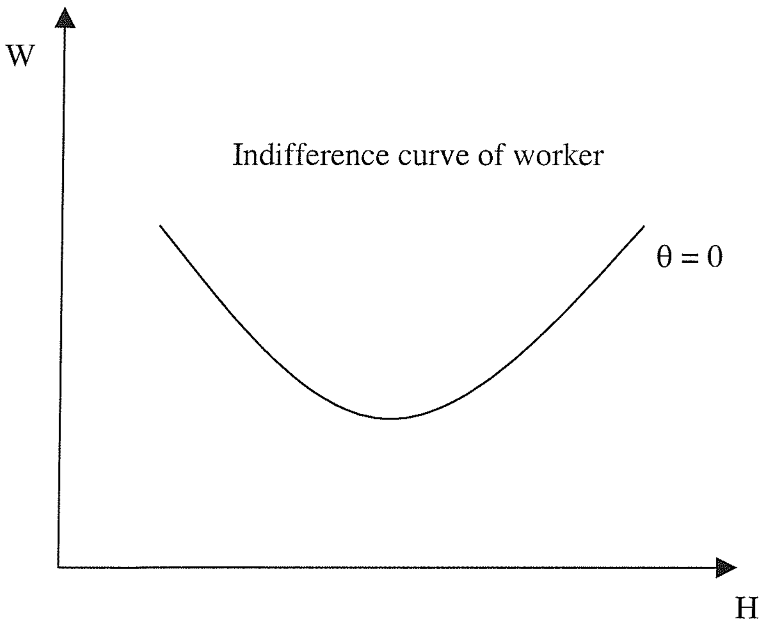

Figure 3.4

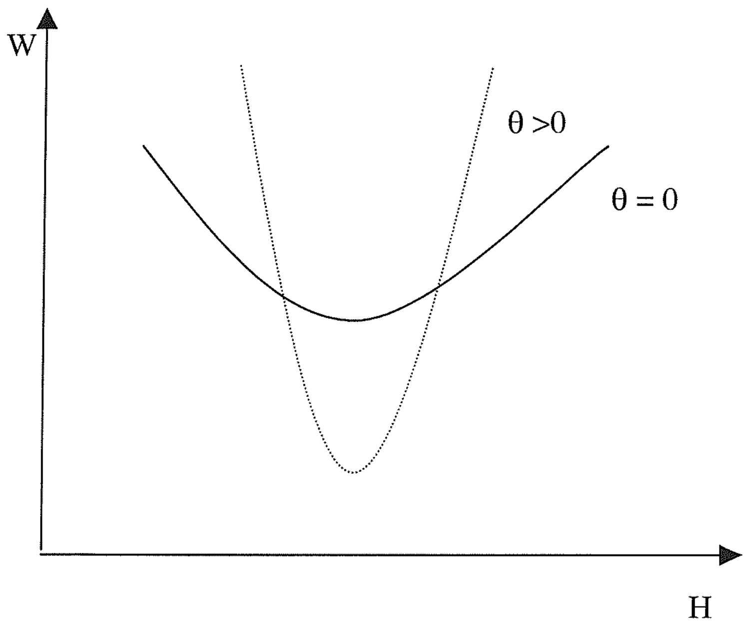

Figure 3.5 Indifference Curve of Worker

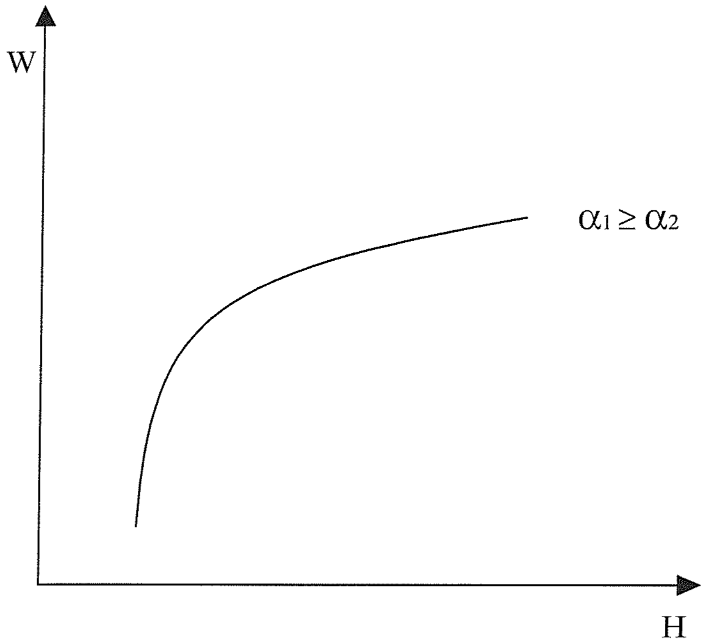

Figure 3.6 Isoprofit Curve

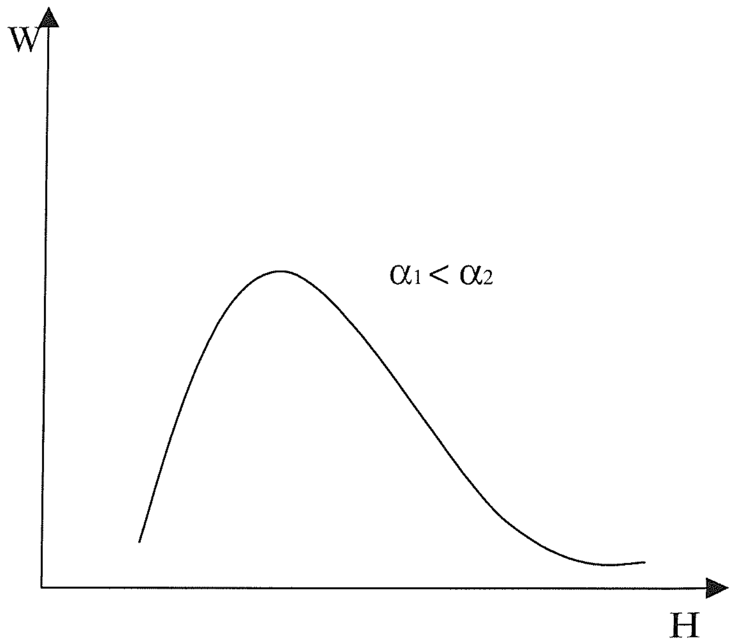

Figure 3.7 Isoprofit Curve

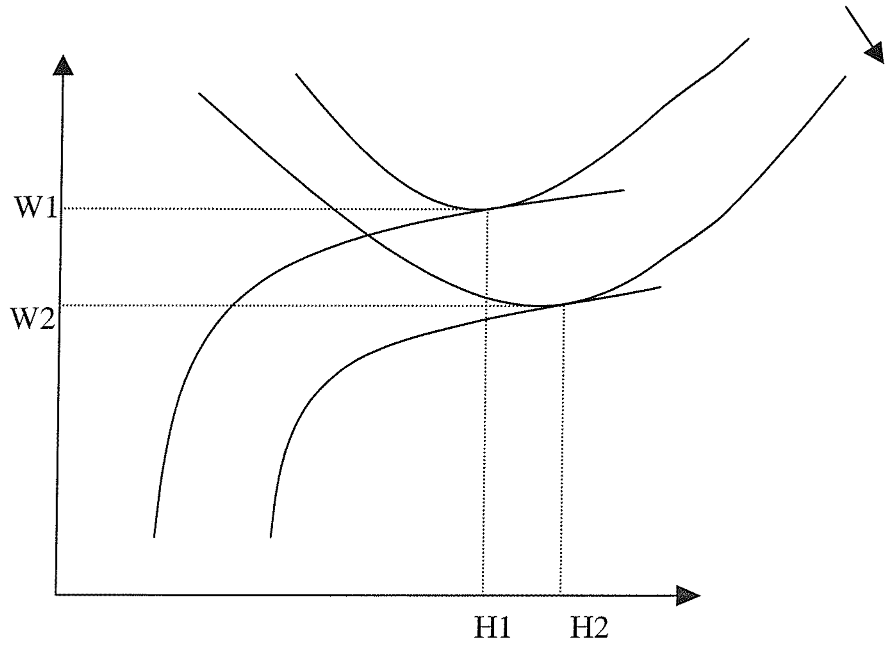

Figure 3.8 Reaction of β change ($\alpha_1 \geq \alpha_2$)

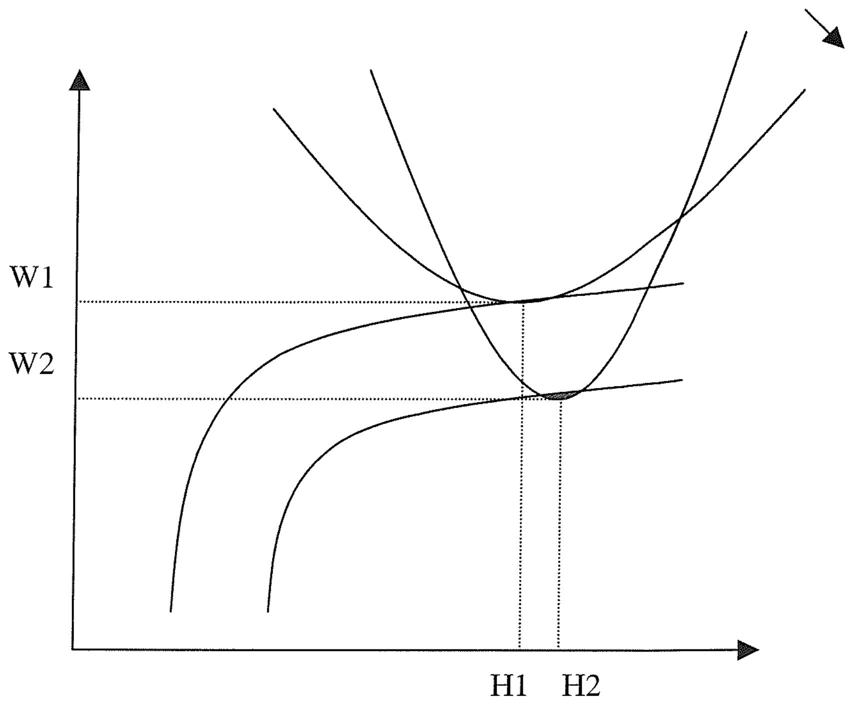

Figure 3.10 Reaction of θ change [$\alpha 1 \geq \alpha 2$]

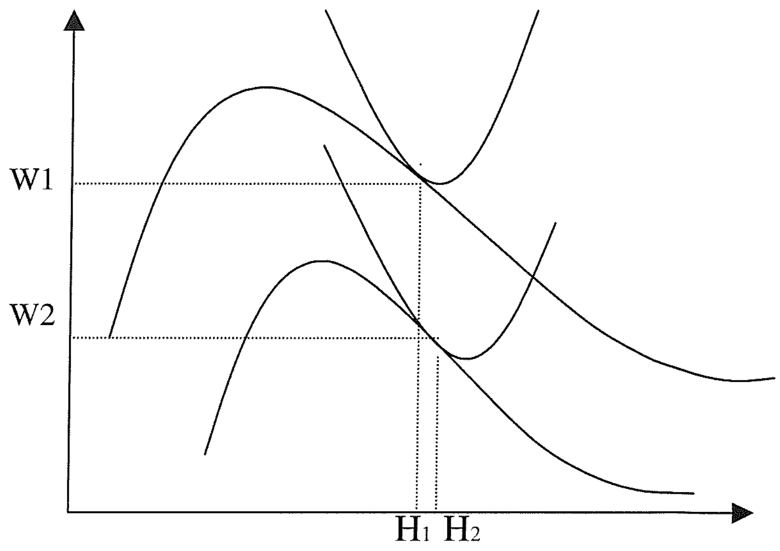

Figure 3.9 Reaction of β change (α1 < α2)

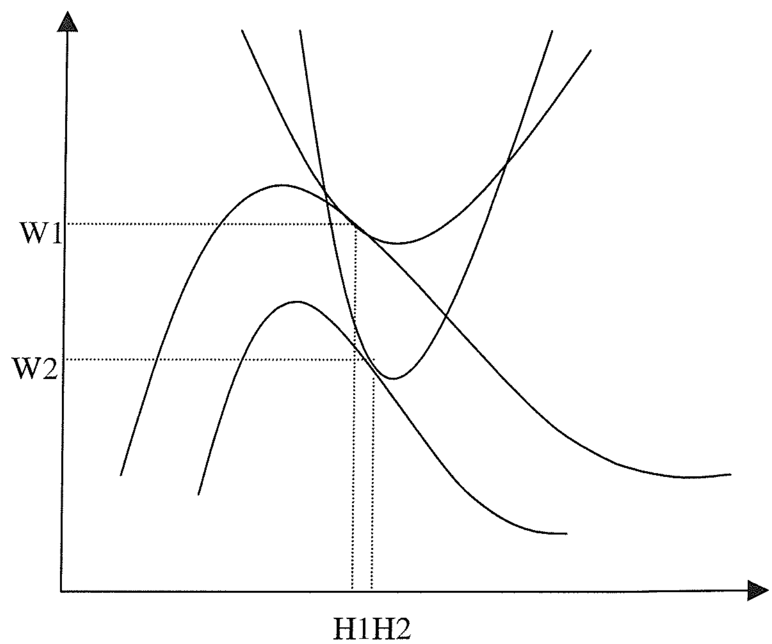

Figure 3.11 Reaction of θ change (α1 < α2)

Chapter Four: An Empirical Analysis of The Union Effect on Working Hours

1 Introduction

It has been shown in Chapter 3 that the union has a negative effect on working hours, a positive effect on wage rate, while the employment effect is ambiguous. Also various empirical studies have stated that union hours markups are negative. It ranges from -0.3% to -15%, and it varies considerably by type of worker, by industry and by occupation. The union tends to reduce the total hours of work, standard hours and unpaid overtime hours, but it will increase the number of paid overtime hours. Moreover hours and weeks exhibit significant procyclical patterns. A 1% increase in unemployment rate is associated with 1.1% decline in weeks worked, 0.6% decline in weekly wages, and 0.3% decline in weekly hours worked. More details about hours empirical finding in the literature have been described in Chapter 2. Many papers have used individual data to test the union effect on hours of work. However the individual data set has not been able to examine how the firm characteristics and the fixed cost of each unit of labor affect hours of work. In this section an firm-level survey data of the electrical engineering industry within UK has been used to test the union effect on hours. Apart from that, another purpose of this paper is to study how firm size influences hours setting. It has been widely noticed that the large firm pays a higher wage than the small firm. However none of them have discussed the hours difference in the firm with different size. They have been found, in general, (i) the presence of union will reduce total hours working about 4%; (ii) the union may play different roles in different firm sizes and different skill levels. The large firms prefer more hours from their worker and somehow, in contrast, the union in a large firm would claim for a large hours reduction, especially for semi-skilled workers in the data set.

