WAGES, HOURS, EARNINGS AND EMPLOYMENT UNDER UNIONISM

By

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Abstract

Most studies on unions have concentrated on examining the union impact on wages. This thesis, in two essays, examines the union impact on wages, hours, earnings and employment, particularly focussing on the union impact on hours of work.

The first essay summarizes previous theoretical union models which normally assume fixed hours of work and extends them so that hours as well as wages and employment can be determined by collective bargaining. Three kinds of union models are employed to examine union impacts on hours as well as union impacts on wages and employment: the monopoly union model (Oswald [1982]), the right to manage model (Nickell [1981]; Nickell and Andrews [1983]) and the efficient contracts model (McDonald and Solow [1980]). The predicted union impact on hours and employment is found to be ambiguous while the union impact on wages is found to be positive.

The second essay is concerned with estimating union-nonunion wage, hours and earnings differentials. Using the 1990 Labour Market Activity Survey, this essay finds that

(1) union-nonunion hours differentials are ambiguous for males, but they are positive for females,

(2) employers in the union sector extract more hours from more able workers and this contributes greatly to the positive union-nonunion hours differential and

(3) union-nonunion hours differentials are smaller for males than for females and as a result, union-nonunion earnings differentials are larger for females than for males.

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Chapter 1

Introduction

Unions are a distinct feature of all industrial societies. As an economic or political organization, unions try to improve the employment conditions of their members. This goal is normally achieved by raising wages, improving working conditions, protecting the workers from arbitrary dismissal by employers, and so forth. The effects of unions, however, are not only limited to their members but also spill over to the rest of society (see, for example, Freeman and Medoff [1979,1984]).

During the past several decades, a large volume of empirical and theoretical work has been carried out in an attempt to understand union impacts on various economic variables. Most of these studies have concentrated on examining the union impact on wages and, to a lesser extent, employment.[1] In particular, only a few economists have formally analyzed the union impact on hours of work. It is important to recognize the differences in mechanisms by which hours are determined in the union and nonunion sectors for at least two reasons. The first reason is to do with the effectiveness of labour market policies. For instance, let us assume that hours in the nonunion sector are mainly determined according to the worker's labour supply schedule, but hours in the union sector are determined by collective bargaining. Now, suppose that the government provides a wage subsidy to low income workers to induce more hours. This policy may be effective in the nonunion sector since the low income workers will tend to substitute additional hours as the price of leisure increases. But, the effectiveness of such policy is less clear

[1] For example, Lewis's 1986 survey contains almost 200 studies on the union wage effects but contains only 21 studies on the union hours effects in the U.S.

in the union sector if the union's decision depends on the median voter's preferences or if the union cares relatively more about the level of employment than hours and hence is unwilling to bargain for more hours at the expense of employment. Therefore, it is in the interest of policy makers to understand the differences between the two sectors in determining hours. Second, if one of the reasons we care about the union impact on wages is the income inequality between the workers in the two sectors, it may be more appropriate to look at the union impact on earnings rather than the union impact on wages. Since the union impact on earnings depends on the union impact on hours as well as the union impact on wages, we need to study the union impact on hours.

Evidence on the union impact on hours is rather mixed (see table 1 in chapter 3 for a summary of previous findings). Although a majority of researchers in this area detect a statistically significant union-nonunion hours differential, they do not agree on the sign of the hours differential or its magnitude. Unfortunately, most empirical studies on this topic adopt very restrictive specifications for the hours equation. Furthermore, their models often treat union status as exogenous. Given the restrictiveness of their specifications, it is questionable whether their estimates on the union-nonunion hours differential are robust to a more general specification of the hours equation.

Theoretical studies in this area are also unsatisfactory. Most theoretical union models have focused on how wages and employment are determined under unionism with assumptions that either working hours per employee are fixed or they are determined according to the labour supply schedule (see, for example, Oswald [1982]). If it is possible that unions can achieve a higher goal by influencing hours of work, i.e., shortening standard workweek or extensively using overtime, both assumptions seem unrealistic. Recent evidence indicates that unions quite often negotiate over hours of work per week (Clark and Oswald [1993]).

In view of the limitations of the earlier studies, it is clear that we need a more general theoretical and empirical framework to examine the union impact on hours. It is the primary goal of this thesis to provide such a framework and to critically evaluate the previous empirical findings in this area.

The two essays of this thesis constitute an attempt to overcome the limitations of previous analyses in measuring the union impact on hours. Although the two essays are mostly concerned with the union impact on hours, they also examine the union impacts on wages, earnings and employment since they are closely related to each other. In addition, both essays show how the obtained results may be applied to other related issues such as male-female wage and earnings differentials and union impacts on hours dispersion.

The first essay examines previous theoretical union models which normally assume fixed hours of work and shows how the predictions obtained from those models might change if hours as well as wages and employment are allowed to be determined by collective bargaining. Three kinds of union models are employed to examine the union impact on hours as well as the union impacts on wages and employment: the monopoly union model (Oswald [1982]), the right to manage model (Nickell [1981]; Nickell and Andrews [1983]) and the efficient contracts model (McDonald and Solow [1980]). In general, the union impacts on hours and employment are found to be ambiguous and depend upon the firm's production technology and the union's objective function. However, under certain assumptions on the bargaining process, the firm's production technology and the union's objective function it is shown that unionization leads to a higher wage rate, lower hours and increased employment if the union cares relatively more about employment than wages and hours, but otherwise, unionization leads to a higher wage rate, but may or may not increase hours and employment. It seems that the only robust prediction obtained from the three union models is that wages are higher in the union sector, which coincides with the main conclusion drawn by Manning (1994). Therefore, it is an empirical matter to determine the union impact on hours.

The second essay is concerned with estimating union-nonunion wage, hours and earnings differentials. The data used in this essay is drawn from the 1990 Labour Market Activity Survey. The model developed in this paper is more general than others in the area. More importantly, the hours equations are specified as structural equations rather than specified as reduced forms. The advantage of this specification is that pure union hours effects can be separated out from union effects on hours which arise because of the union wage effects. This essay presents several interesting results. First, there is mixed evidence for union-nonunion hours differentials for males. The estimates of the union-nonunion hours differential for males vary considerably depending on the estimation methods used. On the other hand, union-nonunion hours differentials for females are found to be positive no matter what estimation technique is used and found to be statistically significant in many cases. Second, relative to the nonunion sector, employers in the union sector seem to extract more hours from better educated and more experienced workers. Evidence for this is shown by larger coefficients on education and tenure in the union hours equation and positive and significant correlations between union hours and union wages for both males and females. This result is interesting since returns to education and experience are usually lower in the union sector. Third, union-nonunion wage differentials are found to be similar between males and females, but union-nonunion hours differentials are found to be much smaller for males than for females. As a result, union-nonunion earnings differentials are found to be larger for females than for males. In addition, this essay discusses how the size of male-female wage differentials might change if maximum likelihood estimates instead of least squares estimates are used, how an increase in female union density affects male-female earnings differentials and whether or not unions reduce the dispersions of wages and hours.

Chapter 2

The Effects of Unionization on Wages, Employment and Hours

2.1 Introduction

Most theoretical union models have focused on how wages and employment are determined under unionism. An implicit or explicit assumption underlying those models is either that working hours per employee are fixed or that they are determined according to the labour supply schedule.[1] Both assumptions are unrealistic. First, one of the important roles of trade unions has been to influence the length of workday and workweek (see, for example, Hannicutt [1984] and Rees [1989]). Recent evidence that unions quite often negotiate over hours of work is presented in Clark and Oswald (1993).[2] Second, from the theoretical point of view it may be suboptimal for unions to choose only wages and let hours to be determined according to their members' labour supply curves when unions can influence both wages and hours.

Recently, a few researchers including Earle and Pencavel (1990), Pencavel (1991), Dinardo (1991) and Johnson (1990) have extended the existing union models by allowing employers and unions to negotiate over hours as well as wages and employment in the collective bargaining process. Focussing on the efficient contracts model, these researchers have obtained several valuable results. For example, Earle and Pencavel (1990) showed

[1] For example, the assumption that hours per employee are determined according to the worker's labour supply curve is used by Oswald (1982).

[2] In their survey of union leaders' views in Great Britain, 53 out of 57 union leaders say yes to the question, "Does your union usually negotiate over hours of work per week?" On the other hand, very few union leaders said that unions negotiate over employment.

that under a "rent-max" form of the union's objective function the optimal hours and employment are independent of the wage rate, which can be interpreted as a contract curve being vertical in both wage-employment and wage-hours spaces.[3] Pencavel (1991) generalized the "rent-max" union objective function and characterized the optimal outcomes of the efficient contract model. Dinardo (1991) showed that under a union's objective function in which the worker's preferences are represented by the Cobb-Douglas utility function, unions decrease hours of work. With a similar union's objective function Johnson (1990) showed that the negotiated hours lie to the left of the each union member's labour supply curve. In other words, each union member would like to work more hours at the negotiated wage rate.

What is not fully addressed in the literature, however, is the shape of the contract curve in the three variable case in which the two parties bargain over wages, employment and hours.[4] Is the slope of the contract curve in wage-employment space positive, negative or vertical? What about the slope of the contract curve in wage-hours space? Under what circumstances can we determine these slopes of the contract curve? Another related issue not fully examined in the literature is the effects of unionization on wages, hours and employment. If hours are fixed, we expect that the wage rate is higher, but the level of employment can be higer or lower or even unaffected under unionism. In the case where hours are determined by collective bargaining, we know little about the union effects on those variables.

In this chapter we show how one can characterize the contract curve when wage, hours and employment are jointly determined by collective bargaining. Although it is not possible to determine the shape of the contract curve under the most general specification

[3]The "rent-max" union objective function is shown in section 2.3.2.

[4]Pencevel (1991) showed that the slope of the contract curve in wage-employment space can be positive, negative or vertical, holding hours constant at the equilibrium. This is not a desirable way to find out the slope of the contract curve since the optimal hours should adjust along the contract curve in wage-employment space.

of the union's objective function, we are able to show, in some special cases, whether the contract curve is downward-sloping or upward-sloping or vertical in wage-employment space and wage-hours space respectively. For example, if the union is utilitarian, it is possible to show that the contract curve is downward-sloping in wage-hours space and upward-sloping in wage-employment space. This may in turn imply that as the bargaining power of the union increases, wages and employment rise, but hours fall.

In order to examine the effects of unionization on wages, hours and employment, we first characterize nonunion outcomes and compare them with the union outcomes obtained under the monopoly union, right to manage and efficient contracts models. In general, we find that unionization leads to a higher wage rate, but the effects of unionization on hours and employment are ambiguous and depend on the specifications of the union's objective function.

The organization of this chapter is as follows. Section 2.2 sets up the basic model without unions and describes optimal nonunion outcomes. In section 2.3, we introduce unions in the economy and examine the effects of unionization on wages, employment and hours under three different union models, i.e., the monopoly union, right to manage and efficient contracts models. Section 2.4 discusses two possible extensions of our results. Section 2.5 summarizes the main results of this chapter. Finally, proofs and figures are presented in Appendices A and B.

2.2 A Simple Model Without Unions

The model presented in this section is a special case of the model in Donaldson and Eaton (1984). Workers are assumed to be homogeneous.[5] Firms are assumed to be

[5]The assumption of homogeneous workers is not necessary here, but it is almost inevitable in the model with unions. The reason is that when union members vote for more than two subjects a union's utility function is bound to be ill-defined. Oswald (1982) shows that a well-behaved utilitarian union utility function can be constructed even when workers are heterogeneous in the two variable case (wage

competitive in the product market and assumed to produce a single consumption good. More importantly, firms are assumed to be utility takers in this model. That is, a firm has to meet its workers' ongoing or reservation utility level when choosing wages and hours. Finally, I assume that workers and hours are perfect substitutes in production and there are no person-specific costs or quasi-fixed costs of employment.[6]

Given the assumptions above, a firm's problem can be written as

$$\max_{W,H,N} \Pi(W,H,N) = G(HN) - WHN \tag{2.1}$$

$$s.t. \;\; U(WH, T-H) \geq \bar{U} \tag{2.2}$$

where W is wage rate, H hours per worker, N number of workers and T total available time for work. The production function G is assumed to be strongly concave in total labour (HN) and the utility function U is assumed to be strongly quasi-concave in income (WH) and leisure ($T-H$). Finally, the output price is normalized to be unity.

The constraint (2.2) implies that the firm has to meet the worker's ongoing utility level $\bar{U}$. At the equilibrium, (2.2) will hold with equality. Hence, it may be rewritten as

$$Y \equiv WH = y(T-H, \bar{U}) \tag{2.3}$$

Since y is strongly convex in leisure, it is true that $y_1 = \partial y/\partial(T-H) < 0$, $y_{11} = \partial^2 y/\partial(T-H)^2 > 0$ and $y_2 = \partial y/\partial\bar{U} > 0$, assuming y to be twice differentiable. Substituting (2.3) into the profit equation (2.1) and maximizing the substituted profit equation

and employment). One of the assumptions he made is that workers are equally productive and hence receive the same wage despite of heterogeneity. Unfortunately, having this kind of heterogeneity does not add much to the model with homogeneous workers. For this reason, we simply assume that workers are homogeneous.

[6]The assumption of perfect substitution between workers and hours is used to simplify our analyses. Donalson and Eaton (1984) allow the case where the total labour takes a form of A(H)N, where $A(H)$ can be a strongly concave function of H. Also, we can allow some kind of quasi-fixed costs of employment in the model. Having fixed costs in the model will affect the optimal wage rate, hours and employment. For example, the employer will increase the number of hours per worker but reduce the number of workers in the presence of fixed costs. However, having fixed costs in the model will not change the main predictions on union effects as long as the size of fixed costs in the union sector is similar to that in the nonunion sector. The role of fixed costs in measuring union impact is discussed in the next section in detail.

with respect to H and N yield the following two first order conditions

$$y_1 H + y = 0 \tag{2.4}$$

$$G'(HN) + y_1 = 0 \tag{2.5}$$

Using (2.3), equations (2.4) and (2.5) can be rewritten as

$$W = G'(HN) \tag{2.6}$$

$$W = -y_1 \tag{2.7}$$

Equation (2.6) looks very familiar. It states that the optimal wage rate should be equal to the value of marginal product of total labour (HN). On the other hand, equation (2.7) states the optimal wage rate should also be equal to the marginal rate of substitution of income for leisure at the utility level $\bar{U}$. The above two equations and (2.3) determine the optimal W, H and N. [7]

In order to understand why equation (2.7) must hold at the equilibrium, we need some preliminary results. Note that equation (2.3) can be rewritten as

$$W = W(H, \bar{U}) \tag{2.8}$$

Equation (2.8) is nothing but the expression for an indifference curve in wage-hours space at $U = \bar{U}$. This indifference curve has the same features as appeared in Altonji and Paxson (1988). That is, the indiffernece curve (2.8) has a U-shape and the associated labour supply curve goes through the bottom of the indifference curve. Figure 1 in Appendix B depicts a family of the indifference curves ($U^1 > U^0$) and the associated

[7] If we replace hours per worker with work intensity in our problem and specify $U = U(W, B)$ where B measures the intensity of work, then our problem becomes similar to the one considered by Johnson (1990), and our solution concepts are still valid. Johnson showed that $\frac{dW}{dB}|_U = \frac{dW}{dB}|_\Pi$ at the equilibrium. In our case, combining (2.6) and (2.7) yields $\frac{dY}{dH}|_U = \frac{dY}{dH}|_\Pi$ at the equilibrium. Therefore, there are no qualitative differences between the two models.

labour supply curve (LS). Note that at the bottoms of indifference curves, i.e., where $\frac{dW}{dH} = 0$, wage rates are minimized while maintaining certain utility levels and also the wage rates are equal to the marginal rate of substitution of the income for leisure. [8]

With these results, we can now explain why equation (2.7) must be true in equilibrium. Since hours and employment are perfect substitutes in production, any combination of H and N such that the product of H and N is a constant will yield the same revenue to the firm. Therefore, the whole problem is reduced to minimizing the labour costs, $W(H, \bar{U})HN$, while keeping HN an optimal level. It is then obvious that in order to minimize the labour costs, H has to be chosen such that W is minimized keeping the utility level at $\bar{U}$ since N can be always adjusted to maintain HN to be a constant. We know from the properties of the indifference curve, the minimum W is achieved at the bottom of the indifference curve $\bar{U}$ and at that point it must be true that the wage rate is equal to the marginal rate of substitution of the income for leisure. Therefore, the optimal W and H will satisfy equation (2.7).

In sum, if hours and employment are perfect substitutes in production and if there are no quasi-fixed costs for employment, the optimal hours per worker for the firm are the hours that each worker would have supplied at the chosen wage rate if the worker had maximized his or her utility at that wage rate. Put differently, the optimal combination of the wage rate and hours for the firm is in accordance with the worker's labour supply curve. The optimal level of employment for the firm is then determined by the total labour demand curve, equation (2.6).

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[8] The slope of an indifference curve can be shown as $\frac{dW}{dH} = \frac{U_2 - WU_1}{HU_1}$, $H \neq 0$. Hence, $\frac{dW}{dH} = 0$ if and only if $W = \frac{U_2}{U_1}$.

2.3 Effects of Unionization on Wages, Hours and Employment

In this section we consider the monopoly union, right to manage and efficient contracts models to see how unionization might affect the wage rate, hours per worker and the level of employment of a firm. However, since the right to manage model is more general than the monopoly union model, we focus on analyzing the right to manage model and examine the monopoly union model as a special case. We also compare the results obtained from this three variable bargaining problem with those obtained from the two variable bargaining problem in which the firm and the union bargain over just the wage rate and employment.

There is no general agreement on the specification of a union's objective function. Therefore, the most general specification may take the form

$$V = V(Y, H, N; \bar{U}) \tag{2.9}$$

where $Y = WH$, $V_1 = \partial V/\partial Y > 0$, $V_2 = \partial V/\partial H < 0$, $V_3 = \partial V/\partial N > 0$, and $\bar{U}$ is a worker's non-union utility level.[9] We use the union's objective function (2.9) when we characterize the outcomes of the monopoly, right to manage and efficient contracts models. However, it is very difficult to predict union effects on the wage rate, hours and employment with the union's objective function (2.9). Therefore, in order to obtain possible predictions we consider a special case

$$V(WH, H, N; \bar{U}) = N[U(WH, T - H) - \bar{U}]^k \tag{2.10}$$

where $k > 0$ and U is a concave utility function of a worker. Note that the parameter k measures the relative weight put on each union member's utility gain. The union's objective function (2.10) has been used by Johnson (1990) and DiNardo (1991) and it is

[9] This union's objective function is used by Earle and Pencavel (1990).

more general than the special union's objective function considered by Pencavel (1991).[10] Finally, the firm's objective function is asssumed to be the same as before.

2.3.1 The Right to Manage Model

The right to manage model (Nickell [1981]; Nickell and Andrews [1983]) in the two variable case (wage and employment) assumes that a union and a firm bargain over a wage rate and given the negotiated wage rate, the firm determines the level of employment unilaterally. In the three variable case, there can be several possible situations.[11] In our problem, the firm is indifferent between hours and employment, so it is not possible to distinguish between the cases where the two parties negotiate over wages and hours and where they negotiate over wages and employment. However, as mentioned in the introduction, unions and firms seem to frequently negotiate over hours but not over employment. Therefore, it is more reasonable to think that the union and firm negotiate the wage rate and hours and the firm determines the level of employment unilaterally in the right to manage model. Following Manning (1987), this problem can be written as[12]

$$\max_{W,H,N} \ \theta lnV(WH, H, N; \bar{U}) + (1-\theta)ln\Pi(W, H, N) \tag{2.11}$$

$$s.t. \ \ G'(HN) - W = 0 \tag{2.12}$$

[10] The special union objective function considered by Pencavel (1991) takes the form, $N[Y+f(H)-\bar{Y}]^k$, where $Y = WH$, $f' < 0$ and $f'' < 0$. Our union's objective function (2.10) is not totally different from his. If $U = Y + ln(T-H)$ with $f(H) = ln(T-H)$ and if $\bar{U}$ is replaced by $\bar{Y}$, then our union's utility function (2.10) becomes Pencavel's.

[11] For example, the union and the firm negotiate over the wage rate and the firm unilaterally chooses hours and employment, or the two parties negotiate over the wage rate and hours and the firm unilaterally chooses the employment, or the two parties bargain over the wage rate and employment and the firm chooses hours unilaterally.

[12] An alternative approach is to maximize $\Omega = V(WH, H, N; \bar{U}) + \beta\Pi(W, H, N)$ subject to $G'(HN) - W = 0$, where β is nonnegative. I follow the specification used by Manning (1987) simply because his specification is more commonly seen in the bargaining models. The results of the two specifications do not differ qualitatively.

Note that if $\theta = 1$ in (2.11), the right to manage model degenerates to the monopoly union model where, in this case, the union chooses the wage rate and hours, and the firm chooses the level of employment at the negotiated wage rate and hours. From the first order conditions for for (2.11) and (2.12) one can show that

$$\frac{dW}{dH}|_V = G''N \cdot \frac{1}{1+\frac{(1-\theta)\alpha_1}{\theta}} \tag{2.13}$$

$$\frac{dW}{dN}|_V = G''H \cdot \frac{1}{1+\frac{(1-\theta)\alpha_2}{\theta}} \tag{2.14}$$

where

$$\alpha_1 = -\frac{G''HN^2V}{(V_1W+V_2)\Pi} \tag{2.15}$$

$$\alpha_2 = -\frac{G''H^2N^V}{V_3\Pi} \tag{2.16}$$

It is straightforward to show from the first order conditions that α_1 and α_2 are positive. Thus, $\frac{dW}{dH}|_V \geq G''N$ and $\frac{dW}{dN}|_V \geq G''H$. This implies that in general, the indifference curves are flatter than the demand curves at the equilibrium in wage-hours and wage-employment spaces respectively. Note that if $\theta = 1$, the slopes of the indifferences are equal to the slopes of the demand curves, which is the equilibrium conditions for the monopoly union model.

The solutions (2.13)-(2.16) are too general to predict the effects of unionization on the wage rate, hours and employment. Thus, we consider a special case where the union's objective function takes the form of (2.10). We also impose $\theta = 1$ to make our points clear.[13] Under these assmuptions, the first order conditions are summarized as follows:

$$WU_1 - U_2 = -NHU_1G'' > 0 \tag{2.17}$$

$$U - \bar{U} = -kNH^2U_1G'' > 0 \tag{2.18}$$

[13]This, of course, is the monopoly union case. The main predictions on union effects are not affected even if $\theta < 1$.

$$W = G' \tag{2.19}$$

The above three equations determine the optimal wage, hours and employment. The main implication of (2.17) is that hours are not determined by a worker's labour supply decision.[14] Therefore, the assumption used by Oswald (1982) that hours are determined by a worker's labour supply decision may not be appropriate in unionized establishments. Furthermore, at the equilibrium, union workers work fewer hours than they would like to work at the equilibrium wage rate since $W > \frac{U_2}{U_1}$. Equation (2.18) states that union workers attain a higher utility level than nonunion workers and equation (2.19) represents the total labour demand curve.[15]

From equations (2.17)-(2.19) one can show that the wage rate will increase as a result of unionization. However, union effects on hours and employment are ambiguous. Figure 2 in Appendix B depicts some possible eqilibrium outcomes. Note that any equilibrium wage rate and hours must lie on the left hand side of the labour supply curve (LS) since $W > \frac{U_2}{U_1}$. Since the nonunion equilibrium is at the bottom of $\bar{U}$ (point b), it is obvious that at any point on U^* where $U^* > \bar{U}$ the union wage rate is greater than the nonunion wage rate. However, the hours can increase (point a_3), decrease (point a_1) or remain at the same level (point a_2). The union effects on hours depend on the shape of the labour supply curve. For example, if the labour supply curve is strongly backward bending, then hours will decrease as a result of unionization. Since G is strongly concave and the wage rate increases after unionization, what is not possible is the situation in which both hours and employment increase after unionization. Otherwise, any other combinations of hours and employment are possible as long as they satisfy equations (2.17)-(2.19).

[14]Remember that the labour supply curve is represented by $WU_1 - U_2 = 0$.

[15]To see how an increase of k affects the optimal wage rate, hours and employment, I derived dW/dk, dN/dk and dH/dk from equations (2.17)-(2.19). The signs of the derivatives depend on the curvature of the total labour demand curve, i.e., G''', the shape of the labour supply curve and the value of k itself. Therefore, in general, we can not determine the effects of k on the optimal wage rate, hours and employment.