The structure of this chapter are as follows: Section II provides the description of the data and the regression model. Section III offers the empirical result and interpretation. The conclusion is in Section IV.

2 The Data

The data used here is an firm-level survey data set from 1979 to 1984 from the electrical engineering industry within U.K. Initially this survey data set was collected under the request of the Industry and Employment Committee of the Economics Research Council to make an independent assessment of the nature of labor force change and its relationship to output and wages in the electrical engineering industry. And these 6 years data set have been reduced to a minimum to address the "cycle", in order to shape the national policies towards redundancy, youth training, and wage policy. It consists of 89 firms and 534 observations. 56 out of 89 firms have a union to represent their manual workers, 38 have a union to represent their clerical workers. The data set has 15 continuous variables and 41 discrete variables. The Continuous Variables includes the average number of employees, average standard hours , average overtime hours, average earning, number of employees made redundant, total net sales, et. al. and one variable HRW can not be identified. The Discrete Variables include the variable for the region, the proportion of SEMI-SKILLED workers that are members of a trade union, proportion of SEMI-SKILLED workers that are female, the dummy variables for clerical workers and for manual workers, redundancy variables, et.

al., and one variable NOVL can not be identified. The unemployment rate of each region is from Economic Trends 1990 Edition.

All workers have been distinguished into 3 categories, craftsmen, semi-skilled and clerical workers. The unionism rate of manual workers (craftsman and semi-skill) is 64.64%, on the other hand the rate for clerical worker is 43.18%. Thus we may conclude that the unionism rate is higher among manual workers. This is consistent with what I drew in the Chapter 1, the manual worker is more likely to be a union member. The following Table 4.1 summarizes the overtime hours and total working hours for each category in each year. The total working hours is calculated from adding overtime hours and standard hours. Since the data of overtime hours for clerical workers is not available, I can only provide the table for craftsmen and clerical workers.

There is a view that union wage markups are positive, for most demographic groups the union total hours markups are negative (Perloff 1987). It can be noticed here in general that the overtime hours and total working hours in the union sector are less than that in the non-union sector. In 1979, Semi-skilled workers in the non-union sector had about two hours more per week than their counter part in the union sector. While in 1984, there was still a one hour difference. In contrast the craftsmen in the non-union sector just worked slightly more than in the union sector. In some years, i.e. 1979, the hours of craftsmen in the non-union sector was about one hour more than it in the union sector, however, in some years it may be the other way around, the union sector works more than non-union sector, i.e. 1983.

Table 4.2 provides the means of overtime hours and Total hours for different sectors, and it can be realized that especially for the semi-skilled worker, the non-union sector worked significantly more than union sector, no matter in overtime or total hours. The difference was about one hour more in union sector. Whereas the gap was just about 0.10 for craftsman. The value of standard deviation indicates that the dispersion of working hours for the semi-skilled in the union sector is smaller than that in the non-union sector, 2.51 vs 2.79 for total hours; but for the craftsman it is higher in the union sector than in the non-union sector, 2.99 vs 2.53 for total hours. This is slightly different to Pencavel 1990 in that the dispersion among individuals in hours and weeks worked is invariably smaller in the union sector from his survey data.

Table 4.1: Overtime and Total hours for Craftsman and Semi-skill

Year	Overtime Hours for Craftsman	Overtime Hours for Semi-skill	Total Hours for Craftsman	Total Hours for Semi-skill
Union Sector				
1979	4.90	3.08	44.75	42.92
1980	4.54	2.76	44.33	42.56
1981	4.24	2.53	43.77	39.53
1982	5.00	3.64	44.02	42.66
1983	5.04	3.51	43.89	42.36
1984	4.81	2.81	43.59	41.60
Non-Union Sector				
1979	6.00	5.17	45.78	44.94
1980	4.28	3.39	43.94	43.05
1981	4.11	3.44	43.50	42.83
1982	5.58	4.73	44.63	43.78
1983	4.21	3.46	43.42	42.67
1984	5.00	3.78	43.94	42.72

Table 4.2: Average hours of Craftsman and Semi-skilled

	Union Sector	Non-Union Sector
Overtime Hours for Craftsman	4.77 (3.03)	4.84 (2.573)
Overtime Hours for Semi-skill	3.07 (2.61)	3.98 (2.861)
Total Hours for Craftsman	44.05 (2.99)	44.17 (2.525)
Total Hours for Semi-skill	42.35 (2.51)	43.31 (2.79)

* The standard deviation are in the bracket.

Some economists have shown there are some links between overtime hours and total working hours. Blanchflower presented in 1996 that the union tends to reduce standard hours and unpaid overtime hours but increases the number of paid overtime hours. Also Hunt (1998) shows that the reduction of standard hours may lead the fall of total working hours and employment. However in this work I can not distinguish paid overtime with unpaid overtime hours, in the mean time, the data of overtime premium is not available. The figure of total hours is derived from adding overtime hours and standard hours. The focus this section is how the total hours would be affected by the union .

3 Econometric Evidence

A large number of papers have used individual level data sets to analyze union and nonunion differences in working hours, i.e. Lewis (1986) finds that the union-nonunion differential for male workers is about -1.8%. In those papers they may use annual hours, weekly hours or even annual weeks as dependent variables. A influential paper by Earle & Pencavel (1990) which adopts the form as

$$\ln h_i = \alpha X_i + \beta U_i + \varepsilon_i$$

where h_i is the measure of individual i's hours of work, U_i is a dummy variable where the individual's job is covered by a collective-bargaining agreement, X_i denotes other characteristics of the worker and of his job, which includes age, schooling, marital status, amount of welfare income, dummy variables for location, dummy variables for major occupational group, dummy variables for industry divisions, etc.

In this work the firm level data has been used to test the union effect on hours of work. The equation utilized here for estimation can be expressed as

$$\ln Y_{it} = c + \alpha X_{it} + \beta Z_{it} + \varepsilon_{it}$$

where subscript i runs across firms and t across time periods. The dependent variable is the natural log of the total weekly working hours. X_{it} represents the explanatory variables, which includes the unemployment rate, the percentage of this category worker, the net sale growth rate, the percentage of part time employees, redundancy workers and new trainees. Unemployment is included as some researchers claim the union prefers to adjust to business cycle downturn by placing workers on temporary layoff instead of reducing their weekly hours of work. The number of part time employees, redundancy workers and new trainees are to catch the fixed cost of labor in the period. Other variables denote the firm characteristics. Z_{it} represents the dummy variables for region, for firm size and union status, as well as the interaction of the firm size with union status. Finally ε_{it} represents the error term. The main concern is how union status affects the working hours. By including the interaction of union status and firm size dummy variables, it enables to observe whether union in large firm plays different role with the union in small firm. All the region has been divided by four parts according to the number of observation. They are South East, South West, Westmidland and others. Also firms have been categorized as small size firm (for less than 300 employees), middle size firm (between 300 to 500 employees), and large size firm (for more than 500 employees). The firm size dummy variable indicates whether the individuals work more hours in the large firm apart from what we have known that large firm pay its employee more than small firm. In order to simplify the equation, in the interaction of union dummy with firm size dummy have only been categorized in the firm with less than 300 employees (small size firm) or more than 300 employees (middle & large size firm). Therefore the coefficient of union * firm dummy ($<$300 employees) would indicate the union's influence on hours determination in relatively small firm, and the union* firm size dummy ($\succcurlyeq$ 300 employees) indicates the influence of union in relatively large firm. Also this simplified distinction would make the estimation more significant in terms of the union's hours influence. In the mean time, other firm characteristics variables and unemployment rate denote how much effect they have on hours of working.

Accurately the union status variable has been defined as follows in the questionnaire:

Do you recognize any trade union at the level of your establishment,

Representing manual workers?

If yes, TUM=1,   No, TUM=0

Representing clerical workers?

If yes, TUC=1,   No, TUC=0.

The sample originally includes 6 time periods and 534 observations, as it is supposed that the number of redundancy workers in the last period would affect the total working hours of this period, rather than this period affects this period. So one year lag of redundancy worker has been used as the independent variable. Some data also are not available for some variables, TSP only pick up the interaction of all these variables. In other words, TSP only uses the observations which datas are available for all the 11 explanatory variables; otherwise it would not be included, even it is just short for one out of the 11 explanatory variables. These two factors have left a total of 174 observation of 5 years period available, from 1980 to 1984, for semi-skilled worker, and 218 observation of 5 years period for craftsmen. The descriptive statistics of both the full sample (534 observations) and restricted sample have been summarized in Table 4.3. The value of the percentage of redundant workers, part time employees, overtime and total hours in the full sample are large than their counterpart in restricted sample, especially we notice that the mean of total number employees in full sample is significantly large than it in the restricted sample. Therefore we may infer there are more large firms among the lost observations. And the coefficients of dummy variable for large firm (including the size dummy for large firm as well as its interaction with union dummy) might be underestimated.

[Table 4.3 insert here]

Because the effects on hours of various categories are not accounted for in the descriptive statistics in Table 4.2, we expect that hours difference can be attenuated in multiple regression analysis. To estimate the equation, the first method I tried is Ordinary Least Squares for semi-skilled workers or craftsmen with 88 firm dummies. It is shown in Table 4.4. Although the test results are consistent with our expectation, as we mentioned before there are only 174 observations available for semi-skilled workers and 218 observations for craftsmen, probably 88 firm dummies are too much for these observations. Therefore we redistribute all the 88 firm dummies into 9 groups for semi-skilled and 11 groups for craftsmen. Then I run the regression with group dummies instead of the 88 firm dummies after it has been accepted by the F test that all the firms in every group are with the same firm specific characteristics. This has been done separately for semi-skilled worker and craftsmen. For the sake of comparability, all the estimators of these two methods are presented together in table 4.4.

Many studies have confirmed that unions have the effect of reducing working hours. Blanchflower (1996) finds there is a negative union effect on working hours in UK; Lewis(1986) shows that the union hours gap for US average is -1.8%, the negative effects were not negligible in size. Earle and Pencavel (1990) report that for white male employees union and non-union hours differential is about -1.1%.

If we look at the 1st and 2nd columns of table 4.4, the OLS model for craftsmen and semi-skilled worker with all the firm dummies, the coefficients of the union dummy are -0.02 in the middle size firm as well as the large size firm for craftsmen, and -0.039 in the middle size firm, -0.044 in the large size firm for semi-skill. Compared with group dummies in the 3rd and 4th columns, we can see they are -0.02 and -0.018 in middle and large size firms respectively for the craftsmen; -0.038 and -0.050 for the semi-skill, which indicates that the union has a negative effect on working hours regardless of firm size. The union will reduce about 4% (Take the antilog and deduct 1) of total hours working in general. It is consistent with other studies, although the effect is slightly bigger. However we have to bear in mind that this data set is from 1979 to 1984 when there was a recessionary period in UK.

Another interesting point we may notice is that the union in large firm and small firm may play different roles in terms of working hours setting. From the 3rd and 4th column, the coefficients of the union effect for craftsmen are -0.02 strongly significant in the middle size firm and -0.018 not significant in the large size firm; the coefficients of the semi-skill are -0.038 strongly significant in the middle size firm and -0.050 significant at the 10% level as well in the large size firm. It seems to indicate that for the different skill levels and different firm sizes, the union's effect is a little different, especially for the semi-skilled workers is changing from the 3.8% reduction to the 5%, although it is not a big difference for craftsmen except it is significant in the middle size firm but not in the large firm. Many economists have shown that the large firm pays a higher wage than the small firm, but none of them discuss the working hours difference.

[Table 4.4 insert here]

Besides the firm size also influences the labor's working hours. For craftsman the middle size firm will increase about 1% total hours working, and the large firm will increase about 1.2% working hours. While for the semi-skilled worker the employee will work about 5% more in the middle size firm, and about 5.5% more in the large firm. It may tell that the large firm prefers more working hours from the employee, in the mean time when they are paying better than the small firm. One possible reason that accounts for this is that in large firm, it is more likely to use a large fixed capital, a more capital intensively production process, the employees are thus more productive than in a small firm. Alternatively some economists claim that, compared with small firms, large firms would provide more on-the-job-training, or hire higher quality workers. Therefore large firms want more hours from their employee. On the other hand, the large firm is more likely to be unionized, from this data set, it shows, in the firms with less than 100 employees only about 3.24% have been unionized, while the unionization rate is 48.72% in the firms with 100-300 employees, 90% with 300-500 employees, and 100% for the firm with over 500 employees. In summary, employees in large firms would usually work for more hours than their counterparts in small firms, while that the union tries to reduce the hours to increase the utility of its members. Especially for the low skill level of workers, unions in large firms will claim for more hours reduction. All the value I described above is for the model with group dummies.

Several studies have found how unemployment rates affect the hours. Pencavel (1990) presents that the effect of unionism on hours is greater in periods of relatively high unemployment, that is, lower employment induces relatively more work sharing in the unionized sector. Perloff (1987) and Pearce (1983) report that to increase unemployment in an area should lower both union and nonunion hours, but union hours should be more sensitive to unemployment rate. As I mentioned before there was a business slump in the UK, the unemployment rate soared up from 2.5% in 1970 to 10.67% in 1984. We can notice that the coefficients of the unemployment rate in all four columns, are all negative and significant.