Finally, it is worthwhile to note that if $k = 1$ in (2.10), i.e., the union cares equally about employment and each member's utility gain from unionization, and if an additional constraint is added to (2.11) and (2.12) that hours are determined by the worker's labour supply decision, i.e., $H = H(W)$, then our monopoly union's problem becomes exactly the same problem that is in Oswald (1982).[16] Notice, however, that his assumption ($H = H(W)$ or $WU_1 - U_2 = 0$) is adhoc and the solution of the monopoly union's problem is suboptimal because the union can attain a higher utility level by setting $WU_1 - U_2 > 0$. In addition, the union effects on hours and employment obtained from his results are different from ours. In our case, those effects are ambiguous if the labour supply curve has a positive slope. But, in his case, hours must increase if the labour supply curve is upward-sloping, and employment must decrease due to the strongly concave production function, given that the wage rate rises after unionization. This result also seems to be too strong because at least in early years unions moved towards the reduction of hours of work.[17]

2.3.2 The Efficient Contracts Model

In the efficient contracts model it is assumed that the union and the firm bargain over wages, employment and hours and therefore, unlike the monopoly union and right to manage models, the outcomes of the efficient contracts model are pareto optimal. Formally, the optimal wage rate, hours and employment in this bargaining problem are the

[16] The union utility function in Oswald (1982) has the same ordering as our union utility function (2.10) when k=1. In addition, Oswald also assumed that hours and employment are perfect substitutes in production. Therefore, if we assume, as he did, that hours are determined by the worker's labour supply decision, our problem becomes exactly the same as his.

[17] See, for example, Hannicutt(1984) for a brief history of labour movement towards shorter working hours in the early 20th century.

solution of the following problem:[18]

$$\max_{W,H,N} \Omega = \theta ln V(WH, H, N; \bar{U}) + (1-\theta) ln \Pi(W, H, N) \tag{2.20}$$

where θ $(0 < \theta < 1)$ represents the union's bargaining power.

From the first order conditions of (2.20), we can obtain the following two relationships:

$$\frac{V_3}{HV_1}|_V = \frac{W - G'}{N}|_\Pi \tag{2.21}$$

$$\frac{WV_1 + V_2}{HV_1}|_V = \frac{W - G'}{H}|_\Pi \tag{2.22}$$

where $V_1 = \partial V/\partial Y$, $V_2 = \partial V/\partial H$ and $V_3 = \partial V/\partial N$. Equations (2.21) and (2.22) are obtained by equating the slopes of the indifference curve with the slopes of the isoprofit curve in wage-employment space and wage-hours space respectively. Note that equations (2.21) and (2.22) determine optimal combinations of wage, hours and employment, and we will refer them as a contract curve in wage-hours-employment space. Like McDonald and Solow (1981) and many others, one can find the slopes of the contract curve by taking total differentials of (2.21) and (2.22) and sloving for $\frac{dW}{dH}$ and $\frac{dN}{dH}$ simultaneously.

Under the most general specification of the union's objective function (2.9), we cannot sign $\frac{dW}{dH}$ and $\frac{dN}{dH}$.[19] In other words, the contract curve can take any shape. Also, it is impossible for us to predict the union effects on the wage rate, hours and employment since the relationship between the union's objective function and the worker's utility function is unclear. Thus, we adopt (2.10) as the union's objective function in order to obtain possible qualitative results.

Under the union's objective function (2.10), equations (2.21) and (2.22) become

$$\frac{U - \bar{U}}{kHNU_1} = \frac{W - G'}{N} > 0 \tag{2.23}$$

[18]Again, I employ the specification used by Manning (1987) for the similar reason presented earlier.

[19]This is true even in the two variable (wage and employment) case. See, for example, Gunderson and Riddell (1988).

$$\frac{WU_1 - U_2}{HU_1} = \frac{W - G'}{H} > 0 \tag{2.24}$$

Equations (2.33) and (2.34) characterize pareto optimal combinations of wage, hours and employment on the contract curve. Taking total differentials of the above two equations, we obtain the following results (see Appendix A for derivations):[20]

$$\frac{dW}{dH} = -\frac{(1-k)(WU_1 - U_2) - kH(U_{11}W^2 - 2U_{12}W + U_{22})}{(1-k)HU_1 + kH^2(U_{21} - U_{11}W)} \tag{25}$$

$$\frac{dN}{dH} = -\frac{N}{H} + \frac{kH(WU_1 - U_2)(U_{11}U_{22} - U_{12}{}^2) - (1-k)(U_{22}U_1{}^2 - 2U_{12}U_1U_2 + U_{11}U_2{}^2)}{U_1{}^2 G'' H[kH(U_{21} - U_{11}W) + (1-k)U_1} \tag{26}$$

The signs of (2.25) and (2.26) depend on the value of k. If $k \leq 1$, it can be shown that $\frac{dW}{dH} < 0$ and $\frac{dN}{dH} < 0$, and hence $\frac{dW}{dN} > 0$.[21] On the other hand, if $k > 1$, we cannot determine the signs of the slopes.

The intuition for the results is as follows. Suppose that the union cares relatively more about employment than each member's utility gain, i.e., $k < 1$. Without loss of generality, assume that the wage rate increases. Since the firm is indifferent between hours and employment, the union can determine hours. As the wage rate rises, each union member may want to work less or more hours depending on whether income effects dominate substitution effects. However, since the union puts more weight on employment, it will try to substitute employment for hours whenever possible.[22] If $k = 1$, the union will still try to substitute employment for hours because of the diminishing marginal utility

[20]The slope of the contract curve in (W,N) space, i.e., $\frac{dW}{dN}$, can be easily inferred from taking the ratio of $\frac{dW}{dH}$ and $\frac{dN}{dH}$.

[21]See Appendix A for the proof.

[22]In general, this argument will depend upon whether or not there are fixed costs of employment. If there are fixed costs of employment, the union may not successfully substitute employment for hours. I have somewhat generalized the firm's objective function as $\Pi = G[A(H)N] - WHN - CN$, where $A(H)$ is a concave function of H and C is fixed costs of employment per worker. In this case the slope of dW/dH includes $A(H)$ and C terms, but the predictions are not so different from those obtained from the simpler model. If the fixed costs, C, is higher in the unionized firm than it is in the nonunionized sector, then the predictions will change. In this case the unionized firm will have an incentive to substitute hours for workers and hence the sign of dW/dH will depend on the size of the fixed costs. If fixed costs increases by a large amount after unionization, it is possible that dW/dH can even be positive.

of income and leisure.[23] Put differently, the union's utility increases with a diminishing rate when income increases but decreases with an increasing rate when leisure decreases. Therefore, the return to an increase in hours, i.e., the return to an increase in income but a decrease in leisure, will be relatively smaller than the return to an increase in employment. In sum, in both cases we expect $\frac{dW}{dN}$ to be positive but $\frac{dW}{dH}$ to be negative.

If the union cares more about each member's utility gain than employment, i.e., $k > 1$, the signs of $\frac{dW}{dN}$ and $\frac{dW}{dH}$ are ambiguous. Here, the union has no strong preference over employment, so union members can attain a higher utility level either through a higher wage rate with more hours or through a higher wage rate with less hours depending on income and substitution effects.[24] Since hours may or may not increase as the wage rate increases, it is also not clear whether employment will increase or decrease with the wage rate. Therefore, the sign of the two slopes is ambiguous.

Assuming that $k \leq 1$, i.e., $\frac{dW}{dH} < 0$ and $\frac{dN}{dH} < 0$, we can draw the contract curve in (W-H-N) space. Figure 3 in Appendix B depicts the contract curve (CC). Note that the curves represented by CwCh, CwCn and ChCn are the projections of the contract curve CC in (W-H), (W-N) and (H-N) spaces respectively.

Union impacts on the wage rate, employment and hours are depicted in figure 4 in Appendix B when $k \leq 1$. Point b represents "before unionization" and point a represents "after unionization". In (W-H) space, point b must be at the bottom of the indifference curve $\bar{U}$ since that point represents the optimal outcomes of the firm's maximization problem without unions. Point a, however, must be on the decreasing portion of the indifference curve U^* since $WU_1 - U_2 > 0$. Finally, movement from b to a implies that both the wage rate and employment increase, but hours decrease after unionization.

Finally, consider a special case where the union worker is risk-neutral in income. In

[23] Note that if $k = 1$, our union objective function is ordinally equivalent to a utilitarian utility function.

[24] When $k > 1$, the denomonator of (2.25) may be seen as the sum of substitution effects and income effects. Also note that if k approaches infinity, $WU_1 - U_2 = 0$.

particular, let us assume the union's objective function to be

$$V(WH, H, N) = N[WH + f(H) - \bar{Y}]^k \tag{2.27}$$

where $f' < 0$, $f'' < 0$ and $k > 0$. The union's objective function (2.27) appears in Pencavel (1991). With this union's objective function and our firm's objective function, we obtain the following two conditions for an efficient bargaining:

$$G'H = (1 - \frac{1}{k})WH + \frac{1}{k}(f - \bar{Y}) \tag{2.28}$$

$$G'N = -f'N \tag{2.29}$$

Pencavel refers equation (2.28) as an efficient contracts employment condition and equation (2.29) as an efficient contracts hours condition. The employment condition states that the maginal revenue product of employment is the weighted sum of income and opportunity costs $(f - \bar{Y})$ and the hours condition states that the marginal revenue product of hours is equal to the disutility of work of union members. The way that Pencavel finds the slope of the contract curve in wage-employment space is to obtain $\frac{dW}{dN}$ from (2.28) holding hours constant.[25] In this case, it can be shown that

$$\frac{dW}{dN} = -\frac{G''H}{(1-k)} \tag{2.30}$$

From (2.30), we can say that if the union cares relatively more about income than employment ($k > 1$), the contract curve has a negative slope and if the union cares more about employment than income ($k < 1$), the contract curve has a positive slope. If $k \to 1$, the contract curve becomes vertical. This case is equivalent to the "rent-max" union's objective function.

Obviously, equation (2.30) cannot represent the true slope of the contract curve in wage-employment space since hours will not be held constant along the contract curve.

[25]In fact, Pencavel (1991) finds $\frac{d(WH)}{dN}$ instead of $\frac{dW}{dN}$. For fixed hours, the two derivatives would generate the same sign.

The correct slopes of the contract curve can be found by solving (2.28) and (2.29) simultaneously. Using the method described earlier, we obtain

$$\frac{dW}{dH} = -\frac{(1-k)(W+f') - kHf''}{(1-k)H} \tag{2.31}$$

$$\frac{dW}{dN} = \frac{(1-k)(W+f')G'' - kHf''G''}{(1-k)(NG''+f'')} \tag{2.32}$$

We know that $G'' < 0$ and $f'' < 0$ from our assumptions. Also, it can be shown that $W + f' > 0$ from (2.28) and (2.29).[26] With these signs, we can show that if $k < 1$, $\frac{dW}{dN} > 0$ and $\frac{dW}{dH} < 0$, if $k \to 1$, both $\frac{dW}{dN}$ and $\frac{dW}{dH}$ approach infinity, and if $k > 1$, both $\frac{dW}{dN}$ and $\frac{dW}{dH}$ are indeterminate. Note that if $k > 1$, we have $\frac{dW}{dN} < 0$ from (2.30), whereas it is ambiguous in (2.32). Also, even though the signs of $\frac{dW}{dN}$ are same in both equations (2.30) and (2.32) when $k < 1$, their magnitudes may be quite different. Since union effects on wage rate and employment depend not only on the sign of $\frac{dW}{dN}$ but also on its magnitude, it is important to recognize the difference between the two methods.

2.4 Extensions

In this section we briefly discuss how one can extend our results to related areas. The first extension deals with work rules or featherbedding (Johnson [1990]) and the second extension is concerned with the sequential bargaining (Manning [1987]).

2.4.1 Featherbedding

It is well known that although the outcomes of a bargaining over both wage and employment are pareto optimal for the union and firm, the firm has an incentive to reduce the level of employment at the negotiated wage. A suggested and practiced way to prevent

[26] This condition is analogous to $WU_1 - U_2 > 0$ in our earlier results.

the firm from cheating is to adopt "featherbedding" which usually specifies the number of workers required per machine.

In our model the firm also has an incentive to reduce hours at the negotiated wage and level of employment.[27] Therefore, it is not sufficient to specify the number of workers required per machine in the contract to prevent the firm from cheating. There are two ways to prevent the firm from doing so. First, if hours and employment are not perfect substitutes, the contract must specify both numbers of hours and number of workers required per machine. Second, if hours and employment are perfect substitutes as in our case, the contract only needs to specify total manhours required per machine. Johnson (1991) recognized the possibility of the second case where the union and the firm might bargain over the wage rate, manhours/capital ratio and hours. In our model we can also allow this case if the firm's objective function is specified as

$$\Pi = G(Z) - WHN - rK \tag{2.33}$$

where $Z = \frac{HN}{K}$ and K and r are capital and rental price respectively. The method described in the previous section to obtain the slopes of the contract curve may directly be applied to this case as well. However, as Johnson (1990) pointed out, the outcomes of this kind of bargaining will not be as efficient as the outcomes obtained by bargaining directly over wage, hours and employment since the union has to consider how the bargaining outcomes may influence capital in negotiation.