A higher unemployment rate does reduce the total hours of working, although the reduction is very small compared with firm size effect and union effect. A 1 percentage of unemployment rise will reduce about 0.25% of hours of work.

The number of part time employees, redundancy workers and new trainees are expected to catch the effect of fixed cost of each labor in the period. We have known from the data, in the 6 years period, the average of redundancy workers in the union sector is about 3.8%, but is only 1.32% in the non-union sector. This figure is consistent with Freeman (1984) that layoff rates are two to four times higher in the union than in the nonunion sector, and union workers are 50 to 60 percent more likely to be on temporary-layoff unemployment as a result. Also Blanchflower (1996) and Medoff (1979) indicate that part time work is less prevalent in the union sector than in the nonunion sector, and the union prefers to adjust to a business cycle downturn by placing workers on temporary layoff instead of reducing their weekly hours of work. The firm has to offer the training cost, or firing cost to each of the new arrivers or leavers. The big number of new trainees, redundancy workers and part time employees is associated with a large amount of fixed cost.

However from the estimators in the regression with group dummies, they show that more part time employees lead to less total hours of working; more redundancy worker in last period lead to more hours of working in this period. A 1% of part time employees rise for craftsman will reduce about 0.17% total hours working; 1% of redundancy workers in the last period rise will increase about 0.032% total hours working. For semi-skilled workers, a 1% of increase of the part time employees will reduce 0.20% hours work; and a 1% of increase of the redundancy workers in last period will increase about 0.032% hours work. Although the estimators of redundancy workers are not as significant as those of part time employees, they are very consistent with these two skill levels. Unfortunately the impact of new trainees is ambiguous. It was a positive effect on craftsmen, more new trainees more working hours, while it has a negative effect on semi-skilled workers, but none of them are statistically significant.

The impact of Net sale growth has the significant positive effect on hours. 1% of sale growth may lift about 0.05% working hours up both to the craftsmen and semi-skilled worker. In fact that is consistent with what we expect; if the firm sells more products, it would ask the employees to work for more hours .

Stewart (1997) studies the relationship between the proportion of workforce and wage. He shows in his equation that in the nonunion sector the average pay of skilled workers is lower, the greater the proportion of the manual workforce they are, but this effect is absent in the union sector. In our equation it tells that there is another relationship between the proportion of workforce and the working hours. In the craftsman equation the estimator of percentage is -0.01, which means that high proportion of craftsman will depress the working hours, but this effect is not significant. In the semi-skilled equation, the influence is significant negative, 1% of semi-skilled worker rise would reduce 0.08% of working hours. This has been proved in our theoretical model, the union which has a high proportion of workforce normally should have high bargaining power. The high bargaining power, the lower hours of work.

Another regression has been run afterwards which also includes the Log weekly wage rate as an explanatory variable, the result which comes out is very similar to what I presented above. The coefficient of the weekly wage is trivial positive, but not significant.

In order to extend the data set, I combine the data for craftsmen and semi-skilled workers together in one equation to retest the confidence of our regression with the same 88 firm dummy variables. On the one hand, I extend the data set to 308 observations available, on the other hand, the number of explanatory variables also are increased . The result is shown in Table 4.5.

[Table 4.5 insert here]

In columns 2 and 3, the regression is run with firm size dummies for middle size and large size. While Columns 4 and 5 are the regressions which combine the middle size with large size, (if this firm has more than 300 employees, it equals to 1; otherwise 0); create the union dummy for small firm and large firm, (if there is a union, it equals to 1, otherwise 0). Compared with Table 4.3, the coefficients in this Table are the average for the Craftsmen and Semi-Skilled, in column 2, most of the signs are still the same as Table 4.3, although some may not be significant, except the coefficient of the percentage of the labor force. It is positive in Table 4.4, but they are negative in Table 4.3. The coefficient for the middle sized firm is 0.024 (0.61), and for the large sized firm is 0.024 (0.51). The combining coefficient of the firm size dummy is 0.018 (1.16), and the large sized firm would prefer its employee to work for more hours, although the coefficient is still not significant.

4 Conclusion

This analysis intends to offer empirical evidence of the union bargaining effect on hours of work. By using the firm level data set for the electrical engineering industry from 1979 to 1984 across U.K., the evidence is found that the union has a negative effect on working hours. In general the union reduce about 4% of total hours working for the semi-skilled, and about 2% for the craftsmen, which is slightly bigger than Lewis (1986)'s 1.8%, and a little less than Pencavel(1990)'s 6.7%. Furthermore, I found that the unions in different firm sizes may play different roles to different kinds of workers in terms of hours setting, for semi-skilled workers in middle size firms, workers in the union sector will work about 3.8% less than their counterparts in the nonunion sector. However in large size firms the hours difference between these two parts is 5%; whilst for the craftsman the effect for middle size and large size firm are nearly the same, one is 2%, and another is 1.8%. The possible reason which accounts for this is that in the large firm, it is more likely to use large fixed capital, and a more capital intensively production process, the employees are thus more productive than in small firm. Alternatively some economists claim that large firms would provide more on-the-job-training or have hired higher quality worker than it in small firms. Hence the employees in large firm have been asked to work for more hours. While unions would claim for hours reduction in order to increase its member's utility, especially for the low skill level of work in large firm.

5 Appendix

1. Average Number of Employees should include all persons on the payroll on average during each period.

2. Part Time Employees are defined as those who work less than 21 hours per week.

3. Number of Employees Leaving include those leaving due to retirement, redundancy or any other reason.

4. The total working hours is obtained by adding overtime hours and standard hours; and the Average Overtime Hours and Standard Hours is for a typical week.

5. Firm size dummy is categorized as small firm (<300 employees), middle size firm ($300 - 500$ employees) and large firm (> 500 employees).

6. Union dummy is defined as: If you recognize there is a trade union represent manual workers/clerical workers at the level of your establishment, TUM / TUC = 1, otherwise TUM / TUC = 0.

7. Percentage of Semi-Skill/Craftsman is defined as the number of Semi-skilled worker/Craftsman divided by the total number of employees.

8. Percentage of Part Time/Laid Off in last period/New Trainees is defined as the number of Part TIme/Laid Off/New Trainee divied by the total number of employees.

9. Sal Growth is defined as (Sales - Sales(-1))/Sales(-1).

Table 4.3 Mean and Standard Deviation of the Full Sample and the Restricted Sample

	Full Sample	Restricted Sample Craftsman	Restricted Sample Semi-Skilled
Total No. of Employees	388.43 (490.06)	340.63 (304.32)	336.27 (327.07)
Percentage of Redundents	4.22% (0.13)	3.76% (0.08)	2.87% (0.07)
Percentage of Part Time	4.09% (0.07)	3.56% (0.05)	2.65% (0.03)
Percentage of New Trainee	0.74% (0.01)	0.8% (0.02)	0.69% (0.01)
Sales Growth	0.12 (1.23)	0.089 (0.17)	0.094 (0.21)
Percentage of Craftsman	0.21 (0.19)	0.22 (0.19)	
Percentage of Semi-Skilled	0.42 (0.26)		0.43 (0.26)
Overtime Hours Craftsman	4.80 (2.84)	4.69 (2.71)	
Overtime Hours Semi-Skilled	3.22 (2.67)		3.13 (2.60)
Total Hours Craftsman	44.02 (2.91)	43.81 (2.77)	
Total Hours Semi-Skilled	42.45 (2.61)		42.27 (2.52)

* Standard Deviation are in the bracket.

Table 4.4: Estimate of hours of work in UK Electrical Engineering Company

	Ln Total Hours		Ln Total Hours		Ln Total Hours		Ln Total Hours	
	Semi-Skill with Firm dummies		Craftsman with Firm dummies		Semi-Skill with group dummies		Craftsman with group dummies	
Constant	3.778	(189.43)	3.766	(175.94)	3.777	(364.44)	3.766	(357.91)
Firm Size Dummy1 / 300-500 Employees	0.041	(1.229)	0.128	(0.39)	0.050	(1.80)	0.010	(0.69)
Firm Size Dummy2 / 500+ Employees	0.045	(1.23)	0.010	(0.29)	0.056	(1.92)	0.012	(0.73)
Firm Size Dummy / < 300 employees * Union	-0.039	(-2.19)	-0.020	(-1.25)	-0.038	(-5.73)	-0.020	(-3.56)
Firm Size Dummy / >300 Employees * Union	-0.044	(-1.14)	-0.020	(-0.52)	-0.050	(-1.77)	-0.018	(-1.22)
Percentage of / Semi-Skill	-0.075	(-2.08)			-0.079	(-8.03)		
Percentage of / Craftsman			-0.97E-03	(-0.04)			-0.010	(-0.89)
Unem. Rate	-0.25E-02	(-2.55)	-0.28E-02	(-3.02)	-0.25E-02	(-3.24)	-0.25E-02	(-3.62)
Sales Growth	0.051	(3.74)	0.056	(3.61)	0.053	(4.83)	0.054	(4.69)
Percentage of / part time employees	-0.237	(-1.39)	-0.203	(-1.68)	-0.198	(-2.32)	-0.18	(-3.92)
Percentage of / laid off in last preiod	0.036	(0.84)	0.025	(0.74)	0.032	(0.95)	0.033	(1.57)
Percentage of / New Trainees	-0.179	(-0.42)	0.25	(1.15)	-0.197	(-0.94)	0.24	(1.70)
LM. het. test	0.01		1.19		0.72E-02		1.18	
D-W Value	1.48		1.65		1.39		1.57	
R^2	0.80		0.84		0.81		0.84	
No. Obser.	174		218		174		218	

* T-values are in the bracket.

Table 4.5: Estimates of Ln Total Working Hours with combining Semi-Skilled and Craftsman

Variables	coefficient	t-value	coefficient	t-value
constant	3.73	161.896	3.73	166.40
Firm Size Dummy: 300-500 employees	0.024	0.61		
Firm Size Dummy: 500+ employees	0.024	0.51		
Firm Size Dummy: 300+ employees			0.018	1.16
Firm Size Dummy(<300 Employees)* Union	-0.03	-1.47		
Firm Size Dummy (>300 Employees)*Union	-0.036	-0.82		
Union Dummy			-0.03	-1.53
Percentage of Craftsman or Semi-Skilled	0.079	6.71	0.079	6.74
Unemployment Rate	-.26E-02	-2.15	-0.26E-02	-2.24
Net Sale Growth Rate	0.064	3.32	0.064	3.34
Percentage of Part Time employees	-0.22	-1.10	-0.23	-1.16
Percentage of Redundancy Worker of Last Period	0.02	0.40	0.019	0.39
Percentage of New Trainees	-0.054	-0.11	-0.74	-0.16
LM het. test	0.046		0.47	
D-W Value	1.00		1.00	
R-squared	0.65		0.65	
No. of Observation	308		308	

Chapter Five: Union and Firm Size Effects on Wage Rate

1 Abstract

In the literature both unions and firm size have been found to influence wage rates. Furthermore if firm size is included as an explanatory variable in the wage regression, the union effect is reduced. Using an firm panel data set which covers a recession period within UK electrical engineering industry, the size effect is shown to differ in the union and non-union sectors. In the union sector, the influence of size on wages is negligible or even negative. However in the non-union sector, wages increase with firm size for manual workers. The union wage differential is also found to be larger during the recessionary phase of our sample. Regardless of the union status, the size effect on wages is in line with monitoring cost theory. The occupation is more difficult to supervise, the size effect would be more stronger. Decomposing union and non-union wage differential, I find that various factors have contributed differently to it, unemployment is one of the most significant factors. However this wage differential is mainly caused by the "price difference", which denotes there exist different wage rates in union and non-union sector given same firm characteristics.

2 Introduction

There is much evidence that unionized workers tend to earn more than non-unionized members, ceteris paribus, i.e. Lewis (1986), Freeman & Medoff (1984), Blanchflower (1990), Stewart (1987). In general, the positive union wage mark-up ranges from 3% to 20%, and it varies with the period, region, occupation and gender. Whereas in some cases, i.e. Ashenfelter (1978), Wabe & Leech (1978), they find there may exist a negative union wage effect. Moreover the union wage appears to be rigid over the business cycle, while the non-union wage is procyclic, e.g. Raisian (1979), Pearce (1983), Freeman & Medoff (1984). So it results that a union wage mark-up appears to decline during inflationary periods and to rise during recessions. Also firm size has been widely noticed to have an effect on wage rates: large employers pay their employees more than small employers. Oi (1983), Miller (1996), Brown (1989) Barron & Black (1987) conclude that hourly wage rate is positively related to both firm and establishment size. The estimates reported by Barron & Black (1987) are typical of these studies and suggest that a 100% increase in employer size is associated with an approximate 2.8% increase in the starting wage and an approximate 1.5% increase in the wage after 2 years.

A few studies have provided explanations for why large firms tend to pay higher wages than small firms? Brown (1989) considers six explanations: higher quality workers, inferior working conditions, more use of high wages to forestall unionization, more ability to pay, facing smaller pools of applicants relative to vacancies, and less able to monitor their workers. Hamermesh (1993) argues that the larger firm is facing lower input price, and is therefore in a better position to adopt new technology. So the large firm is often associated with a faster work pace raising labor productivity and hence wage rate.

Wages not only relates to both unionization and firm size, there is also a direct link between firm size and unionization. The larger the firm, the more likely it is to be highly unionized.[7] Very few papers have studied the relationship among these three factors. For instance, Miller & Mulvey (1996), Pearce (1990) find from their individual level data sets that union/non-union wage differential is reduced if it includes firm size as an explanatory variable in the wage regression. And Green, Machin and Manning (1992) find the weak size-wage relationship in the union sector, but strong in the non-union sector, and conclude that the dynamic monopsony model is the explanation of this phenomenon. Some further questions arise: 1) In a single industry establishment panel data set, will it remain true that unionization and firm size both influence wage rate? 2) Is union influence on wage rate constant over the business cycle? 3) Does the firm size effect vary with union status? 4) What accounts for the union wage differential? Possibly what is the trend over different periods?