2.4.2 Sequential Bargaining

Manning (1987) considers a bargaining situation where the union and firm negotiate over wages and employment sequentially. In particular, he shows that conventional union

[27]This is clear from the fact that at the solution of the efficient bargaining the value of marginal product is strictly less than the wage rate.

models such as the monopoly union, right to manage and efficient contracts models are special cases of the sequential bargaining model, by assigning a particular value to the bargaining power of the union at each stage of the bargaining process. For example, if the union has all the power in negotiating wages and the firm has all the power in negotiating employment, the sequential bargaining model is reduced to the monopoly union model. On the other hand, if both parties have the same bargaining power in negotiating wages and employment, the sequential bargaining model is reduced to the efficient contracts model.

The sequential bargaining model can be also employed in our case where the union and firm negotiate over wages, hours and employment. For example, let us assume that union and firm bargain over a wage rate at the first stage, hours at the second stage and employment at the third stage.[28] Under this scenario the sequential bargaining problem can be written as the following:

$$\max_{N} \ \theta_3 lnV(WH, H, N) + (1-\theta_3) ln\Pi(W, H, N) \tag{2.34}$$

$$\max_{H} \ \theta_2 lnV[WH, H, N(W,H)] + (1-\theta_2) ln\Pi[W, H, N(W,H)] \tag{2.35}$$

$$\max_{W} \ \theta_1 lnV[WH(W), H(W), N(W) + (1-\theta_1) ln\Pi[W, H(W), N(W)] \tag{2.36}$$

Using the definition for Π it is straightforward to show that (1) if $\theta_1 = 1$, $0 < \theta_2 \leq 1$, and $\theta_3 = 0$, the solutions of (2.34)-(2.36) are identical to those of the monopoly union model, (2) if $0 < \theta_1 < 1$, $0 < \theta_2 \leq 1$ and $\theta_3 = 0$, the solutions are identical to those of the right to manage model, and (3) if $\theta_1 = \theta_2 = \theta_3 = \theta$, the solutions are identical to those of the efficient contracts model. The main difference between the monopoly union model and right to manage model is that in the right to manage model unions have no longer monopoly power in setting wages. This is reflected by $\theta_1 < 1$.

[28]It is important to assume that both parties negotiate a wage rate first, but it is not important to assume that hours are negotiated before employment in our model since they are perfect substitutes in production. Our results will be unaffected even if employment is negotiated before hours.

Finally, following Manning (1987), it may be possible to show how the optimal wage rate, hours and employment change in response to the changes of the bargaining powers which are measured by θs. This remains to be a usuful exercise in future research.

2.5 Conclusion

This main purpose of this chapter was to examine the effects of unionization on wages, employment and hours. To do that, we have characterized the nonunion outcomes and compared them with the outcomes obtained under the monopoly union, right to manage and efficient contracts models without assuming fixed hours of work. In general, union impacts on hours and employment are found to be ambiguous while the union impact on wages is found to be positive. However, if some structures are imposed on the union's objective function - for example, if a utilitarian union's objective function is assumed - we have been able to show that under the efficient contracts model the wage rate increases, hours decrease, and employment increases as a result of unionization.

Since the theoretical union models do not provide us with a solid prediction on union impact on hours of work, it remains to be an empirical matter to determine union impact on hours of work. The shapes of labour supply, labour demand and contract curves are some of the important factors determining union impact on hours of work. In the monopoly union model, the employer in the union sector can have all the power in choosing hours of work. Therefore, in this world union impact on hours of work depends upon how employers in the union sector behave differently from employers in the nonunion sector. On the other hand, in the efficient contracts model, hours of work are jointly determined by the employer and the union. Therefore, union impact on hours of work will depend upon the worker's taste for work as well as the employer's selection of hours of work. We will look into these issues in the next chapter.

In this chapter we have also shown how one can find the slope of the contract curve in wage-employment space without assuming fixed hours. The slope obtained in this chapter is quite different from the one obtained by fixing hours. In particular, if the union cares relatively less about employment than the utility gains of its members, we have shown that the contract curve does not necessarily have a negative slope in contrast to the one shown in Pencavel (1991).

Like Johnson (1990) and DiNardo (1991), we have also obtained the result that at the equlibrium union workers would like to work more hours at the negotiated wage rate. The implication of this finding is twofold. First, it means that the usual assumption of fixed working hours or the assumption that workers can choose the number of hours they would like to work may be inappropriate in the union sector. Second, it also means that some of the higher wages that union workers receive could be "compensating wage differentials" for the unsatisfactory hours set by unions and firms. Figure 5 in Appendix B depicts an equilibrim under the efficient contracts model. Under the contract curve (CC) the total union-nonunion wage differential is denoted by $(a-b)$. It can be decomposed as the sum of the compensating differential $(a-c)$ and the pure union-nonunion wage differential $(c-b)$. This notion that union workers might recieve compensating wage differentials for their restrictive work was empirically tested by Duncan and Stafford (1980).

A more challenging task in this area is to analyze union effects on wages, hours and employment in a general equilibrium setting. Some researchers like Diewert (1974) and Khun (1988) have examined union effects on wages and employment in general equilibrium models. However, to my knowledge, no one has shown how wages, hours and employment are determined in a unionized economy in a general equilibrium model. This remains an important future research agenda among labour economists.

Chapter 3

Union-Nonunion Wage, Hours and Earnings Differentials

3.1 Introduction

Understanding what unions do has been an important research agenda among social scientists. Unions affect society in many ways. They not only affect workers' wealth but also affect work rules, absenteeism and many other aspects of work life. Furthermore, unions alter the distribution of income in society.

In Canada, unions are especially important. Although union density has declined in the last decade, it is still the case that approximately 40% of the male labour force and 30% of the female labour force are unionized. Therefore, it is important to understand what unions do and how they affect the economy if any labour market policies are to be effective. Nonetheless, research on unions is quite scarce in Canada in terms of volume and also in terms of variety. There are a handful of studies on the union wage effects, but very few studies deal with other aspects of unions. For this reason, this study examines the union effects on hours of work and earnings, with a hope to obtaining a more comprehensive understanding of the union effects on the Canadian economy.

Quite recently, several researchers in the U.S. have attempted to measure the union-nonunion hours differential using models which are analogous to the ones often used in studies of the union-nonunion wage differential. Although most studies detect a statistically significant union-nonunion hours differential, they do not agree on the sign of the hours differential or its magnitude. For example, Raisian (1983) found that union male heads of households work 1.5% more than nonunion male heads per year. Earle and Pencavel (1990) in their cross-sectional analysis also found that union workers generally work more than nonunion workers, although their estimates differ by gender, colour, industry and occupation.[1] On the other hand, in an analysis of union wage, hours, and earnings differentials in the construction industry, Perloff and Sickles (1987) report that male union workers work 4% less than male nonunion workers per week. DiNardo (1991) also reports that male union workers work 3% to 10% less than male nonunion workers annually.

Unfortunately, most empirical studies on this topic adopt very restrictive specifications for the hours equation in that their models do not allow complete interactions between the union status dummy and exogenous variables. More importantly, their models often treat union status as exogenous. Given that there is increasing agreement on the likelihood that the selection of workers into the union sector is endogenous, their least-squares estimates for the union-nonunion hours differential could be biased.

Perloff and Sickles (1987) allow for the most general structure among studies in this area to date. Allowing wages, hours and union status to be jointly determined, they estimate a system of three equations using full-information maximum likelihood. Even though their analysis is certainly more general than others, their assumption of a single wage equation and a single hours equation for both union and nonunion workers is still restrictive.[2] Furthermore, their hours equations are specified as reduced forms rather than structural equations. As Earle and Pencavel (1990) noted, reduced-form hours

[1]Their estimates for union-nonunion annual hours differentials range from 0.2% to 1.8% for white men, 18.3% to 18.4% for white women, 5.3% to 7% for nonwhite men, and 4.2% to 6.6% for nonwhite women. These estimates are further broken down by industry and occupation. See table 4 in their paper (p165) for details.

[2]Even though Perloff and Sickles (1987) include complete interaction terms between explanatory variables and union status in the wage equation, their specification of a single wage equation for both union and nonunion workers is still restrictive in that they assume the error term in the union wage equation to have the same variance as the error term in the nonunion wage equation. This is inconsistent with what Freeman (1980,1982) and others have found previously.

equations make it difficult to separate the pure union hours effects from the union hours effects resulting from union wage effects.

The model developed in this chapter is more general than others in the area. The generalization is achieved in three main ways. First, separate wage and hours equations are specified for union and nonunion sectors. Hence, our model allows for different mechanisms in determining wages and hours between the two sectors and also allows for differences in the distributions of union and nonunion wages and hours. Second, the hours equations are specified as structural equations rather than specified as reduced forms. The advantage of this specification is that pure union hours effects can be separated out from union effects on hours which arise because of the union wage effects. Finally, a separate participation equation is used to take account of the censoring on wages and hours. This specification is more general than the Tobit specification used by Perloff and Sickles.

This chapter also presents a new way of decomposing union-nonunion hours differentials. In previous studies union-nonunion hours differentials are calculated either from estimates of reduced-form hours equations or from estimates of structural hours equations. The first type of hours differentials can be thought of as total hours differentials since the hours differentials include union wage effects on hours, and the second type can be thought of as pure hours differentials. Unfortunately, these two types of hours differentials have not been linked in a systematic way. This chapter shows how one can decompose total hours differentials as the sum of pure hours differentials and derived hours differentials which result from the union and/or employer's hours adjustment to union-nonunion wage differentials. By doing this, we will have a better understanding of the nature of union-nonunion hours differentials.

This chapter presents several interesting empirical findings. First, there is mixed evidence for union-nonunion hours differentials for males. The selectivity-unadjusted estimates for union hours differentials for males are found to be negative and statistically significant as most of the U.S. research has found. However, the differentials become statistically insignificant when the extended Heckman-Lee 2SLS estimation method is used and become even positive and statistically significant when full information maximum likelihood is used. Therefore, negative estimates for union hours differentials for males obtained by previous studies are not robust to more general estimation methods. On the other hand, union-nonunion hours differentials for females are found to be positive in all three methods and statistically significant except for the extended Heckman-Lee 2SLS method. Our obtained positive union-nonunion hours differentials for females are consistent with Earle and Pencavel's (1990) findings for females in the United States.

The second main result presented in this chapter is that additional hours worked by better educated and more experienced workers are larger in the union sector than in the nonunion sector. Specifically, education and experience account for 51% of the positive union-nonunion hours differential for males and 33% of the positive pure hours differential for females.[3] This result is interesting since returns to education and experience are usually lower in the union sector. This phenomenon may occur if employers in the union sector favour better educated and more experienced workers because they pay less for education and experience than their counterparts in the nonunion sector.

The third new finding presented in this chapter is positive and statistically significant correlations between the error terms in union wage equations and the error terms in union hours equations for both males and females. To the extent that the error terms in wage equations reflect unmeasured workers' abilities, the positive correlation in the union sector implies that more able workers work more hours in the union sector. This finding is also consistent with the hypothesis that employers in the union sector have an incentive to extract more hours from more able workers.

In addition, this chapter discusses how the size of male-female wage differentials might

[3]The figures are obtained from maximum likelihood estimates. See section 3.7.5 for the details.

change if maximum likelihood estimates instead of least squares estimates are used, how an increase in female union density affects male-female earnings differentials and whether or not unions reduce the dispersions of wages and hours.

The organization of this chapter is as follows. In Section 3.2, I briefly review previous studies of the union-nonunion hours differential. Section 3.3 lays out the econometric model. The data, variables and descriptive statistics are described in Section 3.4. Section 3.5 presents union-nonunion wage, hours and earnings differentials based on selectivity-unadjusted estimates. Here, I also propose alternative ways to measure union-nonunion hours differentials. Section 3.6 reports the results obtained from selectivity-adjusted estimates. Section 3.7 discusses the full information maximum likelihood estimates of the system of six equations. Union-nonunion differentials in wages, hours and earnings obtained from maximum likelihood are also presented in this section. Section 3.8 discusses three related issues to which our results may be applied. Section 3.9 briefly summarizes the results and contains concluding remarks. Finally, the specification of the likelihood function, derivation of variances and tables are presented in Appendices C-F.

3.2 A Brief Review of Previous Studies on the Union-Nonunion Hours Differential

As discussed in the introduction, empirical studies of the impact of unions on hours of work present quite different estimates for the union- nonunion hours differential, mainly due to differences in both model specification and data. Table 3.1 illustrates the range of estimates of the hours differential found in previous studies (Note: WH denotes weekly hours, AH annual hours and AW annual weeks).[4] Column 3 in table 3.1 indicates the

[4]Study 3 in table 3.1 estimated an hours equation similar to specification (3.2), but the union variable was measured as the fraction of unionized workers to the total number of employees in a city. Then the union-nonunion hours gap was calculated as the hours gap resulting from one standard deviation increase in the union variable. The union-nonunion hours differentials for study 1 and 4 are obtained

specification of the hours equation which takes one of the following forms:

$$H_i = X_i\Delta + \alpha U_i + e_i \tag{3.1}$$

$$lnH_i = X_i\Delta + \alpha U_i + e_i \tag{3.2}$$

$$lnH_i = X_i\Delta + \alpha U_i + \gamma lnW_i + e_i \tag{3.3}$$

where X_i is a 1xK row vector of exogenous variables, Δ a Kx1 column vector of parameters, U_i the union status dummy (U_i=0,1), W_i the hourly earnings, α and γ the coefficients of U_i and W_i respectively, and e_i the error term.

Although estimates of the union-nonunion hours differential vary considerably from study to study, it seems that unionization reduces hours of work at least for male workers.[5] In table 3.1, 7 out of 9 studies show that unionization has a negative impact on hours of work for males.

For males, estimated union-nonunion annual hours differentials (AH) range from -10% to 7% with an average of -2%, estimated union-nonunion weekly hours differentials (WH) range from -7% to 2.4% with an average of -3.2%, and estimated union- nonunion annual weeks differentials (AW) range from 1.1% to 4.6% with an average of 2.9%. Study 2 is the only study I am aware of measuring the union-nonunion hours differential for females. Estimated female union-nonunion hours differentials in study 2 are positive in all categories and quite large, especially for white females.

Although equations (3.1)-(3.3) are the specifications commonly used in the literature to measure the union-nonunion hours differential, least-squares estimates of the union status dummy (U_i) in equations (3.1)-(3.3) may be biased due to endogeneity of the

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by evaluating the hours differentials at the average hours of nonunion workers. Union-nonunion hours differentials for specifications (3.2) and (3.3) are approximately equal to the coefficient of the union status dummy, so I used the estimated coefficient of the union status variable to compute the union-nonunion hours differential for studies 2, 5, 6, 7, 8 and 9.

[5]From the survey on the union-nonunion hours differential, Lewis (1986) also claims that the typical estimate of the union hours differential for male workers is about -1.8%.

determination of union status. Many studies have been concerned with the effects of endogeneity of union status on estimates of union-nonunion wage differentials and have tried to produce consistent estimates by applying sample selection bias procedures (for example, see Lee [1978] and Heckman [1976]). In addition, having the hourly earnings variable (W_i) in the hours equation (3.3) can cause a severe endogeneity problem because (i) the hourly earnings variable is likely to be correlated with the hours of work and (ii) the hourly earnings also depends on union status which is likely to be endogenous.[6]

3.3 The Econometric Model

The econometric model developed in this section has a system of six equations - hourly earnings and weekly hours equations for union and nonunion workers, union status equation and participation equation. The six equations are formally presented below.

The hourly earnings of individual i in the union and nonunion sector is assumed to be determined according to

$$lnW^*_{ui} = Z_{ui}\Gamma^u + e_{1i} \tag{3.4}$$

$$lnW^*_{ni} = Z_{ni}\Gamma^n + e_{2i} \tag{3.5}$$

where lnW^*_{si} is the latent value for the natural log of usual hourly earnings, Z_{si} is a vector of exogenous variables and Γ_s is a vector of corresponding parameters where s=u,n. It is assumed that $e_{1i} \sim N(0, \sigma^2{}_1)$ and $e_{2i} \sim N(0, \sigma^2{}_2)$.

The vectors Z_{ui} and Z_{ni} include age, education, tenure, province, occupation, industry and firm size variables.[7] Therefore, our specifications for union and nonunion wage

[6]There is also a problem of constructing the hourly earnings variable by dividing weekly or annual earnings by the dependent variable (H_i). This problem is well discussed in Borjas (1980).

[7]Several authors (Barzal [1973]; Moffitt [1984]; Altonzi and Paxson [1988]; Biddle and Zarkin [1989]) argue that wages should depend on hours of work for the reason that individuals face some kinds of constrants in choosing hours such as a market earnings locus which is determined by individuals' tastes and firms' production technology and costs. We assume that hours do not enter the wage equations for two reasons. First, the standard specifications for the wage equations in the literature are based on the

Table 3.1: Estimates of the Union-Nonunion Hours Differential in Previous Empirical Studies

	Estimated Gap (%)	Equation	Worker Coverage
1. Dinardo (1991)	-3∼-10 (AH) -4∼-7 (WH)	(3.1)	Male Male
2. Earle and Pencavel (1990)	0.2∼1.8 (AH) -1.1∼-2.1 (WH) 2.3∼3 (AW)	(3.3)	White male
	18.3∼18.4 (AH) 9.4∼10.7 (WH) 7.6∼8.9 (AW)	(3.3)	White female
	5.3∼7 (AH) 1.6∼2.4 (WH) 3.7∼4.6 (AW)	(3.3)	Nonwhite male
	4.2∼6.6 (AH) 3.9∼4.8 (WH) 0.3∼1.8 (AW)	(3.3)	Nonwhite female
3. Montgomery (1989)	-6 (WH)	(3.2)	Workers in SMSAs
4. Perloff and Sickles (1987)	-4 (WH)	(3.1)	Male construction workers
5. Raisian (1983)	0.4 (WH) 1.1 (AW)	(3.2)	Male heads of households Male heads of households
6. Olson (1981)	-5 (WH)	(3.2)	Full-time workers
7. Ichniowski (1980)	-1 (WH)	(3.2)	Fire fighters
8. Ehrenberg (1973)	-2∼-9 (AH)	(3.2)	Fire fighters
9. Ashenfelter (1971)	-7 (WH)	(3.2)	Fire fighters

equations are based on the theory of human capital as well as industrial, occupational and regional wage differentials. Wages in the union sector are known to be determined by job characteristics rather than personal characteristics. Therfore, it is particularly important to include industrial and occupational dummies in the union wage equation. We also include firm size variables in order to allow for threats effects.[8] The fact that wages in the union sector are determined by collective bargaining is reflected in different coefficients between the union and nonunion wage equations.

Following Earle and Pencavel (1990), hours equations include the hourly earnings in order to control for the union wage effects on hours:

$$lnH^*_{ui} = X_{ui}\Delta^u + \gamma^u lnW^*_{ui} + e_{3i} \tag{3.6}$$

$$lnH^*_{ni} = X_{ni}\Delta^n + \gamma^n lnW^*_{ni} + e_{4i} \tag{3.7}$$

where lnH^*_{si} is the latent value for the natural log of usual hours worked per week[9], X_{si} is a vector of exogenous variables, Δ^s is a corresponding vector of parameters and γ^s is a coefficient of the hourly earnings, where s=u,n. Similarly, I assume that $e_{3i} \sim N(0, \sigma^2{}_3)$ and $e_{4i} \sim N(0, \sigma^2{}_4)$.

The vectors X_{ui} and X_{ni} include variables related to family backgrounds and all the variables appearing in the wage equations except firm size dummies. We exclude firm size dummies in the hours equations for identification.[10] If hours equations represent labour supply curves, excluding firm size dummies seems to be a natural choice since

human capital theory, and we want to compare the union wage differentials obtained from the standard specifications with those obtained from our joint estimation. Second, it is difficult to think that union workers also face those kinds of constraints since wages and hours in the union sector are determined by collective bargaining. For this reason we choose not to include the hours in the wage equations.

[8]It is generally believed that employers in larger nonunionized firms have higher probability of being unionized and hence, may pay higher wages to their employees to prevent unionization.

[9]I chose hours per week as a dependent variable since unions and firms quite often negotiate over hours per week in collective bargaining (see for example Clark and Oswald [1993]).

[10]Firm size dummies measure the number of employees in all locations in Canada. See Appendix Table F.1 for definition.

they are demand side variables. However, if hours equations represent the contract curve or possibly the demand curve, which might be true in the union sector, the firm size dummies could enter the hours equations if one wants to control for employment in the hours equations. In this case we expect the sign of firm size dummies to be negative since hours and employment are generally considered to be substitutes in production. The problem is that our data set does not provide information on employment at the locations where individuals work. Therefore, it is difficult to think that having the firm size variables will capture the possible substitutability between hours and employment. To test this, we have run (3.6) and (3.7) with the firm size variables and also have run the reduced-form hours equations. We found that all the coefficients on the firm size variables are statistically insignificant for both male union and nonunion workers and positive for female union and nonunion workers which contradicts our expectations.[11] Therefore, we choose not to include the firm size dummies in the hours equations.

We assume the hours in the nonunion sector are mainly determined according to the worker's labour supply schedule. The coefficient on the wage rate (γ^n) in the nonunion hours equation can be positive, negative, or zero depending on the magnitudes between income and substitution effects. On the other hand, hours in the union sector may be determined by the employer's response to the union's wage increase (monopoly union model) or by a joint agreement on wages and hours between the two parties (efficient contracts model) which may reflect both supply and demand sides of hours. In the first case the union hours equation will represent the demand for hours and in the second case it will represent a contract curve. Since we are unable to distinguish between the two, the union hours equation is assumed to include both possibilities. The coefficient on the wage rate (γ^u) in the union hours equation may also be positive, negative, or zero. In particular, the negative coefficient on the wage rate does not necessarily indicate that

[11]Actual estimates are available upon request.

the union hours equation represents the demand for hours since the contract curve may well have a negative slope. This possibility has been shown in the previous chapter.

It is desirable to include fixed costs in hours equations. Unfortunately, the data set we use does not provide information on such costs. One way to circumvent this problem is to think that some of the fixed costs can be captured by occupation and industry. For example, employers in the service sector may face small fixed costs relative to those in the manufacturing sector and hence, workers in the service sector may work less than their counterparts in the manufacturing sector. In such a case, we can indirectly control for fixed costs in hours equations.

Let U_i be an indicator variable which equals one if individual i is in the union sector and zero otherwise, then the determination of union status may be put in a standard probit form:

$$U_i = \begin{cases} 1 & if U_i^* \geq 0, \\ 0 & otherwise. \end{cases} \tag{3.8}$$

and

$$U_i^* = Q_i \Lambda + e_{5i} \tag{3.9}$$

where Q_i is a vector of exogenous variables and Λ is a vector of corresponding parameters. Note that the latent variable U_i^* captures the utility gain from joining the union and also the firm's selection based on productivity. Since the utility gain from joining the union is likely to depend on the union-nonunion wage and hours differentials, Q_i is assumed to include all the variables in Z_i and X_i. Equations (3.8)-(3.9) are a typical probit model. After normalizing the variance of e_{5i}, ${\sigma^2}_5$, to be unity, we can obtain consistent estimates for Λ by probit estimation.

Finally, since hourly earnings and weekly hours are observed only for the employed, we specify a participation equation to correct for censoring.

$$P_i = \begin{cases} 1 & if P_i^* \geq 0, \\ 0 & otherwise. \end{cases} \tag{3.10}$$

and

$$P_i^* = S_i\Phi + e_{6i} \tag{3.11}$$

where P_i^* is the latent variable which measures the utility gain from entering labour force. In other representations, P_i^* may measure the difference between desired hours and reservation hours or the difference between desired hours and minimum hours required by firms.[12] S_i is a vector of exogenous variables which include personal characteristics and Φ is a vector of parameters. Equations (3.10) and (3.11) are also a typical probit model. We will normalize the variance of e_{6i}, $\sigma^2{}_6$, to be unity for identification.

The likelihood function is based on equations (3.4)-(3.11) and on the assumption of joint normality of the error terms $(e_1, e_2, e_3, e_4, e_5, e_6)$. To estimate equations (3.4)-(3.11), the observations are partitioned into three groups: nonworkers, union workers and nonunion workers. Thus, the likelihood function of any individual i can be written as

$$\begin{aligned} L_i &= (1 - P_i)Pr(e_{6i} < -S_i\Phi) + \\ &P_iU_iPr(e_{1i}, e_{3i}, e_{5i} > -Q_i\Lambda, e_{6i} > -S_i\Phi) + \\ &P_i(1 - U_i)Pr((e_{2i}, e_{4i}, e_{5i} < -Q_i\Lambda, e_{6i} > -S_i\Phi) \end{aligned} \tag{3.12}$$

Note that the likelihood function (3.12) assumes that participation and union status are jointly determined. In other words, it allows for a possibility that some individuals do not participate in the labour market because they have low probability of getting a

[12] Zabel (1993) tests several participation specifications and concludes that the general form like equations (3.10)-(3.11) performs better than others in explaining labour supply decisions.

job in the union sector. One can construct a more restricted likelihood function in which union status is realized only after individuals participate. However, such a model should be tested rather than assumed. Our specification allows for testing such a model.