In this paper I include the firm size effect in the wage regression and will be investigating empirically the union influence over wage rate. Some economists, i.e. Krueger (1993), Dunne and Schmitz (1995), find that the firms and industries which adopt new technologies are profitable, and the employees associated with new technologies are more productive, therefore the wages may represent this surplus to be higher. The control of using the observations within a single industry helps me to rule out the technology hypothesis on labor productivity. As this data set covers the period when UK was confronted with an economic slump, the union influence on wage over the business cycle can be tested. The structure of this study is organized as follows. Section I provides the whole background of the union and firm size effect on wage rate, as well as several possible explanations for the firm size wage effect from recent literature. Section II presents the regression model over the whole sample, union sector and nonunion sector respectively for craftsmen, semi-skilled and clerical workers to analyze those effects. In the section III and IV we shed some light on the level decomposition to explain

[7] See Miller and Mulvey (1996)

the source of the union wage differential by splitting into the "price difference" and "observed firm's characteristics difference", and trend decomposition to analyze how the wage differential changes between different periods. We draw the conclusion in section V.

3 Background

3.1 Union and Wage Rate

As we indicated in Chapter Two, there are two kinds of union bargaining models in common use: the Right to Manage model and the Efficient Bargain model. These models differ according to whether the union is bargaining with the firm over employment levels or as well as wage rate. In both models, unions increase the wage rate above the competitive level. In general the positive mark-up have been found to range from 3% to 20%, and varies with the period, region and occupation.

Also Lewis (1963), Mellow (1981) and Wunnava (1991) find that the union wage premium is counter-cyclical. Even during the period of slump, while the nonunionized firm pay lower wage rates, the union wage rate is still rigid. There are several explanation accounts for the union wage rigidity. Wachter (1986) denotes that high transaction costs and labor legislation governing collective bargaining force the employer to agree the long-term contracts, and it caused the existence of union wage rigidity. Freeman (1984) and Medoff (1979) show that unionized firms rely on the temporary layoffs rather than the wage reduction, as the senior employees have the more powerful influence on union policies. In most cases, junior workers suffer the temporary layoffs, while the union wage holds steady. Vroman (1989) provides another explanation that unions offer the employer an inherent employee monitoring system to compensate their members, however, nonunion firms pay an incentive wage to encourage their employees to work more efficiently. When the economy is in contraction, nonunion workers work hard to avoid losing their jobs, therefore, the employer has less incentive to pay them the efficiency wage. While union workers are covered by the rigid long term contract, they still maintain their wage level.

The union is also likely to affect the overall distribution of earnings, and reduce the wage dispersion. Freeman (1981) (1984), Lemieux (1998) suggest that the union is associated with lower wage dispersion. By using a individual data set, and the standard deviation of the log wage as the measure of dispersion, Freeman found that the standard deviation of the log wage are 0.29 and 0.35 among union workers in manufacturing and nonmanufacturing, respectively, compared with 0.40 and 0.45 among nonunion workers. One potential route is to standardize the rate of pay. It reduces the dispersion by permitting less individual variation in wages for workers with similar years of seniority, and restricts the firm from differentiating among workers. A wage rate or range of rates is established for given jobs, rather than for individuals. Also the number of pay categories is limited by the collective bargaining agreements. This finding is supported by empirical evidence of a standard log earning regression for separate union and nonunion sector, and conclusions can be drawn that the difference in wage dispersion between the union and nonunion sectors are attributable to three sources: differences in characteristics between union and nonunion workers; differences in earnings function parameters between the union and nonunion sectors; and differences in the variation of the residual in the two sectors.

3.2 Firm Size and Wage Rate

While there is a union wage gap, much evidence shows there also exists a firm size wage gap: big firms pay their employees high wage rates than their counterparts in small firm. Mellow (1982), Brown (1990) conclude from their CPS data that hourly earning were positively related to both firm and establishment size.

Furthermore, Brown indicated that the size-wage premium of 35% was of similar magnitude to the 36% wage gap for men and women, and exceeded the wage gap of 29% for union over nonunion workers and 14% for white over black employees.

Several explanations have been provided to the size effect on wage rate.

3.2.1 Labor quality explanation

The theory of the labor quality explanation says that big firms hire high quality workers. Why? One of the possible reasons is by Oi (1983). He suggests that larger firms prefer high quality labor because of greater monitoring cost. In big firm, it is difficult to observe the employee's performance, and especially for some occupation employees, their work is very difficult to evaluate. Thus it induced the employer to choose a production method to economize their total input relative to the output. Assume that each entrepreneur has fixed endowment time $\overline{H}$ to divide between management and supervision. If each worker needs h units of time for supervision, then the time available for management is $H = \overline{H} - hN$. The efficient management time is given by

$$T = \lambda H = \lambda(\overline{H} - hN)$$

where λ is a parameter that converts the non-supervisory time into management time, and output is a function of labor and management input,

$$Q = f(N, T) = f(N, \lambda(\overline{H} - hN))$$

M workers with quality u can be combined to $N = uM$ efficiency units of labor services, and wages is an increasing function of quality u. $W = W(u)$. The firm now is to maximize its profit along both a numbers margin as well as a quality margin. Equilibrium satisfies two conditions:

$$\begin{aligned} Puf_n &= W(u) + \delta \\ W'(u) &= [W(u) + \delta]/u \end{aligned}$$

Where P is the price level, and δ is the implicit cost of supervision occasioned by the division of time from management to monitoring labor.

Thus a positive correlation between firm size and wage is generated by matching high-λ entrepreneurs with high-u employees.

Shapiro & Stiglitz (1984) and Green, Machin & Manning (1996) describe that in the large firm, workers have a low probability of being caught shirking, the firm hence pays his employee a high wage premium, and encourages the worker to put more effort in return. Assume that effort e is a function of W,

$$e = e(W) \qquad\qquad \text{with } e'(W) > 0$$

. The total labor input N , $N = eM$, and it is minimized when the elasticity of effort with respect to the wage equal to unity,

$$We'(W)/e = 1$$

If $W = W(e)$ is the inverse of $e(W)$, cost is at a minimum when the marginal cost of effort is equal to unity,

$$W'(e) = W(e)/e$$

Moore (1911) and Hamermesh (1980) provided another explanation that because of the use of large fixed capital in larger firms, the more efficient workers are more valuable to the large than to the small firm. More capable workers are surely more attracted and retained in larger firms as they can provide them with more opportunities, better organization and large capital. Thus the higher wage of a large employer may be due to the difference in labor quality, the people working for a larger firm would earn no more than they would elsewhere.

3.2.2 Compensating differential explanation

The compensating differential explained that the higher wage rate in the larger firm is the compensation of the worse working condition there, as work in the large establishment seems to be more the impersonal or unpleasant environment. Workers may have less idle time, accept more responsibility, or it may be more noisy, working on line with less freedom. In a competitive market it has to be compensated by the high wage rate or their fringe benefit. However, Brown and Medoff (1989) test this theory by 1973-77 QES data. They include variables like weekly hours, dummy variables indicating dangerous or unhealthy conditions on the job, variables giving commuting time, and so forth. The finding is contradictory to the theory that the direct information on the job's condition can only explain very little of the size-wage effect. Furthermore they questioned whether there is any persuasive evidence that working conditions are really worse in large establishments. Out of 42 job characteristic variables in the data set only 21 showed there is negative relationship between good characteristics and establishment size

3.2.3 Rent sharing explanation

Large firms have greater market power or face a lower "price" for non-labor inputs, produce a greater ability to pay higher wage rates. In large firms they use a more capital intensive production process, and demand more equipment, capital, hence they have more favorable credit terms, lower interest rates, seller, communication services and insurance offer volume discount. Also it is possible that large firms have less elastic product demand curves, and greater potential profits to share with their workers. Oi and Idson (1999) state there are at least three factors to be countered for positive relationships between the firm size and the surplus of revenues over labor costs : (1) lower price for non-labor inputs (2) greater market power (3) larger overhead cost to amortize sunk cost for capital and a firm-specific work force.

Dunne and Schmitz (1995) find that the incidence of establishments adopting new technologies rose from 7.9% for plants with less than 100 employees to

85.4% for those with 500 or more workers. Wages were positively related to both firm size and technology use. This can be explained in part by the fact that larger and older firms have the higher relative demand for capital, especially new equipment, therefore confront lower "price" for non labor inputs. Domes et al. (1997) assemble some data supporting that the older and larger firms happened to have more skilled employees and were hence better situated to adopt the new innovations.

In more detail Hildreth and Oswald (1997) show, from their estimation of the Nash bargaining model, wages and profit per employee are positively related. In a modified model (i.e. one with frictions), in the short run there is comovement between wages and profit, and in the long run, it does not exist. However in the strict competitive model, there is no positive correlation between profits and wages.

Some papers argue that in the large firm job tenure is longer, and quit rate is lower. It may be because it is easy to move from one assignment to another within the firm, more promotion opportunity. Or it may be the small firms always provide general training, but large firms provide specific training. Therefore the two wage-tenure profiles have similar slopes, but one is growing faster in the large firm. Usually large firms also give their employees more on-the-job training. Meanwhile there are also other explanations for the size wage effect, for instance, forestall unionization, less applicants relative to the vacancies, and so forth.

Given the union effect as well as the firm size effect on the wage rate, it is also well known that firm size has the strong relationship with unionism, the larger the firm, the more likely to be unionized. Miller and Mulvey (1996) denote that there is a positive monotonic relationship between the union density rates and the firm size. In fact, in our establishment level survey data set, (more details about this data set will be presented in the following section), it also shows, for the manual worker, 32% of the firms with less than 100 employees have been unionized, compared with 49% of the firm with 100-300 employees and 90% of the firm with 300-500 employees. In the firm for more than 500 employees, 100% have been unionized. So the question arose, is it due to the union effect or firm size effect which play the role on wage raising? Alternatively both of them have the strong effect on the wage rate. Miller and Mulvey (1996) find that when the firm size is included as a regressor, the estimated union/nonunion wage differential falls from around 9 percent to around 2 percent. The following model -the Monopsony Model, addressed an interesting idea that the firm size effect on wage is determined by an indicator which measures the competitiveness of labor market. In the union sector, the effect is weaker, and in the non-union sector there is significant positive relationship.

3.2.4 Monopsony model

In this section we consider the interesting model from Green, Machin and Manning (1996). The model is also analyzed by Burdett and Mortensen (1989). Assume the number of workers is M, an employed worker has productivity p, and an unemployed worker has the benefit b. The employed worker quit the job with exogenous probability q and all workers, no matter whether being employed or unemployed, get the job offer with probability k, which is random draw from the firm. Unemployed people always accept the job offer, and employed persons only accept the offer with the wage higher than his current.

First Burdett-Mortensen proved in this model that there is a unique equilibrium and a positive relationship $w(L)$ between wage and the firm size. In equilibrium the flows out of unemployment kU must equal flows into unemployment $q(M-U)$, we can have $kU = q(M-U)$,

$$U = qM/(q+k) \tag{5.1}$$

In the mean time quits from the firm must equal recruits to the firm,

$$[q + k(1 - G(L)]L = kU + k\Sigma_{\underline{L}}^{L} xg(x) \tag{5.2}$$

where $G(L)$ is the distribution function of firm size at the interval $[\underline{L}\ L]$

From (5.2) we could have the size of the smallest firm, and $\underline{L}$ will be given as

$$\underline{L} = kU/(q+k) = kqM/(q+k)^2 \tag{5.3}$$

Assume that in steady-state equilibrium, the profit of the firm Π_0 would be constant across all the firm, and there is no fixed cost, hence we have

$(p - w(L))L = \Pi_0$

then

$$w(L) = p - \Pi_0/L \tag{5.4}$$

Π_0 can be worked out by considering the profits of the smallest firm. Employment is given as (3) and the lowest wage equals unemployment benefit b, hence $\Pi_0 = (p-b)\underline{L}$.

combining (5.3) and (5.4) ,

$$w(L) = p - (p-b)\frac{\phi M}{(1+\phi)^2 L} \tag{5.5}$$

where $\phi = q/k$. It shows that firm size and wage relationship depends on the parameter ϕ. It changes from group to group. Burdett-Mortensen argued that the ϕ is a indicator of the competitiveness of the labor market. It is reasonab to assume $\phi < 1$, otherwise $q > K$, which may imply that unemployment rate would exceed 50%. Therefore the elasticity of wages with respect to firm size in increasing with ϕ.For instance, the female workers may have a higher quit rate q and lower probability k to get another job offer due to the childcare or domestic responsibilities, we might expect the wage-size relationship to be stronger for women, and the labor market for women is more monopsonistic.

Furthermore Green, Machin and Manning argue that if wage rate is bargained by the union, and the wage rate is set high enough, employment will be determined by labor demand, not labor supply, hence it would not be a significant relationship between wage and firm size in the union sector, on the contrast to the nonunion sector, the relationship would be positive. This can be seen as

Figure 5.1. Supported by the estimates of different wage equations for union and non-union workers, men and women using BSAS, GHS and WIRS data, the finding is consistent with the estimation.

So far we have summarized the union and firm size effect on wage rate, and some possible explanations in the literature. In the next section we are going to explore the work by combining these two effects in the same regression, and also the firm size effect in the union and non-union sector respectively with our establishment survey data within one industry.

[Figure 5.1 insert here]

4 Data and Regression Models

To assess the relationship between the union coverage, firm size and wages, the data set we used is an firm level survey, which consists of 89 firms from across the UK within the electrical engineering industry for 6 years from 1979 to 1984. In this data set there are about 27% firms which have the employees less than 100, about 28% firms which have employees between 100 to 300, and 45% firm have more than 300 employees. [8] 32% of small firms (with <100 employees) have unions to represent their manual worker, 18% have unions to represent their clerical worker; in middle sized firm (with 100-300 employees), the unionization rates are 49% for manual workers and 21% for clerical workers; in a large firm (with >300 employees) they are 96% and 73% respectively. This result clearly infers that the large is the firm, the more likely it is to be unionized.