The specification of the likelihood function is done by rewriting a four variate normal density function as the product of a bivariate normal distribution function and a bivariate normal density function.[13] A complete specification of the likelihood function is presented in Appendix C. The variance-covariance matrix for the estimated parameters is formed using the outer product of first partial derivative matrix.

The specifications of the hourly earnings and weekly hours equations are commonly seen in the labour supply literature. The identification of parameters in the system requires either (1) independence between wages and hours or (2) having at least one variable in the hourly earnings equations that is not in the hours equations. In our specification firm size variables are included in the hourly earnings equations but not in the weekly hours equations, so correlation coefficients between the error terms as well as the parameter vectors in equations (3.4)-(3.11) can be estimated by maximizing the likelihood function (3.12).

3.4 Data

3.4.1 General Description

The basic sample of individuals used to estimate our model is drawn from the 1990 Labour Market Activity Survey (LMAS) which is a supplement to the January 1991 Labour Force Survey (LFS). The 1990 LMAS provides demographic information for all individuals interviewed at the reference week (the first week of 1991) and weekly retrospective information on up to 5 jobs that individuals held in 1990. For the cross-sectional

[13] Even if our model is based on a six variate normal distribution, estimation of the likelihood function requires only a four variate normal distribution. This is evident from equation (3.12).

analysis I use the information on the jobs held by individuals at the last week of April 1990. This choice is made to reduce seasonality and to make my data set comparable with other cross-sectional data sets such as the U.S. Current Population Survey (CPS).[14] In cases where individuals have more than one job at that week, I use the information on the job with most hours worked per week (main job).[15]

The initial sample consists of observations on 63,007 individuals with 30921 males and 32086 females. However, I make the following deletions for estimation. First, I exclude people who are younger than age 20 and older than age 65, full-time students and disabled people. Second, I exclude the people whose main jobs are classified as self-employed, unpaid family workers or farmers.[16] Third, I delete individuals with missing data on firm size variables. A detailed table showing the selection criteria employed is given in Appendix Table F.3.

After the deletions the total sample consists of 13374 male workers, 2586 male non-workers, 11904 female workers and 7197 female non-workers. For estimation I extract a 25% random sample of each group, so there are 3344 male workers, 647 male non-workers, 2976 female workers and 1799 female non-workers in the random sample.[17]

The public use 1990 LMAS does not have a class of worker variable, i.e., the public sector dummy.[18] This could be a drawback since the public sector dummy is known to be a very important variable in both earnings and union status equations.[19] Fortunately,

[14]For example, Earle and Pencavel (1990) used the May 1979 CPS.

[15]Out of 63007 individuals, 2824 people (4.5%) had more than one job at the last week of April 1990. A similar sample selection is made in Earle and Pencavel (1990) and DiNardo (1991).

[16]Here, farmers are the people in the agricultural industry or people reporting their occupation as farmers.

[17]Using the whole sample is not a problem for least squares estimation. However, it is very time-consuming and expensive for maximum likelihood estimation. For this reason, I was forced to use a random sample.

[18]The definition of public sector is based on whether the employing enterprise is owned by government. This includes various public services and crown corporations as well as federal, provincial and municipal administrations.

[19]For example, Robinson and Tomes (1984), Gyourko and Tracy (1988) and more recently Gunderson

the class of worker variable has been added in the public use 1990 LMAS by the special request to Statistics Canada. Hence, the data set used in this chapter has this additional information.

Appendix Table F.1 provides definitions of the variables and Appendix Table F.2 provides sample means by gender, union status and participation. The data on unemployment rates by sex and province for April 1990 are extracted from the CANSIM. The tenure variable is constructed using information on "When did...start working on this job?". Thus, the tenure variable is intended to measure experience on the current job. The firm size variables measure the number of employees in all locations in Canada.

3.4.2 Descriptive Statistics on Variables

Examination of Appendix Table F.2 indicates that for both male and female workers differences in personal characteristics do not appear to be significant between the union and nonunion sectors, except that a greater portion of females have university degrees in the union sector. However, there appear to be sizable differences in tenure, industry, type of employment and the size of the firm. For example, a greater portion of union workers have longer tenure, work in non-service industries, are employed in the public sector and work in larger firms.

The differences in personal characteristics between workers and nonworkers come from age, education and the number of children of age under 5. Both male and female nonworkers are relatively older and have lower education. Also, as expected, the presence of young children is correlated with female participation and provincial unemployment rates affect both male and female participation.

Table 3.2 reports descriptive statistics on hourly earnings, weekly hours and weekly

and Riddell (1993) have shown that there is a significant wage differential between the private and public sectors. They have also detected a significant and positive correlation between union status and the employment in the public sector.

earnings for males in several key sectors.[20] The average union-nonunion hourly earnings differential is about 15%. As expected, the hourly earnings differential is larger for males in the construction industry, for blue collar workers and for part-time workers. The average union-nonunion hours differential is about -5%. Apart from part-time workers, union workers work fewer hours than nonunion workers. Finally, the average union-nonunion weekly earnings differential is about 9%, which is smaller than the average union-nonunion hourly earnings differential. Therefore, uncontrolled union-nonunion earnings differentials for males become smaller if one uses weekly earnings instead of hourly earnings as a measure of the differential. In addition, hours as well as earnings are less dispersed in the union sector than in the nonunion sector. This indicates that the earnings inequality within the union sector is smaller than the earnings inequality within the nonunion sector.[21]

The means and standard deviations of the earnings and hours for females are presented in Table 3.3. The average union-nonunion hourly earnings differential is about 35% for females. Like males, the part-time workers gain a lot from unionization. The average union-nonunion weekly hours differential is small but positive, so the average union-nonunion weekly earnings differential becomes a bit greater than the average hourly earnings differential. This means that the uncontrolled union-nonunion earnings differential increases if union effects on hours are taken into account. Lastly, for females, the dispersion of hours is smaller, but the dispersion of earnings is larger in the union sector

[20] Sample sizes by gender and sector are reported in Appendix Table F.4. Also, note that the measures for hourly earnings and weekly hours are the "usual hourly earnings ($)" and "usual hours worked per week" respectively. The weekly earnings is the product of the two. The figures in parentheses are sample standard deviations. The columns "%" denote union-nonunion differentials.

[21] For approximation we have calculated four Lorenz ordinates. In the union sector, the bottom 25% of the total workers earn 15.4% of total earnings, 50% earn 39.4%, and 75% earn 65.4%. In the nonunion sector, the bottom 25% earn 11.7% of the total earnings, 50% earn 34.9%, and 75% earn 59.2%. Therefore, it is reasonable to conclude that earnings inequality is smaller in the union sector than in the nonunion sector.

Table 3.2: Descriptive Statistics on Hourly Earnings, Weekly Hours and Weekly Earnings by Sector for Males in 1990

	Hourly Earnings			Weekly Hours			Weekly Earnings		
Sector	Union	Nonunion	%	Union	Nonunion	%	Union	Nonunion	%
Manufact	16.04	16.12	-0.55	40.44	41.55	-2.67	642.65	669.45	-4.00
	(4.4)	(8.3)		(5.3)	(6.5)		(173.0)	(356.6)	
Construct	19.52	13.89	40.56	41.71	45.45	-8.24	811.64	638.49	27.12
	(6.4)	(5.5)		(8.9)	(12.2)		(314.8)	(334.9)	
OtherInd	18.00	15.09	19.22	39.97	42.38	-5.69	716.84	629.77	13.83
	(6.3)	(8.4)		(8.1)	(12.4)		(278.9)	(391.6)	
BlueColr	16.86	13.00	29.71	40.98	42.95	-4.57	687.69	557.28	23.40
	(5.4)	(5.5)		(7.4)	(9.7)		(247.8)	(263.9)	
Mgr/Prof	20.17	19.51	3.40	39.51	42.72	-7.51	793.22	826.74	-4.05
	(6.8)	(9.4)		(8.2)	(11.7)		(303.4)	(453.5)	
OtherOcc	16.78	13.02	28.87	39.78	42.29	-5.94	666.23	535.10	24.51
	(5.6)	(7.3)		(7.9)	(13.0)		(231.5)	(314.0)	
FullTime	17.61	15.38	14.49	41.01	43.59	-5.91	718.24	662.69	8.38
	(5.9)	(8.1)		(6.7)	(10.3)		(256.0)	(374.0)	
PartTime	17.79	13.39	32.88	23.44	16.78	39.74	425.87	202.17	110.65
	(7.5)	(8.8)		(13.5)	(8.9)		(292.8)	(140.6)	
Private	16.73	15.09	10.90	40.72	42.82	-4.89	680.56	641.17	6.14
	(5.6)	(8.1)		(7.8)	(10.8)		(261.7)	(378.7)	
Public	19.06	18.69	1.96	39.85	41.01	-2.84	752.17	739.52	1.71
	(6.1)	(8.3)		(7.5)	(17.4)		(259.1)	(352.4)	
Total	17.62	15.31	15.03	40.39	42.70	-5.41	707.84	647.39	9.34
	(5.9)	(8.2)		(7.7)	(11.3)		(262.9)	(377.8)	

Table 3.3: Descriptive Statistics on Hourly Earnings, Weekly Hours and Weekly Earnings by Sector for Females in 1990

	Hourly Earnings			Weekly Hours			Weekly Earnings		
Sector	Union	Nonunion	%	Union	Nonunion	%	Union	Nonunion	%
Manufact	10.76	10.57	1.78	37.19	38.34	-3.01	403.98	405.57	-0.39
	(4.1)	(4.6)		(6.6)	(8.7)		(174.4)	(203.5)	
Construct	12.96	10.60	22.21	47.30	33.64	40.58	699.52	359.83	94.40
	(4.4)	(3.6)		(30.7)	(9.3)		(569.7)	(169.1)	
OtherInd	15.38	10.93	40.72	34.28	34.23	0.14	531.61	372.00	42.91
	(5.9)	(5.8)		(9.3)	(11.2)		(257.0)	(221.6)	
BlueColr	10.56	8.65	22.06	37.92	39.42	-3.79	406.87	345.30	17.83
	(3.8)	(3.1)		(8.3)	(10.4)		(178.7)	(172.8)	
Mgr/Prof	17.61	13.62	29.27	34.43	36.74	-6.29	609.82	492.00	23.95
	(6.3)	(6.4)		(10.0)	(9.3)		(279.5)	(248.7)	
OtherOcc	12.60	9.82	28.37	34.20	33.10	3.32	435.11	322.80	34.79
	(4.1)	(4.9)		(8.1)	(11.5)		(187.7)	(184.1)	
FullTime	14.94	11.06	35.16	38.55	39.18	-1.62	575.04	431.21	33.36
	(5.6)	(5.1)		(5.0)	(7.0)		(229.5)	(207.9)	
PartTime	13.94	10.28	35.55	21.68	18.87	14.91	303.63	181.11	67.66
	(6.7)	(7.1)		(8.1)	(7.4)		(206.3)	(125.7)	
Private	13.10	10.66	22.96	34.57	34.78	-0.62	455.94	370.04	23.21
	(5.2)	(5.3)		(9.1)	(10.9)		(230.7)	(209.8)	
Public	16.60	14.12	17.58	34.98	33.24	5.24	582.08	458.65	26.91
	(6.1)	(8.5)		(9.2)	(12.9)		(257.8)	(312.1)	
Total	14.72	10.88	35.21	34.76	34.68	0.22	514.06	375.81	36.79
	(5.9)	(5.6)		(9.1)	(11.0)		(251.5)	(218.9)	

Table 3.4: Union-Nonunion Hours Differentials Estimated from Equations (3.1)-(3.3)

Equation	Male Workers (%)	Female Workers (%)
(3.1)	-3.65(-3.81)	-0.33(-0.23)
(3.2)	-3.56(-2.93)	3.15(1.65)
(3.3)	-2.90(-2.38)	3.05(1.53)

than in the nonunion sector.[22]

3.5 Selectivity-Unadjusted Estimates

3.5.1 Union Status Dummy Models

For comparison with union-nonunion hours differentials obtained by previous U.S. studies I begin by estimating the hours equations (3.1)-(3.3) described in section 2.[23] Table 3.4 reports the estimated union-nonunion hours differentials.[24] The estimates for males in table 3.4 are quite consistent with the previous estimates presented in table 3.1: males in the union sector work fewer hours per week than males in the nonunion sector. For females, the union-nonunion hours differential is positive and significant at better than 0.2 level when specifications (3.2) and (3.3) are used, but it becomes insignificant when specification (3.1) is used. For females, only specification (3.3) has been used previously, i.e., by Earle and Pencavel (1990). Therefore, we can only compare our estimate from specification (3.3) with Earle and Pencavel's. Although our estimate from specification

[22] I am not aware of any study which examines the difference of wage dispersions between females in union and nonunion sectors. Therefore, at this point, I am unable to compare my finding with others.