The main difference of this paper, in contrast to other work, is that it is controlled within the same industry, for all the firms use more or less the same technology. Also the firm level data provides information on industry and firm characteristics, which individual data set usually do not. Therefore we can find

[8] The number of employees in the firm is variable with year, i.e. in some firms might be less than 100 in this year, and more than 100 in the following year.

whether it is the firm size, union status or other firm specific characteristics that affect the wage rate, having excluded the technology effect. As it has been indicated in the literature that even for the same quality workers, if they work in different firm may lead to different productivity due to the larger firm in better situations to adopt new technologies. Thus the hypothesis that the large firm pays their worker at a higher wage rate is not because of the firm-size effect, it is because the higher productivity in large firm compared with the same worker in small firm, can be ruled out from our regression.

Another advantage of our data set is that it covers a period in which for some years the UK is confronted with an economic slump, so the data is able to capture the effect of business cycle. We have found in literature that the union seems to increase wage rate, and the union wage premium is counter-cyclical. We are intending to test whether the union is playing different role during different business year. Furthermore, unionism is significantly related to the firm size. There is sizeable literature that has shown that the large firm is more likely to be highly unionized, which this data set also reveals. By examining the firm size effect in union sector and nonunion sector separately, we are able to explore the size and union effect on wage rate.

In most of the union literature, the union effect on wages is measured by an exogenous dummy variable whether the individual worker is a member of a union or bargaining unit, or covered by union bargaining. A few studies have tried to treat the union status variable as endogenous by estimating a system of equations consisting of at least an equation or equations that determine union status and a wage equation. Lewis (1982) believes, from the practical point of view of estimating the mean wage gap in the work force, that the simultaneous equations estimates are considerably less reliable than OLS counterparts.

4.1 The equation and the definitions of variables

To carry out the analysis, in this paper I will follow the traditional approach and treat union status as exogenous. The equation we estimated has the form

$$\begin{aligned} LnYit &= C + \alpha_1 \, \mathrm{Si\,zeD\,mm\,y}_{it} + a_2\mathrm{RATIO}_{it} + a_3\mathrm{RUNEMP}_{it} \\ &\quad + a_4\mathrm{RUNEMP(\text{-}1)}_{it} + a_5 \, \mathrm{GSAL}_{it} + a_6 PPT_{it} \\ &\quad + a_7 PTRAIN_{it} + a_8 PRED_{it} + \beta_t YEAR_t \\ &\quad + \delta_i G_i + \varepsilon_{it} \end{aligned} \tag{5.6}$$

where LnY_{it} is the natural logarithm of average weekly earnings in firm i at time t, C is constant, and ε_{it} is the error term, which is assumed with standard normal distribution. α_i, β_i and δ_i are the coefficients of the explanatory variables.

I will now define the variables used in the regression model.

Size Dummy: (0,1) firm size dummy for the firm which has more than 100 employees, as it shows in the literature, the large firms pay a higher wage rate to their employees for the reasons we have provided.

RATIO: the percentage of this skill level worker, the number of craftsmen, semi-skilled and clerical workers divided by the total employees. A few studies have indicated that, i.e. Stewart (1997), in the nonunion sector, the greater proportion of the manual workerforce, the lower average pay of the manual workers. However this effect is absent in the union sector.

RUNEMP is the regional unemployment rate divided by national unemployment rate, and RUNEMP(-1) is the one year lag of RUNEMP. This is the indicator of regional labor market condition. It has been found that the regional unemployment rate usually has a negative relation with the wage rate, as the employers have less incentive to pay higher wage rate when they face a large pool of labor supply. Also many economists, i.e. Layard and Nickell (1986), estimate the unemployment elasticity of real wages to be approximately -0.06. And Christofides & Oswald (1992) find that real wage is a decreasing function of the level of regional unemployment, as high unemployment in the local labor market may weaken the union's relative bargaining power and tends to depress the wage.

GSAL, which is yielded by $[Sal - Sal(-1)]/Sal(-1)$, where Sal is the sales of this year, and Sal (-1) is the sales of last year. Sales Growth is the net sales growth rate to measure whether the firm has more ability to pay, as Christofides & Oswald (1992), Hildreth & Oswald (1997) have found that the real wage is an increasing function of the level of past profitability of this firm. Union bargaining can be seen as a bargain over how total industry's rents can be divided. A large surplus tends to raise the level of pay.

The percentage of part time employees, the percentage of new trainees, and the percentage of redundant employees, which are calculated from the number of part time employees, new trainees, and redundants divided by the total number of employees. Many studies have confirmed, i.e. Blanchflower (1996), Freeman(1984), that part time work is less prevalent in the union sector than in the nonunion sector, and the union prefers to adjust to a business cycle downturn by placing workers on temporary layoff instead of reducing their weekly hours of work. This also indicates the fixed cost of the firm during the period. obviously more part time employees, more new trainees and more redundant workers would increase the firm's hiring, firing and training cost.

G_i is defined as group dummy, which group firm i supposed to be in. The 89 firms have been divided into different groups, each group gathers the similar specific firms. There are 5 and 8 groups for craftsmen in the union and the non-union sector; 7 and 6 groups for semi-skilled worker in the union and the non-union sector; and 8 groups for clerical worker in both the union and the non-union sector. These have been accepted by the F test that the restriction is valid.

4.2 Econometric Estimates 1: Regression in the union and non-union sector respectively

In order to test wage profile separately in the union and nonunion sectors, I run equation 5.6 for these three skill groups in the union and nonunion sector respectively. As we only have 534 observations in the data set, it seems not enough for adding 89 firm specific dummy variables. Therefore we estimated the equation with dummies for groups of firms, which gathered the similar specific firms in the same group, and all these have been accepted by F test that the restriction is valid. The regression is estimated separately for the craftsmen, semi- skilled and clerical workers. In the craftsman wage equation, firms have been divided into 5 groups in the union sector, and 8 groups in the non-union sector; The semi-skilled have been divided into 7 and 6 in the union and non-union sectors; and for clerical workers are in 8 groups in both the union and non-union sectors. The method has been used is OLS, and result is presented in the following table. TSP only picks up the observation which datas are available for all the explanatory variables. In other words those observations which datas are available for all the 13 explanatory variables are being used; otherwise it would not be included, even it is just short for one out of the 13 explanatory variables. Therefore there are only 254 observations for craftsmen (166 in union sector, 88 in nonunion sector), 207 for the semi-skilled (134 in the union sector, 73 in the nonunion sector) and 205 for clerical workers (91 in the union sector, and 114 in the nonunion sector) rather than 534. The descriptive statistics of both the full sample (534 observations) and restricted sample have been summarized in Table 5.1. We would notice the total number of employees is large in the full sample than it in the restricted samples, which indicate there are more large firms in the lost observations. We can also find the value of percentage of part time worker, new trainees and redundents are slightly large than it in the counterpart. Therefore we may expect the coefficients of firm size dummy possibly underestimated.

[Table 5.1 Insert here]

The econometric estimates result has been presented in table 5.2.

[Table 5.2 Insert here]

From Table 5.2 we can find that the wages in the base year 1979 (the constant term) are higher in the union sector than it in the nonunion sector. It is just slightly higher for craftsman 4.67 in the union sector vs 4.63 in the nonunion sector, while it is much higher for clerical workers in the union sector 4.52 than it in the nonunion sector 4.15. Moreover wages are increasing significantly with each year for both the union and nonunion sectors, which are increasing from about 12% in 1979/1980 to about 42% in 1979/1984. So wage levels are raising steadily over the six years. While wage profile in the union sector is steeper than it in the nonunion sector. The percentage increased every year in the union sector is higher than it in the nonunion sector, especially during 1981 and1982 in which the UK was confronted by a recession. The average increase of the period in the union sector, for craftsmen is about 8.2% more than it in the nonunion sector, and for semi-skilled is about 3.2% more and it is about 3.4% for clerical. Given the same characteristics, the union wage rate is consistently higher than the nonunion wage throughout the period. Table 5.3 provides the data of GDP, Engineering sales, Unemployment rate and the difference of year coefficients $\triangle$ (coefficient of year in union sector minus its counterpart in nonunion sector).

[Table 5.3 Insert here]

We can notice that during that period, the UK economy was facing a slump. The GDP dropped by about 2.60% and 1.47% respectively in 1980 and 1981 compared with the year before. While the engineering sector lagged behind the whole economy. From the data of the engineering sales, it hits the lowest recession in 1981, 1982 and 1983, then starts to climb up in 1984. The unemployment rate was getting higher from 1981. It soared from 5.18% in 1980 to 9.73% in 1981, till 1983's 12.83% and 1984's 12.7%. The biggest wage gap in 1981 and 1982 for all three groups indicates that the union wage is sticky across the time period, whereas the nonunion wage is confronted with the recession, the employer is reducing his employees wage rate, labor demand, therefore the union and nonunion wage gap is higher during the recession. More tests will be done upon whether union effect on wage rate is significantly higher during recession period.

Firm size effect on wage rate behaves quite differently in union and nonunion sector. The size dummies in the union sector are all with negative signs. It is -0.08 (-4.41) for craftsman, -0.005 (-0.27) for semi-skilled, and -0.16 (-2.45) for clerical worker. T- values are in brackets. Although it is not significant for semi-skilled, it is negative and significant for the other two groups of worker. In contrast, in the nonunion sector they are positive for manual workers, negative not significant for clerical workers. The coefficients are 0.11 (2.99), 0.02 (0.67), -0.04 (1.40) for craftsmen, semi-skilled and clerical workers respectively. Again T-values are in the brackets. The general belief is that unions would raise the wage rate for its members, especially in the large firm where is more likely to be unionized and would be more bargaining power for the union. To standardize the wage rate, the large firm is likely to reduce part of the increasing wage. The coefficients state that this is particularly for white collar and high skilled workers. However, in the nonunion sector, the big firm is consistent with the higher wage rate for manual workers.

It has to be clarified that the definition of size dummy in this chapter differs to it in Chapter 4. In Chapter 4 all firms have been distinguished into 3 categories: small firm with less than 300 employees, medium firm with 300-500 employees and large firm with more than 500 employees. In this chapter only two category has been defined as: small firms are with less than 100 employees and medium & large firm are with more than 100 employees. Initially the definition of size dummy in this chapter has been defined as small firm are with less than 300 employees and large firms are with more than 300 employees, however the adjustment has made the estimation result more robust. The estimation result is somehow very sensitive to this adjustment. It might be because this data set is relative small, any change of the explanatory variable would be delivered distinctly to the estimation result. This would be more significant in table 5.4 where the regression is regardless to the union status, which would make all the size dummy coefficients as well as the T-values trivial. Therefore in this Chapter, a different definition of the size dummy has been adopted.

It is well established in the literature that large firms pay higher wages than small firms, independent of any influence of unionism. While the result of the above regression reports that firm size may contribute a different effect to wages. This effect is associated with the union status. We may still observe that the wages in the large firm is higher than in the small firm, however, this size-wage relationship is flat or downward in the union sector, and positive in the nonunion sector. Compared to Green, Machin and Manning (1996)'s finding, it would not be a significant relationship between wage and firm size in the union sector, while in the nonunion sector, the relationship would be positive. The finding of this paper is slight different to some extent. It indicates a downward sloping size wage relationship in union sector. Similarly Pearce (1990) finds from 1979 CPS data that nonunion wage steepens sharply with establishment size, while union wage flatten. Whereas this paper still differs to Green, et. al. (1996) and Pearce (1990), both of those two papers use individual data set, and do not provide separate estimates to skilled, semi-skilled and clerical workers.

Weiss and Landau (1984) also study the size wage relationship. They have shown that the larger employer has to pay higher wages in order to satisfy the greater labor input requirement relative to the available small labor pool. When positive hiring costs are introduced, they found there may be a flat or even downward sloping size wage relationship. If hiring costs are more important at higher skill levels, the relationship is likely to be weaker at higher skill level.

The values of firm size coefficients also infer that the size-wage relationship is associated with the occupation in terms of monitoring costs. Recalling the coefficients in the regression, for craftsman they are -0.08 (-4.41) and 0.11 (2.99), both significant in the union and nonunion sector; for clerical they are -0.16 (-2.45) and -0.04 (-1.40), significant in the union sector, but for nonunion sector is significant in 10% level, not at 5% level; for semi-skilled they are -0.005 (-0.27) and 0.02 (0.67), both of them are not significant. This result is consistent with the monitoring cost theory. The occupation is more difficult to supervise, the more significant size wage relationship would be. In these three groups it is possibly easiest to supervise semi-skilled workers as you could restrict them working on line without too much freedom, or evaluate their working effort more easily by their outcome. Hence the size-wage relationship is weaker. It would be more difficult to supervise their working effort for clerical workers and craftsmen - high skilled workers, thus the size would be significantly large to encourage them to work more efficiently. Pearce (1990) concludes that the size-wage relationship would be weaker for services and sales workers, and stronger for Manager. Among white-collar workers, secretaries are easier to monitor than professionals, and so the size-wage relationship would be stronger for professional than for female clerical workers. Among blue-collar workers, the laborers are the least skilled and presumably cheaper to monitor, and the size-wage relationship would be weaker for laborers than for other blue-collar workers. A test of the size-wage relationship with respect to occupation regardless of the union status would be conducted in the following regression.

The coefficients of real unemployment rate and one year lag are negative in most columns, although some of them may be positive but not significant. Higher regional unemployment rate would depress local wage rate, especially to clerical workers, which is the only category for white collar workers in this data set. If we add RUNEMP and RUNEMP(-1) up, they are -0.36 and -0.07 for union and nonunion workers respectively. This might be inconsistent with the union's wage rigidity theory – the wage rate would be rigid in the union sector over business cycle.