[23] The X variables used in the regressions are similar to those employed by Earle and Pencavel (1990) except I include provincial unemployment rates as Perloff and Sickles (1987) do. The omission of unemployment rates does not change qualitative results. The actual regressors (X) are shown in Appendix Table F.6.

[24] Union-nonunion hours differentials obtained from equation (3.1) are calculated evaluating at mean hours of nonunion workers. Union-nonunion hours differentials obtained from equations (3.2) and (3.3) are obtained by $(e^{\alpha} - 1) \cdot 100$. The figures in parentheses are t-ratios.

(3.3) is a bit smaller than the average estimate of Earle and Pencavel, both estimates indicate that females in the union sector work more hours per week than their nonunion counterparts.

As mentioned earlier, specifications (3.1)-(3.3) are too restrictive and may be subject to the endogeneity problems since union staus and wages are possibly correlated with the error terms in the hours equations. We will correct these problems one by one in the subsequent sections.

3.5.2 Selectivity-Unadjusted Estimates of Hourly Earnings and Weekly Hours Equations

In this section we turn to more general specifications of the hours equations where hours equations are specified separately for the union and nonunion sectors. Ths OLS and 2SLS estimates of equations (3.6)-(3.7) for males are presented in Appendix Table F.6.[25] The most significant difference between the two sets of estimates is on the coefficient of the hourly earnings. In the OLS case, the coefficient on the hourly earnings is negative and significant for nonunion workers whereas in the 2SLS case it is negative and significant for union workers.[26] Provided that the selection bias is not serious, the 2SLS estimates are consistent but the OLS estimates are not, especially in the union sector where wage and hours might be determined jointly. The positive coefficient on the hourly earnings for nonunion workers indicates an upward-sloping labour supply curve. This result seems to contradict the backward bending labour supply curve often found in the literature on the male labour supply. Note however that previous studies on labour supply have not distinguished between union and nonunion sectors. To compare with previous estimates

[25]The predicted wage, $ln\hat{W}$, is used as an instrument for lnW in 2SLS estimation.

[26]It is not uncommon to see that the sign of the estimated coefficient on the wage variable in hours equations changes when the predicted value is used. For example, Vella (1993) obtains a negative coefficient on the wage variable in hours equations when actual wage rates are used but obtains a positive coefficient when the predicted values are used instead.

of labour supply elasticities, I pooled the two sectors and estimated the hours equation. The estimated labour supply elasticity with respect to the wage was found to be -0.065 but it was not significant at the 0.1 level. The positive and statistically significant elasticity obtained for the nonunion sector disappears when we do not separate the two sectors. On the other hand, the coefficient on the hourly earnings for union workers is found to be -0.008 and significant at the 0.2 level. One should not however interpret the figure as a labour supply elasticity since one of the results in the previous chapter is that hours in the union sector are not determined by the worker's labour supply schedule.[27] The negative coefficient for union workers may imply that employers in the union sector react to a wage increase by reducing the number of hours of work or may just depict a negative sloping contract curve between wages and hours. In sum, the previous estimates of the labour supply elasticity are misleading since the differences in determining hours between union and nonunion sectors are not taken into account in estimation.

One unexpected result seen in Appendix Table F.6 is that the coefficient on male heads in the union sector is negative and significant. To the extent that being a head reflects a family responsibility, we expect the sign of the head variable to be nonnegative. However, the unexpected sign may well be due to the non-ramdomness of sample selection. In fact, as we will see later, this coefficient becomes insignificant when sample selection problems are corrected.[28]

First, personal tastes and incentives can affect the coefficients for both union and nonunion males. Second, the coefficients on education and tenure in the union sector can be determined by the firm's selection as well as taste factors. The 2SLS estimates on high education for nonunion males are all negative while the corresponding estimates for

[27]In chapter 2 we showed that the wage rate is greater than the marginal rate of substitution of income for leisure at the equilibrium in the union sector.

[28]The insignificant coefficient on the male union heads may be due to the fact that a large portion of the male union workers are head of family so that hours are insensitive to being a head.

union males are all positive. [29] Although this pattern is not so evident for tenure, the 2SLS estimate on tenure 11 to 20 years is negative and significant for nonunion males. From these estimates, we can say that males with high education and longer tenure in the nonunion sector work less, but those in the union sector work more. More importantly, we can see that the coefficients on high education and longer tenure for the union males are consistently larger than those for nonunion males. There are two possible reasons for why union workers with high education and longer tenure might work more. If education and tenure measure the worker's productivity, both the demand and contract curves will shift to the right as the level of education and/or tenure rise. Therefore, we would expect that hours increase with education and tenure at the same wage rate. Another possibility is that employers in the union sector may have an incentive to extract more hours from better educated and more experienced workers since return to education and tenure is generally lower in the union sector than in the nonunion sector.[30] These two factors can also explain why the coefficients on education and tenure are larger for union males than nonunion males.

Concerning industry and occupation, there appears to be no significant pattern between union and nonunion males. In both sectors, workers in the service industry tend to work fewer hours than those in the manufacturing industry. [31] This result provides some evidence for that fixed costs of employment may be smaller in the service sector and hence, workers in that sector work less holding other things constant. The public sector employees are seen as working a shorter workweek than the private sector employees in both union and nonunion sectors.

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[29]This pattern is also true in the OLS estimates.

[30]This explanation make sense more in the monopoly union model than in the efficient contracts model. The coefficients on the wage rate in the hours equations are negative for both males and females. However, we cannot say that the hours equations represent demand for hours since the contract cuve may also have a negative slope. We need more information to reach a solid conculsion.

[31]Note that manufacturing sector is the omitted sector. See Appendix F for detailed information on our base person.

Next, the OLS and 2SLS estimates of the hours equations for females are presented in Appendix Table F.7. Like males, the coefficients on the hourly earnings change significantly and the sign of the coefficients is reversed when the 2SLS estimation is used. In the 2SLS case, the coefficient on the hourly earnings is 0.036 and significant at the 0.01 level for nonunion females. This result is consistent with previous estimates of labour supply elasticity for females when sample selection bias is not corrected. However, some researchers (for example, Nakamura, Nakamura and Cullen [1979], Robinson and Tomes [1985] and Smith and Stelcner [1988]) found that the positively sloped labour supply schedule for females disappears when sample selection bias is corrected. We will test their argument in the subsequent sections. For females in the union sector the coefficient on the hourly earnings is -0.001 but insignificant. This pattern is very similar to that of males.

Like males, the coefficients on education and tenure for union females are considerably larger than those for nonunion females. This result is also consistent with the hypothesis that employers in the union sector tend to extract more effort from better educated and more experienced workers.

Finally, the estimates of hourly earnings equations (3.4)-(3.5) are presented in Appendix Table F.5. Since the estimation results are quite familiar to researchers in this area, I just point out that the coefficients on firm size variables are generally larger for nonunion workers than for union workers. This is consistent with the hypothesis that nonunion workers in larger establishments are paid some premium by their employers who try to prevent unionization.

3.5.3 Alternative Methods on Union-Nonunion Differentials

The coefficients obtained from the hourly earnings and hours equations are then used to compute union-nonunion wage and hours differentials for various groups. We compute the wage and hours differentials for group k as:[32]

$$WD_k = \bar{Z}_k(\hat{\Gamma}^u - \hat{\Gamma}^n) \tag{3.13}$$

$$HD_k = \bar{X}_k(\hat{\Delta}^u - \hat{\Delta}^n) + ln\bar{W}_k(\hat{\gamma}^u - \hat{\gamma}^n) \tag{3.14}$$

where $\bar{Z}_k$, $\bar{X}_k$ and $ln\bar{W}_k$ are the vectors of average values for group k, and the estimated coefficients are obtained by the OLS or 2SLS.[33]

Equations (3.13) and (3.14) are the conventional way of measuring union-nonunion differentials. Note that equation (3.14) calculates the union-nonunion hours differential holding the wage rate constant between the two sectors. I will refer to this differential as the pure hours differential since this differential does not include the union effects on hours which rise because of the union wage effects.

It will be also interesting to know the union-nonunion hours differential which includes both the union-nonunion hours differential resulting from union wage effects and the pure hours differential. I will refer this differential as the total hours differential and refer the hours differential resulting from union wage effects as the derived hours differential.

In order to see how the total hours differential may be decomposed as the sum of the pure hours differential and the derived hours differental, we first replace lnW in (3.14) with the predicted value, $ln\hat{W}(Z)$. Now, the predicted hours for union and nonunion workers with characteristics X and Z, but not W, are

$$ln\hat{H}^u(X^u, Z^u) = \hat{\gamma}^u ln\hat{W}^u(Z^u) + X^u\hat{\Delta}^u \tag{3.15}$$

$$ln\hat{H}^n(X^n, Z^n) = \hat{\gamma}^u ln\hat{W}^n(Z^n) + X^n\hat{\Delta}^n \tag{3.16}$$

The total union-nonunion hours differential for group k evaluated at mean characteristics

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[32]Another way to measure the union-nonunion wage (hours) differentials is to calculate the difference in predicted union and nonunion wages (hours), which was used by Lee (1978). I also applied this method, but results are not significantly different from those obtained by our present method.

[33]The variance of WD_k is then calculated as follows: $Var(WD_k) = \bar{Z}_k VC(\hat{\Gamma}^u - \hat{\Gamma}^n)\bar{Z}_k{}'$ where VC(x) is the variance-covariance matrix of x. Similarly, $Var(HD_k) = X\bar{W}_k VC(\hat{\Phi}^u - \hat{\Phi}^n)X\bar{W}_k{}'$ where $X\bar{W}_k = (\bar{X}_k, ln\bar{W}_k)$, $\hat{\Phi}^u = (\hat{\Delta}^u, \hat{\gamma}^u)$ and $\hat{\Phi}^n = (\hat{\Delta}^n, \hat{\gamma}^n)$.

is then

$$\begin{aligned} HD_k &= ln\hat{H}^u(\bar{X}_k, \bar{Z}_k) - ln\hat{H}^n(\bar{X}_k, \bar{Z}_k) \\ &= \hat{\gamma}^u \bar{Z}_k \hat{\Gamma}^u + \bar{X}_k \hat{\Delta}^u - \hat{\gamma}^n \bar{Z}_k \hat{\Gamma}^n - \bar{X}_k \hat{\Delta}^n \\ &= \hat{\gamma}^u \bar{Z}_k \hat{\Gamma}^u + \bar{X}_k \hat{\Delta}^u + \hat{\gamma}^u \bar{Z}_k \hat{\Gamma}^n - \hat{\gamma}^u \bar{Z}_k \hat{\Gamma}^n - \hat{\gamma}^n \bar{Z}_k \hat{\Gamma}^n - \bar{X}_k \hat{\Delta}^n \\ &= \bar{X}_k(\hat{\Delta}^u - \hat{\Delta}^n) + (\hat{\gamma}^u - \hat{\gamma}^n)\bar{Z}_k \hat{\Gamma}^n + \hat{\gamma}^u \bar{Z}_k(\hat{\Gamma}^u - \hat{\Gamma}^n) \end{aligned} \quad (3.17)$$

The sum of the first two terms of the last line is another measure of the pure union-nonunion hours differential. The main difference between the pure hours differential measured by (3.14) and that measured by (3.17) is that the former uses the average wage rate of all workers in group k while the latter uses the average wage rate of nonunion workers in group k in calculation. The last term of (3.17) represents the derived union-nonunion hours differential. As mentioned earlier, this derived hours differential measures the employer and union's hours adjustment to wage increases in the union sector.[34]

Union-nonunion earnings differentials is defined by the sum of the union-nonunion wage differentials and the union-nonunion hours differentials. In principle, union-nonunion earnings differentials can be obtained either by the sum of (3.13) and (3.14) or by the sum of (3.13) and (3.17). However, we prefer the latter since it seems more sensible to treat wages as endogenous in calculating earnings differentials. Finally, the parameters in equation (3.13) are obtained by OLS and the parameters in equations (3.14)-(3.17) are obtained by 2SLS. The variances of the pure, derived and total hours differentials measured by (3.17) are obtained by the δ-method.

[34]Note that equation (3.17) can be alternatively expressed as $HD_k = \bar{X}_k(\hat{\Delta}^u - \hat{\Delta}^n) + (\hat{\gamma}^u - \hat{\gamma}^n)\bar{Z}_k\hat{\Gamma}^u + \hat{\gamma}^n \bar{Z}_k(\hat{\Gamma}^u - \hat{\Gamma}^n)$. In this case, the derived differential is the average nonunion worker's labour supply response to the union-nonunion wage differential. Equation (3.17) is adopted here since the interpretation of the derived differential is more natural. In both specifications, the derived differential is very sensitive since the sign of the derived differential totally depends on the sign of $\hat{\gamma}^u$ (or $\hat{\gamma}^n$). This may be a shortcoming of the decomposition method used in equation (3.17).