Sales Growth is positive and significant for manual workers in the union sector, negative (may or may not significant) in nonunion sector. For clerical workers, in both sectors, none of them are significant. 10% of net sales growth in the union sector would raise the craftsmen's wage by about 0.2% and semi-skilled worker for 0.3%. The firm's profitability is positively related to the union's wage rate. While in the nonunion sector, there is no positive relationship between wage and firm's profitability. This is consistent to Christofides & Oswald (1992), Hildreth & Oswald (1997), that in a Nash bargain, wages and profit per employee are positively related; in a competitive model, there does not exist this positive relationship.

The proportion of work force has different impact in these three groups. It is negative for craftsmen in both sectors, but a higher proportion of craftsmen reduce more wages in the nonunion sector. For semi-skilled and clerical workers, they are both positive in the union and nonunion sector, but one is significant in the union sector, and another is significant in the nonunion sector. Somehow this is not consistent with Stewart (1997), in the nonunion sector, the greater proportion of the manual workerforce, the lower the average pay of the manual workers; while this is absent in the union sector. As a reference, the values of percentage work force are provided as follows: in the union sector, 20% of employees are craftsmen, 41% are semi-skilled, and 20% are clerical workers; in the nonunion sector, 31% are craftsmen, 29% are semi-skilled, and 22% are clerical workers.

The percentage of part time employees, new trainees and redundant workers are all negative in the union sector for manual workers. Most of them are significant at the 5% level, except the percentage of new trainees and redundant workers are only significant at the 10% level. A large percentage of part time employee, new trainees and reduntent workers intends to depress the wage rate. This negative effect is about two times stronger for semi-skilled workers than it for craftsmen. An important point we have to be clear is that in this data set it can not be distinguished in the total number of new trainees, part time workers, redunrents that how many are craftsmen, how many are semi-skilled and clerical workers. However in the nonunion sector, they contribute different effects to the wage rate, some are positive, and some are negative. It works the same to clerical worker in union and nonunion sector.

4.3 Econometric Estimates 2: Regression regardless of union status

In addition, in order to examine union's effect on wage rate over this business cycle, the following equation (5.7) is estimated regardless of the union status.

$$\begin{aligned} LnYit &= C + \alpha_1 \mathrm{Si}\, zeDummy_{it} + a_2 RATIO_{it} + a_3 RUNEMP_{it} \\ &\quad + a_4 RUNEMP(-1)_{it} + a_5 \mathrm{GSAL}_{it} + a_6 PPT_{it} \\ &\quad + a_7 PTRAIN_{it} + a_8 PRED_{it} + \beta_t YEAR_t \\ &\quad + \gamma_i Union_{it} * YEAR_t + \delta_i G_i + \varepsilon_{it} \end{aligned} \tag{5.7}$$

The definition of variables in equation (5.7) are the same as in equation (5.6), except one extra variable *Union* is a dummy variable for union status. If there exists a union in the firm, $Union = 1$, otherwise it equals to zero. As we did in equation (5.6), 89 firms have been gathered in a group which has similar specifics. All craftsmen, Semi-skilled and Clerical have been divided in 11, 8 and 10 groups respectively. The reason of running this regression is because in equation (5.6) the year effect consists of both union effect and time trend. Therefore to separate these two terms in equation (5.7) enables us to examine the pure union effect over the business cycle. The estimators are presented in Table 5.4.

[Table 5.4 insert here]

Again it can be seen clearly that there is a significant time trend for the wages. It is increasing steadily over the period. And the unemployment rate is negativly related to the wages although it is not significant. A higher unemployment rate depresses the wage rate. In Table 5.2 it has shown that size effect behaves differently in the union and nonunion sectors. It has a flat or downward relationship in the union sector, and a positive relationship in the nonunion sector. While in Table 5.4, the size effect with respect to occupation regardless of its union status infers that there is a positive relationship between wage and firm size. It seems that the size effect is different according to the union status within the firm, the average wage of the entire firm is positive related to its firm size. The larger is the firm, the higher wage it pays. However the coefficients of size dummy somehow are different to equation (5.6). The size effect is significantly larger for clerical workers with a 7% rise if the employee works in the large firm. For semi-skilled workers it is a 2.7% wage up to work in large firm, t-value also shows that it is nearly significant at a 5% level. While for craftsmen it is 2% higher, but not significant.

The interactions of the union dummy with year turn out quite surprisingly. The coefficients of the union effect range from -0.21 to 0.024. On average, it is about -16% for craftsmen, 0.3% for semi-skilled, and -7% for clerical workers. It seems that unions depress craftsman and clerical's wages, but raise them for semi-skilled workers. It shows that wages in the union sector are more flexible than it in nonunion sector. If we assume that nonunion wages in small firms (with <100 employees) are 100, the wages in the firms with different sizes and union statuses are quite different. We summarize these in Table 5.5.

Table 5.5: Wages differences according to firm size and union status

	Craftsman	Semi-skilled	Clerical
Small & Unionized	84	100	93
Large & Nonunionized	102	103	107
Large & Unionized	83	103	100

* Note: We assume the wage rate in a non-unionized small firm (less than 100 employees) is 100.

This is inconsistent with the theory that unions increase the wage rate or large firms pay higher wage rates to the employee. We may conclude that this equation is somehow misspecified when we include the interaction of union dummy with the year as explanatory variables. Another explanation could be that the dependent variable in the wage equations do not include non-wage benefit. It would be higher for craftsmen-high skilled worker in union sector. When wages are measured by wages plus fringe benefit, i.e. pension and paid vacations, size-wage effects are stronger than the common wages are used. However it still shows that the union wage gap is inversely related to skill, being highest for semi-skilled workers. Ashenfelter (1978) has the same finding in US for white men of craftsmen, operatives and laborers. The largest union wage differential is for laborers, the smallest is for craftsmen, in some periods, it is even negative. Hirsch & Addison (1985) also conclude that unions tend to narrow skill differentials and benefit the most relatively least skilled worker. The union wage differential appears quite small for women, and this may help to explain women's lower likelihood of choosing union representation.

Table 5.4 also shows that union wage differentials would be higher in a recession year. The coefficients of the union effect are highest in 1981 and 1982 for all three groups: for craftsmen it is about 2% higher than average of the period; about 2.5% higher for semi-skilled and clerical workers. Recalling Table 5.3, we have known that U.K. was confronted with an economic slump during the data period. And it was in the lowest recession in 1981 and 1982. To test whether the union effect on wage rate is significantly different in recessionary period. I run the following equation (5.8) again, which is very much similar to equation (5.7). But instead of using an explanatory variable of interaction of Union with each year, I create another two variables: one is REC, which stands for 1981 and 1982, which is most recession period in the data set; and another is OTH, which stands for other years. Therefore the equation would appear as:

$$
\begin{aligned}
LnY_{it} &= C + a_1 \operatorname{Si} ze_{it} D \operatorname{mm} y + a_2 RATIO_{it} + a_3 RUNEMP_{it} \\
&\quad + a_4 RUNEMP(-1)_{it} + a_5 \text{Sales Growth}_{it} + a_6 PPT_{it} \\
&\quad + a_7 PTRAIN_{it} + a_8 PRED_{it} + \beta_t YEAR_t \\
&\quad + \gamma_i Union_{it} * REC + \eta_i TUM_{it} * OTH \\
&\quad + \delta_i G_i + \varepsilon_{it} \qquad (5.8)
\end{aligned}
$$

So the coefficients of γ and η indicates the union effect on recession period and others respectively. So the question is to test whether γ is insignificant different with η. The γ and η for craftsmen are -0.15 (-6.77), -0.178 (-9.71); for semi-skilled are 0.023 (1.16), -0.01 (-0.63); for clerical workers are -0.05 (-1.55), -0.088 (-3.26). It can be noticed that γ would be higher than η for about 3%, especially for semi-skilled workers, it is from positive to negative. Unfortunately the further F tests for Restricted Least Square show that we can reject the hypothesis that γ is insignificant to η for all three group workers.

The estimators of other explanatory variables are different to Table 5.2 to some extent, i.e. the net sales growth rates are trivial and not significant in all three groups. As experiments I run equation (5.8) without one, two, or all of these variables (Sales Growth, Percentage work force, new trainee, redundents), the results show more or less similar to Table 5.4.

As we expect wage rate varies with quality of worker. High skilled workers would have high wage rates. Many papers use individual data sets to study how wage rate is affected by the quality of worker. The explanatory variables are mostly education, experience, gender, et. al. have been used as quantitative indicators for the quality of worker they have. Whereas the data used in this paper is an establishment level data set, we can not observe the employees' quality of this firm. If we believe the wage equation could be

$$W = aGENDER + \beta UNION + \gamma QUALITY + \varepsilon_1 \qquad (5.9)$$

And QUALITY could be affected by gender and union, as female workers tend to have relatively less education and experience than males, also unionized firms are more attractive than their counterparts due to the higher wage rate. Therefore the auxiliary equation can be

$$QUALITY = \varsigma GENDER + \tau UNION + \varepsilon_2 \tag{5.10}$$

Combine equation (5.8) and (5.9), the real wage equation should be displayed as

$$W = (a + \gamma\varsigma)GENDER + (\beta + \gamma\tau)UNION + \varepsilon \tag{5.11}$$

In this circumstance, both GENDER and UNION would be biased. This may be especially worse for clerical workers, as clerical includes a wide range of jobs by quality, also consisting of large proportion of female workers. Thus originally the equation I run includes explanatory variable Percentage of femal worker, and has been ruled out in TABLE 5.2. In this paper the wage equations are very sensitive to whether the percentage of female workers has been included, especially for clerical workers, as more than 50% of clerical workers are female. Whereas the wage equation for craftsmen is not sensitive, with or without gender, the reason for this is because there are only about 2% female worker.

5 Level Decomposition of Union Wage Differentials

Miller and Muley (1991, 1992 and 1994) have investigated whether the union and nonunion wage differential can be explained by over-award pay, differential levels of paid overtime and differences in the distribution of union and non-union employees across industries. However, taken together, these phenomena can explain no more then one-quarter of the estimated wage differential. These results seemingly imply that large parts of the union wage premium observed in the analysis may result from an unmeasured difference among union and nonunion workers and firms.

In this paper, I decompose the union wage differential into observed "firm's characteristic difference" and the "price difference" in the union and nonunion sector, to find what accounts for the differential. Here I use a method for the union wage differential explanation, which Oaxaca (1973), Blau and Beller (1992) have adopted to decompose the gender earnings gap. Originally this method appeared in Oaxaca (1973)'s paper, and since it has been widely used in gender literature to analyze the wage rate difference in rates of compensation for female and male. By standardizing the equation (5.6), we can rewrite it as

$$LnY_{it} = X_{it}\beta_i + \varepsilon_{it} \qquad i = 1, ..., 89 \tag{5.12}$$

where ε_{it} is distributed normally with mean zero and variance one for all time t. More specifically if this firm is in the union sector, we write it as

$$LnY_{jt} = X_{jt}\beta_j + \varepsilon_{jt} \qquad j = 1, ..., n \tag{5.12'}$$

Where in our data set n equals to 57 when Y represents craftsmen and semi-skilled unionized average weekly earning, and equals to 37 when Y represents clerical unionized average weekly earning. If this firm is not in the union sector, we write it as

$$LnY_{kt} = X_{kt}\beta_k + \varepsilon_{kt} \qquad k = 1, ..., m \tag{5.12''}$$

Where m equals to 32 when Y represents craftsmen and semi-skilled nonunionized average weekly earning, and equals to 52 when Y represents clerical nonunionized average weekly earning. In our data set, there is not any firm which changed its union status during the data period. In other words, it was been unionized/not unionized for the whole six years.

From the properties of Ordinary Least Squares estimation, we yield

$$Ln\overline{Y}_{jt} = \overline{X}_{jt}\widehat{\beta}_j \tag{5.13}$$

$$Ln\overline{Y}_{kt} = \overline{X}_{kt}\widehat{\beta}_k \tag{5.14}$$

Where $\overline{Y}_{jt}$ and $\overline{Y}_{kt}$ are the mean value of average weekly earning in the union and non-union sector respectively. $\overline{X}_{jt}$, $\overline{X}_{kt}$ are the vectors of mean values of the regressors for unions and non-unions respectively. And β_j ,β_k are the corresponding vectors of the estimated coefficients. The explanatory variables are the same in equation (5.13) and (5.14).

Then we can get the union wage difference by subtracting (5.14) from (5.13) as

$$Ln\overline{Y}_{jt} - Ln\overline{Y}_{kt} = \overline{X}_{jt}\widehat{\beta}_j - \overline{X}_{kt}\widehat{\beta}_k \tag{5.15}$$

Adding and subtracting $\overline{X}_{jt}\widehat{\beta}_k$ in order to obtain union attributes in terms of " price difference ", then we can have

$$\begin{aligned} Ln\overline{Y}_{jt} - Ln\overline{Y}_{kt} &= (\overline{X}_{jt}\widehat{\beta}_j - \overline{X}_{jt}\widehat{\beta}_k) + (\overline{X}_{jt}\widehat{\beta}_k - \overline{X}_{kt}\widehat{\beta}_k) \\ &= \overline{X}_{jt}(\widehat{\beta}_j - \widehat{\beta}_k) + (\overline{X}_{jt} - \overline{X}_{kt})\widehat{\beta}_k \end{aligned} \tag{5.16}$$

The left hand side of equation (5.16) is the total earning differential, and on the right hand side, the first term we could interpret as "price difference", which explain the estimated effects the different wage rate in the union and nonunion sector for the same firm characteristics. In other words, if two identical persons worked in identical firms but in different sectors, they may get different income as there is price difference $\triangle\beta = \widehat{\beta}_j - \widehat{\beta}_k$. The second term, we could interpret as "observed firm's characteristic difference", which explain the estimated effects by differences in measured firm's characteristics, including regional labor market condition. In other words, if we assume there is no "price difference", the wage structure in the nonunion sector would also apply to the counterpart in the union sector. There is only firm's characteristic difference, but there is no "price difference".

In a similar manner, by adding and subtracting $\overline{X}_{kt}\widehat{\beta}_j$ on the left hand side of the equation (5.15), we can get

$$\begin{aligned} Ln\overline{Y}_{jt} - Ln\overline{Y}_{kt} &= (\overline{X}_{jt}\widehat{\beta}_j - \overline{X}_{kt}\widehat{\beta}_j) + (\overline{X}_{kt}\widehat{\beta}_j - \overline{X}_{kt}\widehat{\beta}_k) \\ &= \overline{X}_{kt}(\widehat{\beta}_j - \widehat{\beta}_k) + (\overline{X}_{jt} - \overline{X}_{kt})\widehat{\beta}_j \end{aligned} \qquad (5.16')$$

Thus the first term is still "price difference" $\triangle\beta = \widehat{\beta}_j - \widehat{\beta}_k$. but multiplied by the explanatory vectors in the nonunion sector, the second term is applying the union wage structure to the nonunion by assuming that there is no "price difference" to measure the "observed firm's characteristics difference".

[Table 5.6 insert here]

Table 5.6 reports the level decomposition results of union wage differential of all the three group workers. The "price difference" in the fifth column is taken from $\triangle\beta$, the price different coefficient, multiplied with the mean of the explanatory variable in the union sector $\overline{X}_j$. In the last column, it is the "observed firm's characteristic difference", which is by applying the wage structure of nonunion sector also into union counter part, and multiplied with mean explanatory variable difference between these two sectors. Like what we did in previous regression, all the regressions are estimated with group dummies, but they are not presented in the table.

As shown from the above table, $\triangle\beta$ of firm size dummy in all three groups are negative, -0.20(-4.56), -0.03(-0.59) and -0.12(-1.67) respectively. The contribution of the size effect is quite large especially for craftsmen and clerical workers to the union and nonunion wage gap among all the price difference factors, 12% and 22%. Apart from that, the proportion of work force also accounts for big part of the wage gap, positive for craftsman and negative for clerical workers. For semi-skilled workers, the proportion of work force dummies is not a big factor, while firm size is still a significant factor. In general, it is consistent with what we found in the above wage equation, in 1981 and 1982 the values of $\triangle\beta$ are generally greater compared with other years, i.e. in clerical sector, $\triangle\beta$ equal to 0.067 and 0.062 respectively in 1981 and 1982, in contrast to 0.006, 0.022 and 0.002 for other years.

Unemployment is the most significant factor which causes the wage rate to be different in the union and nonunion sector for all three group workers. $\triangle\beta$ equals to -0.38 and 0.12 for semi-skilled worker, -0.32 and -0.06 for clerical worker, and -0.45 and 0.16 for the craftsman. The values of "price difference" also indicate that the rates of unemployment have offered a big contribution to the total wage difference, it is the biggest factor in contrast to other explanatory variables. The sum of "price difference" of these two variables are -0.36 for craftsmen, -0.24 for semi-skilled workers, and -0.29 for clerical workers, however, the sum of "price difference" of the total five years dummies, they come as 0.07 for craftsmen, 0.027 for semi-skilled workers, and 0.026 for clerical. Since we have defined RUNEMP and RUNEMP(-1) these two variables as regional unemployment rate divided by the national unemployment rate, it seems to tell that the unemployment effect contributed more to the total union wage difference than the time effect. In other words, the total union wage difference is more responsible to the regional effect than it over time.

Sales growth, percentage of new trainees, part time employees and redundancy workers also contributes differences to the wage rate. Higher sales growth rates lead to positive wage differences for manual workers, and negative for clerical worker. While the percentage of new trainees, part time employees and new trainees are not persistent over all these three group workers. It may contribute a positive gap for craftsman, i.e. the percentage of new trainees, however, is negative gap for semi-skilled worker. As equation (5.6), the percentage of female worker is not included in the equation. However it can be noticed that higher skill level for manual worker, the lower the percentage of female workers. There is only 1.2% and 3.8% female workers in the union and nonunion sectors as craftsmen, 33.4% and 33% as semi-skilled workers, however, 55.9% and 53.01% clerical workers are female.

The final column of Table 5.6 indicates how much wage difference is from the observed firm's characteristics difference. From the value of SUM for each category worker, we can find another interesting point. In fact, they are -0.375 and 0.105 for craftsmen for "total price difference" and "total observed firm's characteristic difference" respectively; -0.231 and 0.012 for semi-skilled worker; -0.408 and -0.142 for clerical worker. These numbers have shown that, for all three groups, craftsman, semi-skilled, and clerical worker, the union wage difference is mainly from price difference. The wage difference caused by firm's characteristics difference is rather small, especially for semi-skilled workers. Therefore we may conclude that the "price difference" and "firm's characteristic difference" have different independent contributions to the union and nonunion wage difference. It is different with the skill or gender of the worker. However the union wage difference is mainly caused by the price difference, there are different wage rates in two sectors given the same firm characteristics. And this is especially significant for low skilled workers.

6 Trend Decomposition of Union Wage Differential

The trend decomposition method provides another description of the source of changes in the wage difference by comparing the different time periods. Let $\triangle Ln\overline{Y}_t$ denote the log-earning difference in time t,

$$\begin{aligned}\triangle Ln\overline{Y}_t &= Ln\overline{Y}_{jt} - Ln\overline{Y}_{kt} \\ &= \overline{X}_{kt}(\widehat{\beta}_{jt} - \widehat{\beta}_{kt}) + (\overline{X}_{jt} - \overline{X}_{kt})\widehat{\beta}_{jt} \\ &= \overline{X}_{kt}\triangle\beta t + \triangle\overline{X}_t\widehat{\beta}_{jt}\end{aligned}$$

where we ignored the error term, and $\triangle\beta_t = \widehat{\beta}_{jt} - \widehat{\beta}_{kt}$, $\triangle\overline{X}_t = \overline{X}_{jt} - \overline{X}_{kt}$. The rate of change between two period t, s becomes

$$\begin{aligned}\triangle Ln\overline{Y}_t - \triangle Ln\overline{Y}_s &= \overline{X}_{kt}\triangle\beta_t - \overline{X}_{ks}\triangle\beta_s + \triangle\overline{X}_t\widehat{\beta}_{jt} - \triangle\overline{X}_s\widehat{\beta}_{js} \qquad (5.17) \\ &= \overline{X}_{kt}\triangle\beta_t - \overline{X}_{kt}\triangle\beta_s + \overline{X}_{kt}\triangle\beta_s - \overline{X}_{ks}\triangle\beta_s + \triangle\overline{X}_t\widehat{\beta}_{jt} \\ &\quad -\triangle\overline{X}_t\widehat{\beta}_{js} + \triangle\overline{X}_t\widehat{\beta}_{js} - \triangle\overline{X}_s\widehat{\beta}_{js} \\ &= (\overline{X}_{kt} - \overline{X}_{ks})\triangle\beta_s + \overline{X}_{kt}(\triangle\beta_t - \triangle\beta_s) + (\triangle\overline{X}_t - \triangle\overline{X}_s)\widehat{\beta}_{js} \\ &\quad +\triangle\overline{X}_t(\widehat{\beta}_{jt} - \widehat{\beta}_{js})\end{aligned}$$

which is the trend decomposition equation.

The first term, on the right hand side of equation (5.17), reflects the firm's characteristics changes for the nonunion sector in the two periods; The second term measures return to the "price difference" change in the two time periods. The third term we could explain as the change in measured firm's characteristics factors, holding price fixed as in the union sector for base year s; The fourth term captures the change of the return to these factors.

The following table is the result of trend decomposition of union wage differential. The data set has been only split into two period, the first period is from 1979 to 1981; the second period is from 1982 to 1984. Union1 and union2 mean the first and second period in union sector; non-1 and non-2 mean the first and second period in the nonunion sector. The 1st term in the table is by holding price fixed in the second period of union sector $\widehat{\beta}_{j2}$, the change of firm's characteristics factors between the two period, $\triangle X_2 - \triangle X_1$; the second term on the seventh column of the table represents the change of the return to these factors; the third term, $(\overline{X}_{k2} - \overline{X}_{k1})\triangle\beta_2$ reflects job characteristics changes for the nonunion sector in the two periods; the last column is from $\overline{X}_{k1}(\triangle\beta_2 - \triangle\beta_1)$, which indicates the return to the "price difference" change in the two periods.

[Table 5.7 insert here]

The analysis should be cautiously treated due to the data set. For instance, there are only 42 observations for nonunion craftsman in first period, and 46 observations in second period. However, we could still notice the last column, the return of the "price difference" is a large source of the change for all the group workers. Also we could get from the data set, the wage difference for the craftsmen are -3.18% and -1.33% in first and second period respectively; for the semi-skilled workers -3.06% in the first period and -2.36% in the second period; 5.13% in the first period and 2.02% in the second period for the clerical workers. On the one hand we are wondering the negative wage gap for the manual workers, on the other hand, we notice the union wage gap is on the trend of decreasing. There are small wage differences in the second period relative to the first period. Apart from the negative wage difference, Stewart (1995) has the same finding by WIRS data set, also Hildreth (1999) by BHPS data, there is a decline in the unionization and also a fall in the union wage difference since 1980. He contributes this trend as the inability of unions to establish wage differentials in new establishment. However we can not give the explanation for this phenomenon.

7 Conclusion

In this paper I have analyzed firm size wage effect and union wage effect with our electrical engineer industry survey data from 1979 to 1984. I find that there is a size effect upon wage rate for all three groups of workers, and is behaving differently in the union and nonunion sectors. In the union sector, it is a flat or downward sloping relationship between size and wages, while in nonunion sector it is consistent with positive relationship for manual worker. In general, wages increase with the year in both union and nonunion sectors, whereas wage profile in the union sector is steeper than in the nonunion sector. The percentage of wage increase in the union sector is consistently larger than it is in the nonunion sector. And this is specifically large during recession period. Our results have shown that the union and nonunion wage differential is higher during the recession year. In 1981 and 1982 of this data set, when British electrical engineering industry was suffering slump, union effect would hold about 3% wage up for unionized worker, especially for low skilled workers.

The size effect is associated with occupation. The more difficult to supervise, the stronger the size effect would be on the wage rate; the easier to monitor, the lower the size effect. Hence there is larger size effect on clerical workers - white collar workers and craftsmen - high skilled workers, as it is more difficult to evaluate their performance. It is relatively easier to supervise the semi-skilled workers by restricting them from working on line or simply calculating their output, therefore their size effect is weak.

Moreover, by splitting the union wage differential into " price difference" and "observed firm's characteristics difference" from the level decomposition, we found that the "price difference" and "firm's characteristic difference" have independent contributions to the union nonunion wage difference. However the union wage difference is mainly caused by the "price difference", which means there exist different wage rates in union and non-union sector given the same firm characteristics. The source of the difference may be different from occupation to occupation, but unemployment is the most significant factor for all three group workers. Total union wage difference is more responsible to regional effect than it over time. In addition, the size of firm and the proportion of work force are also important factors for wage difference.

In the trend decomposition of union wage differentials, the return of the "price difference" is noticed as a large source that accounts for the change in different period. Also there is a declining trend of the union wage differential.

8 Appendix

1. Average Number of Employees should include all persons on the payroll on average during each period.

2. Part Time Employees are defined as those who work less than 21 hours per week.

3. Number of Employees Leaving include those leaving due to retirement, redundancy or any other reason.

4. $\frac{\text{Regional Unemp}}{\text{National Unemp}}$ is defined as the unemployment rate where the firm is in divided by the national unemployment rate.

5. Union dummy is defined as: If you recognize there is a trade union represent manual workers/clerical workers at the level of your establishment, Union = 1, otherwise Union = 0.

6. Percentage of Semi-Skill/Craftsman is defined as the number of Semi-skilled worker/Craftsman divided by the total number of employees.

7. Percentage of Part Time/Laid Off in last period/New Trainees is defined as the number of Part TIme/Laid Off/New Trainee divied by the total number of employees.

8.Sal Growth is defined as (Sales - Sales(-1))/Sales(-1).

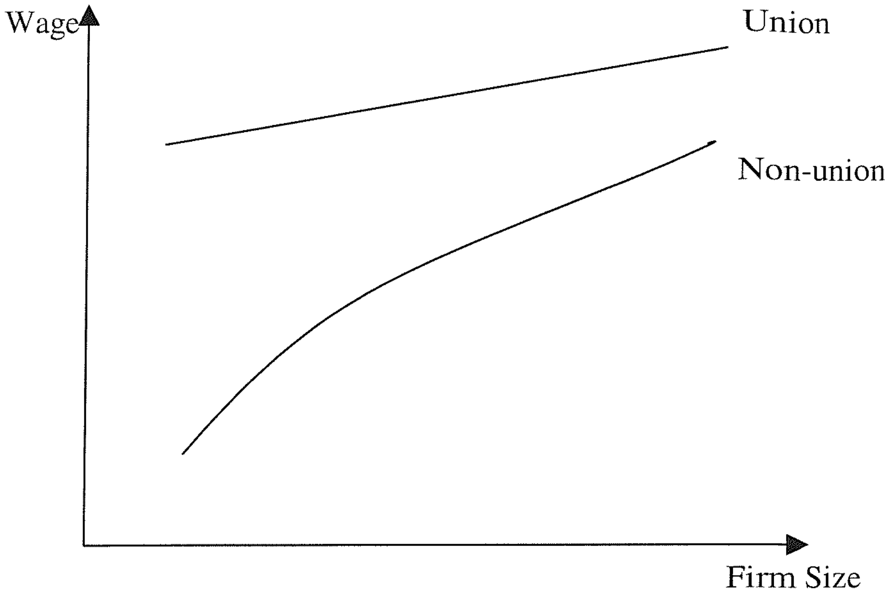

Figure 5.1 Wage Curve with Union Status

Table 5.1 Mean and Standard Deviation of the Full Sample and the Restricted Samples

	Full Sample	Restricted Sample Craftsman	Restricted Sample Semi-Skilled	Restricted Sample Clerical
Total No. of Employees	388.43 (490.06)	341.08 (305)	338.35 (326.15)	330.76 (324.85)
Percentage of Redundents	4.22% (0.13)	3.72% (0.08)	2.86% (0.07)	2.86% (0.07)
Percentage of Part Time	4.09% (0.07)	3.58% (0.05)	2.68% (0.03)	3.14% (0.04)
Percentage of New Trainee	0.74% (0.01)	0.87% (0.02)	0.75% (0.01)	0.94% (0.02)
Sales Growth	0.19 (1.23)	0.14 (0.68)	0.24 (1.49)	0.14 (0.72)
Percentage of Craftsman	0.21 (0.19)	0.23 (0.20)		
Percentage of Semi-Skilled	0.42 (0.26)		0.43 (0.25)	
Percentage of Clerical	0.21 (0.17)			0.19 (0.12)

* Standard deviation are in the brackets

Table 5.2: Wage equation in union and nonunion sector respectively

Variables	Craftsman		Semi-skilled		Clerical	
	Union Sector	Nonunion Sector	Union sector	Nonunion Sector	Union Sector	Non-union Sector
Constant	4.67 (119.14)	4.63 (46.01)	4.29 (114.65)	4.13 (57.12)	4.52 (27.38)	4.15 (64.19)
Year 2	0.16 (10.85)	0.08 (2.29)	0.15 (9.28)	0.13 (4.69)	0.12 (2.30)	0.11 (2.85)
Year 3	0.25 (16.55)	0.16 (4.46)	0.25 (14.87)	0.21 (5.35)	0.25 (4.56)	0.18 (4.68)
Year 4	0.32 (22.09)	0.21 (6.17)	0.33 (20.44)	0.29 (7.78)	0.33 (6.38)	0.27 (7.19)
Year 5	0.38 (26.54)	0.29 (8.71)	0.39 (24.37)	0.34 (9.38)	0.38 (7.47)	0.35 (9.74)
Year 6	0.44 (31.23)	0.40 (11.92)	0.45 (27.68)	0.44 (11.22)	0.41 (8.42)	0.41 (10.90)
Size Dummy (>100)	-0.08 (-4.41)	0.11 (2.99)	-0.005 (-0.27)	0.02 (0.67)	-0.16 (-2.45)	-0.04 (-1.40)
Percentage of Work Force	-0.08 (-2.84)	-0.73 (-7.79)	0.12 (3.57)	0.13 (1.44)	0.01 (0.04)	0.24 (2.49)
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$	-0.22 (-5.44)	-0.10 (-0.87)	-0.11 (-2.61)	0.26 (1.82)	-0.33 (-2.10)	0.11 (0.93)
$\frac{\text{Regional Unemp}}{\text{National Unemp}}(-1)$	0. (0.003)	0.06 (0.66)	-0.03 (-0.77)	-0.15 (-1.24)	-0.03 (-0.24)	-0.18 (-1.72)
Sales Growth	0.02 (3.80)	-0.03 (-2.56)	0.03 (4.47)	-0.005 (-0.88)	-0.01 (0.75)	0.02 (0.97)
Percentage of Part Time	-0.23 (-2.40)	0.79 (1.99)	-0.43 (-2.44)	-1.68 (-4.02)	0.21 (0.56)	-0.76 (-1.61)
Percentage of New Trainee	-0.72 (-1.71)	-0.54 (-1.06)	-2.78 (-4.40)	1.04 (1.35)	2.07 (0.48)	1.25 (2.16)
Percentage of Redundents	-0.08 (-1.50)	0.16 (-1.04)	-0.16 (-2.28)	-0.17 (-0.73)	-0.35 (-1.69)	0.09 (0.38)
R square	0.93	0.88	0.95	0.89	0.77	0.83
LM het. Test	10.48	0.03	1.40	0.30	1.33	1.83
F test (Zero Slope)	105.66	24.18	140.72	23.61	10.80	21.37
No. of observations	166	88	134	73	91	114

* T values are in the parenthesis

Table 5.3: GDP, Unemployment rate and TUM in different year

	GDP* (£million)	Engineering Sales**	Unemployment Rate	△ Year Coefficients		
				Craftsman	Semi-Skilled	Clerical
Year 1979	324 543	106	4.05%	—	—	—
Year 1980	316 089	100	5.18%	8%	2%	1%
Year 1981	311 455	91	9.73%	9%	4%	7%
Year 1982	318 447	93	11.8%	11%	4%	6%
Year 1983	333 510	96	12.83%	9%	5%	3%
Year 1984	342 279	102	12.7%	4%	1%	0%

Data Source: Economic Trends Annual Supplement 1990 Edition

GDP* is measured by category of total expenditure at 1985 prices

Engineering Sales** is measured on the base of 1980 average monthly sales, which is 100. The data are from Economic Trends Annual Supplement 1986 Edition.

Table 5.4: Wage equations for Craftsman, Semi-skilled and Clerical worker

Variables	Craftsman	Semi-skilled	Clerical
Constant	4.73 (100.27)	4.17 (100.56)	4.16 (60.99)
Year 2	0.09 (2.58)	0.12 (3.91)	0.09 (2.24)
Year 3	0.17 (4.93)	0.20 (6.54)	0.17 (4.05)
Year 4	0.22 (6.73)	0.28 (9.17)	0.27 (6.41)
Year 5	0.29 (8.49)	0.36 (12.14)	0.36 (8.82)
Year 6	0.38 (11.62)	0.44 (14.25)	0.42 (10.00)
Size Dummy(>100)	0.02 (1.03)	0.03 (1.96)	0.07 (3.06)
Union *Year 1	-0.22 (-6.69)	-0.01 (-0.37)	-0.08 (-1.63)
Union*Year 2	-0.16 (-5.33)	0.004 (0.15)	-0.06 (-1.38)
Union*Year 3	-0.16 (-5.36)	0.022 (0.84)	-0.03 (-0.77)
Union*Year 4	-0.14 (-4.87)	0.024 (0.88)	-0.07 (-1.54)
Union*Year 5	-0.15 (-4.89)	-0.0004 (-0.02)	-0.10 (-2.21)
Union*Year 6	-0.18 (-6.22)	-0.03 (-1.20)	-0.11 (-2.42)
Percentage of Work Force	-0.30 (-8.17)	0.18 (6.31)	0.11 (1.23)
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$	-0.01 (-0.23)	0.008 (0.16)	0.05 (0.58)
$\frac{\text{Regional Unemp}}{\text{National Unemp}}(-1)$	-0.02 (-0.31)	-0.04 (-0.88)	-0.13 (-1.51)
Sales Growth	-0.001(-0.14)	0.002 (0.65)	0.0008 (0.06)
Percentage of Part Time	-0.19 (-1.58)	-0.51 (-2.96)	-0.30 (-1.22)
Percentage of New Trainee	-0.28 (-0.66)	0.39 (0.83)	1.22 (2.11)
Percentage of Redundents	-0.12 (-1.51)	-0.09 (-1.18)	0.11 (0.77)
R-Squared	0.82	0.90	0.74
F test (zero slope)	32.41	62.30	17.28
LM het. test	3.96	0.11	0.05
No. of observations	254	207	205

· T value are in parenthesis.

Table 5.6: Level Decomposition for the craftsman, semi-skill, clerical

	Union	Nonunion	$\triangle\beta$	Price Diff.	Firm's Chara. Diff.
Craftsman:					
Year 2	0.157	0.08	0.077 (2.02)	0.012	—
Year 3	0.25	0.155	0.095 (2.49)	0.015	—
Year 4	0.322	0.207	0.115 (3.09)	0.02	—
Year 5	0.382	0.287	0.095 (2.65)	0.016	—
Year 6	0.439	0.4	0.039 (1.06)	0.007	—
Size Dummy	-0.082	0.116	-0.198 (-4.56)	-0.17	0.042
Percentage of Work Force	-0.079	-0.727	0.648 (8.29)	0.13	0.068
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$	-0.218	-0.105	-0.323 (-2.55)	-0.31	0.005
$\frac{\text{Regional Unemp}}{\text{National Unemp}}(-1)$	0	0.058	-0.058 (-0.58)	-0.056	0.004
Sales Growth	0.024	-0.036	0.06 (3.93)	0.008	-0.0004
Percentage of Part Time	-0.227	0.79	-1.017 (-2.49)	-0.036	-0.0024
Percentage of New Trainee	-0.725	-0.544	-0.181 (-0.27)	-0.008	-0.011
Percentage of Redundents	-0.079	-0.164	0.085 (0.51)	0.0006	0.001
SUM*				- 0.375	0.105
	Union	NonUnion	$\triangle\beta$	Price Diff.	Firm's Chara. Diff.
Semi-skilled					
Year 2	0.153	0.143	0.01 (0.01)	0.0016	—
Year 3	0.255	0.206	0.049 (1.13)	0.0078	—
Year 4	0.335	0.294	0.041 (0.99)	0.0070	—
Year 5	0.395	0.343	0.051 (1.24)	0.0092	—
Year 6	0.45	0.442	0.005 (0.12)	0.0009	—
Size Dummy	-0.005	0.02	-0.025 (-0.59)	-0.0213	0.007
Percentage of Work Force	0.115	0.134	-0.019 (-0.46)	-0.0084	0.004
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$	-0.11	0.266	-0.375 (-3.70)	-0.357	-0.007
$\frac{\text{Regional Unemp}}{\text{National Unemp}}(-1)$	-0.032	-0.155	0.123 (0.81)	0.118	0.002
Sales Growth	0.03	-0.005	0.035 (0.28)	0.006	-0.0001
Percentage of Part Time	-0.432	-1.68	1.248 (7.05)	0.030	0.015
Percentage of New Trainee	-0.16	-0.169	0.009 (0.04)	0.0003	-0.004
Percentage of Redundents	-2.78	1.04	-3.82 (-3.83)	-0.024	-0.003
SUM*				-0.23	0.012

	Union	NonUnion	$\triangle\beta$	Price Diff.	Firm's Chara. Diff.
Clerical:					
Year 2	0.12	0.11	0.006 (0.01)	0.001	—
Year 3	0.25	0.18	0.067 (1.01)	0.011	—
Year 4	0.33	0.27	0.062 (0.97)	0.011	—
Year 5	0.38	0.35	0.022 (0.36)	0.004	—
Year 6	0.41	0.41	0.002 (0.03)	0.0003	—
Size Dummy	-0.16	-0.04	-0.12 (-1.67)	-0.101	-0.011
Percentage of Work Force	0.01	0.24	-0.23 (-0.83)	-0.043	-0.002
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$	-0.34	0.11	-0.45 (-2.22)	-0.453	0.009
$\frac{\text{Regional Unemp}}{\text{National Unemp}}(-1)$	-0.03	-0.19	0.16 (0.93)	0.158	-0.149
Sales Growth	-0.01	0.02	-0.03 (-1.24)	-0.006	0.0014
Percentage of Part Time	0.21	-0.76	0.97 (1.62)	0.029	0.015
Percentage of New Trainee	-0.35	-0.09	-0.44 (1.41)	-0.022	0.0026
Percentage of Redundents	2.07	1.25	0.82 (0.19)	-0.0030	-0.008
SUM*				-0.408	-0.142

* T values are in the bracket.

* SUM means the sum for total price difference or total observed job characteristic difference.

Table 5.7: Trend Decomposition of Union Wage Difference in two period

Variables	Union1	Union2	Non-1	Non-2	1st term	2nd term	3rd term	4th term
Craftsman:								
Size Dummy	-0.067	-0.083	0.11	0.44	-0.0011	-0.006	0.025	-0.19
Percentage of Work Force	-0.12	-0.048	-0.97	-0.61	0.0004	-0.007	0.001	-0.085
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$	-0.19	0.47	-0.038	-0.18	0.009	0.026	0.029	0.708
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$(-1)	-0.018	-0.66	0.12	0.4	-0.005	-0.035	-0.049	-0.81
Sales Growth	0.023	-0.05	-0.004	0.074	0.01	-0.008	-0.0016	-0.023
Percentage of Part Time	-0.17	-0.28	1.59	0.42	0.0011	0.0002	0.0035	0.043
Percentage of New Trainee	-0.066	-0.13	-0.038	0.21	0.0004	-0.0014	-0.0003	-0.007
Percentage of Redundents	-0.43	-1.48	0.085	3	0.013	0.001	-0.003	-0.029
Semi-skilled:								
Size Dummy	-0.008	0.021	0.012	0.004	0.0006	0.0092	-0.0012	0.021
Percentage of Work Force	0.12	0.092	0.045	0.03	0.0005	-0.0007	0.0004	-0.005
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$	-0.11	0.279	-0.087	-0.34	0.0097	-0.018	0.018	0.62
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$(-1)	-0.064	-0.376	-0.11	0.73	0.0026	0.0022	-0.060	-1.08
Sales Growth	0.031	-0.077	-0.01	-0.001	0.023	-0.019	-0.0068	-0.01
Percentage of Part Time	-0.404	-0.396	-3.09	-1.45	0.0008	0	-0.0053	-0.057
Percentage of New Trainee	-0.31	-0.145	-0.43	-0.05	0.0016	0.005	-0.0006	-0.002
Percentage of Redundents	-2.59	-3.77	1.54	-0.44	0	0.0035	0.0033	0.008
Clerical:								
Size Dummy	-0.25	-0.19	-0.03	-0.02	0.0056	0.016	0.007	0.031
Percentage of Work Force	0.15	0.16	0.1	0.41	-0.0005	-0.0001	-0.0009	-0.057
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$	-0.38	0.47	0.14	-0.1	0.027	0.058	0.015	0.97
$\frac{\text{Regional Unemp}}{\text{National Unemp}}$(-1)	0.009	-0.88	-0.13	-0.04	-0.061	-0.056	-0.011	-0.88
Sales Growth	-0.025	-0.2	0.007	0.026	0.061	-0.039	-0.009	-0.02
Percentage of Part Time	0.749	0.39	-1.32	0.34	-0.0012	0.0002	-0.0003	-0.068
Percentage of New Trainee	0.62	-0.69	-0.45	0.23	-0.0001	-0.037	-0.003	-0.027
Percentage of Redundents	31.57	-2.88	1.12	1.72	0.0087	0.303	-0.017	-0.39

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