Table 3.5: Union-Nonunion Hourly Earnings, Weekly Hours and Weekly Earnings Differentials by Sector for Males in 1990, Selectivity-Unadjusted

		WH				
Sector	HE	Pure1	Pure2	Derv.	Total	WE
Manufact	0.121	-0.008	-0.007	-0.001	-0.008	0.113
	(0.026)	(0.020)	(0.021)	(.0008)	(0.021)	(0.033)
Construct	0.281	-0.055	-0.053	-0.002	-0.055	0.226
	(0.041)	(0.033)	(0.033)	(0.002)	(0.033)	(0.052)
OtherInd	0.130	-0.013	-0.012	-0.001	-0.013	0.116
	(0.022)	(0.018)	(0.019)	(.0008)	(0.019)	(0.029)
BlueColr	0.178	-0.008	-0.006	-0.001	-0.007	0.170
	(0.021)	(0.017)	(0.016)	(.0007)	(0.015)	(0.027)
Mgr/Prof	0.006	-0.027	-0.027	-.0001	-0.027	-0.020
	(0.026)	(0.024)	(0.024)	(.0004)	(0.024)	(0.036)
OtherOcc	0.228	-0.029	-0.027	-0.002	-0.029	0.199
	(0.029)	(0.025)	(0.025)	(0.004)	(0.025)	(0.038)
FullTime	0.136	-0.018	-0.016	-0.001	-0.018	0.118
	(0.017)	(0.015)	(0.014)	(.0007)	(0.015)	(0.022)
PartTime	0.206	-0.035	-0.033	-0.002	-0.035	0.172
	(0.020)	(0.017)	(0.017)	(0.002)	(0.017)	(0.026)
Private	0.145	-0.043	-0.042	-0.001	-0.043	0.102
	(0.017)	(0.015)	(0.016)	(.0007)	(0.015)	(0.023)
Public	0.110	0.077	0.079	-0.001	0.078	0.188
	(0.044)	(0.031)	(0.031)	(.0008)	(0.031)	(0.054)
Total	0.138	-0.018	-0.017	-0.001	-0.018	0.120
	(0.016)	(0.014)	(0.015)	(.0007)	(0.014)	(0.022)

3.5.4 Hourly Earnings, Weekly Hours and Weekly Earnings Differentials

Table 3.5 reports the union-nonunion differentials for males.[35] The union-nonunion hourly earnings differentials reported in table 3.5 reflect standard findings. That is, a larger earnings gain in the union sector falls to workers in the construction industry,

[35]In table 3.5, HE=Hourly Earnings, WH=Weekly Hours, WE=Weekly Earnings. Pure1 and Pure 2 are obtained by equations (3.14) and (3.17) respectively. Derv. and Total are the derived and total hours differentials respectively. The standard errors for the hours and earnings differentials are obtained using the δ-method and reported in parentheses.

blue collar workers and part-time workers while workers with high-paid jobs such as managers or professionals gain little in the union sector. This result provides some evidence for the hypothesis that earnings inequality among workers is smaller in the union sector than in the nonunion sector.

Pure union-nonunion hours differentials measured by equation (3.14), i.e., Pure1, are generally negative, which means unionized male workers work less than nonunionized male workers if they have the same characteristics and receive the same wage rate. The hours gap is about -2% on average. Two interesting results are shown with the pure hours differential. First, unionization reduces weekly hours for part-time workers as well as for full-time workers. The fact from raw data that part-time male workers in the union sector work 40% more than their counterparts is not due to unionism but due to differences in characteristics of the workers between the two sectors. Second, there is a significant difference between unions in the private sector and unions in the public sector in terms of their effects on hours. Unionization has a negative impact on hours in the private sector while it has a positive impact in the public sector.

Pure2 in table 3.5 reports pure union-nonunion hours differentials obtained from using a decomposition term in equation (3.17). Comparing Pure1 estimates with the Pure2 estimates, one can immediately notice that the two sets of figures are very close, although Pure2 estimates are generally less precisely estimated in the sense that Pure2 estimates are obtained using fitted values of wage rates. Our proposed measure of the pure union hours differential (Pure2) appears to be a good approximation for the conventional measure of the pure union hours differential (Pure1).

On average, the derived union-nonunion hours differential is -0.1% and significant at the 0.2 level. Hence, there is some evidence that a part of the union hours differentials are due to union effects on wages. Total union-nonunion hours differentials still indicate that union workers in the private sector work less than their counterparts while the opposite is true in the public sector. As for the economy, total union-nonunion hours differential is -2%.

Finally, union-nonunion weekly earnings differentials are positive and significant. However, the union-nonunion weekly earnings differentials are systematically smaller than union-nonunion hourly earnings differentials except for the public sector. This is a new finding which previous literature has not addressed. An implication of this result is that the earnings inequality between union and nonunion workers is in fact smaller if we look at weekly earnings rather than hourly earnings.

Next, the union-nonunion hourly earnings, weekly hours and weekly earnings differentials for females are reported in table 3.6. From the estimates in the table, one can see striking differences between males and females. Unlike males, female union workers work more than their counterparts. Furthermore, pure union-nonunion hours differentials are positive and significant at the 0.05 level whereas derived union-nonunion hours differentials are not significant. As a result, average total hours differential is about 6% and significant at the 0.05 level. Union-nonunion earnings differentials are now bigger than union-nonunion wage differentials, which indicates an increase in inequality between union and nonunion females if inequality is measured by weekly earnings rather than hourly earnings.

One may think that females with a strong attachment to the labour market and high taste for work may prefer employment in the union sector since jobs in the union sector are usually "full-time" jobs and protected by unions from arbitrary dismissal by employers. If this is true, even the 2SLS estimates will not be consistent due to the problem of a non-random sample. For this reason, we now turn to selectivity-adjusted estimates.

Table 3.6: Union-Nonunion Hourly Earnings, Weekly Hours and Weekly Earnings Differentials by Sector for Females in 1990, Selectivity-Unadjusted

		WH				
Sector	HE	Pure1	Pure2	Derv.	Total	WE
Manufact	0.085	-0.018	-0.016	-.0001	-0.016	0.069
	(0.039)	(0.044)	(0.044)	(.0008)	(0.044)	(0.059)
Construct	0.420	0.009	0.009	-.0004	0.009	0.429
	(0.228)	(0.300)	(0.225)	(0.003)	(0.300)	(0.343)
OtherInd	0.120	0.068	0.070	-.0001	0.070	0.190
	(0.019)	(0.023)	(0.023)	(.0008)	(0.023)	(0.030)
BlueColr	0.170	-0.009	-0.006	-.0002	-0.006	0.164
	(0.044)	(0.050)	(0.046)	(.0002)	(0.046)	(0.067)
Mgr/Prof	0.112	0.025	0.028	-.0001	0.028	0.140
	(0.026)	(0.029)	(0.030)	(.0008)	(0.030)	(0.039)
OtherOcc	0.116	0.093	0.094	-.0001	0.094	0.210
	(0.022)	(0.026)	(0.026)	(.0008)	(0.026)	(0.034)
FullTime	0.113	0.049	0.052	-.0001	0.052	0.165
	(0.018)	(0.022)	(0.022)	(.0008)	(0.021)	(0.028)
PartTime	0.141	0.090	0.091	-.0001	0.090	0.231
	(0.019)	(0.022)	(0.023)	(.0008)	(0.022)	(0.029)
Private	0.115	0.027	0.028	-.0001	0.028	0.143
	(0.020)	(0.024)	(0.023)	(.0008)	(0.023)	(0.030)
Public	0.135	0.167	0.172	-.0001	0.171	0.306
	(0.040)	(0.044)	(0.044)	(.0008)	(0.044)	(0.060)
Total	0.119	0.058	0.060	-.0001	0.060	0.180
	(0.018)	(0.021)	(0.022)	(.0008)	(0.021)	(0.028)

3.6 Selectivity-Adjusted Estimates

If we assume that the error term in the participation equation and the error term in the union status equation are uncorrelated, we can write selectivity-corrected wage and hours equations as follows:[36]

$$lnW_{ui} = Z_{ui}\Gamma^u + \sigma_{15}\frac{f(Q_i\Lambda)}{F(Q_i\Lambda)} + \sigma_{16}\frac{f(S_i\Phi)}{F(S_i\Phi)} + u_{1i} \tag{3.18}$$

$$lnW_{ni} = Z_{ni}\Gamma^n - \sigma_{25}\frac{f(Q_i\Lambda)}{1-F(Q_i\Lambda)} + \sigma_{26}\frac{f(S_i\Phi)}{F(S_i\Phi)} + u_{2i} \tag{3.19}$$

$$lnH_{ui} = X_{ui}\Delta^u + \gamma^u lnW_{ui} + \sigma_{35}\frac{f(Q_i\Lambda)}{F(Q_i\Lambda)} + \sigma_{36}\frac{f(S_i\Phi)}{F(S_i\Phi)} + u_{3i} \tag{3.20}$$

$$lnH_{ni} = X_{ni}\Delta^n + \gamma^n lnW_{ni} - \sigma_{45}\frac{f(Q_i\Lambda)}{1-F(Q_i\Lambda)} + \sigma_{46}\frac{f(S_i\Phi)}{F(S_i\Phi)} + u_{4i} \tag{3.21}$$

where σ_{ij} is the covariance between e_i and e_j, f is the standard normal density function and F is the standard normal distribution function.

One can easily show that the conditional means of u_{ki} are zero. The conditional variances of u_{ki} are, however, not so obvious. Appendix D presents derivations of conditional variances of u_{ki}.

The parameters in equations (3.18) and (3.19) are estimated by the Heckman-Lee's two stage method. The parameters in equations (3.20) and (3.21) are then estimated by replacing actual union and nonunion wages with predicted union and nonunion wages in the Heckman-Lee two stage method.[37] A similar estimation method was also used by Nakamura, Nakamura and Cullen (1979). As is clear from equations (C10)-(C13) in Appendix D, the variance-covariance matrix of the OLS estimates will not be consistent due to heteroscadastic error terms. This problem is then further complicated by the

[36]If the two error terms are correlated, equations (3.18)-(3.21) are misspecified. In this case, we must include $E[e_1|U = 1, P = 1], E[e_2|U = 0, P = 1], E[e_3|U = 1, P = 1]$ and $E[e_4|U = 0, P = 1]$ instead of the two inversed Mill's ratios in equations (3.18)-(3.21). Estimation of this model is not much easier than estimation by maximum likelihood. Hence, in this section we estimate a special case where the two error terms (e_5 and e_6) are uncorrelated. We will relax this assumption when we estimate the model by maximum likelihood.

[37]The predicted wages do not include the two inversed Mill's ratios. Like Vella (1993), we wish to remove the effect of selection bias operating through wages when estimating hours equations. Inclusion of the two inverse Mill's ratios, however, does not change the estimates significantly.

fact that $\hat{\Lambda}$, $\hat{\Phi}$ and $ln\hat{W}_i$ are used in place of Λ, Φ and lnW_i. The correct asymptotic variance-covariance matrix of the parameter estimates in equations (3.18)-(3.21) is very complex and computationally difficult to obtain. Therefore, I use White (1980)'s method to correct the problem of heteroscadasticity. Asymptotically efficient estimates and the associated variance-covariance matrix are obtained in the next section when the full-information maximum likelihood is employed.

3.6.1 Selectivity-Adjusted Estimates of Hourly Earnings and Weekly Hours Equations

Appendix Table F.9 presents the selectivity-adjusted estimates of the hourly earnings equations for males and females. The coefficients on education and tenure are generally smaller for union workers than for nonunion workers. Male construction workers earn more in the union sector than in the nonunion sector. The significant coefficient on firm size variables for nonunion females supports a hypothesis that employers in the nonunion sector pay more as the size of firm gets bigger in order to prevent unionization. Thses findings are generally consistent with previous findings.

For males, the covariance between nonunion wage and union status (σ_{25}) is -0.224 and significant at the 0.05 level. The negative estimate of σ_{25} means that males who enter the nonunion sector are the ones who are better in terms of generating higher wages at the nonunion jobs. In other words, males selected into the nonunion sector earn more than average nonunion workers with the same characteristics and working conditions.[38] The negative and significant covariance between union wage and participation (σ_{16}) is puzzling. One would expect this covariance to be positive if individuals who work in the union sector are drawn from an upper section of union wage distribution. We will

[38] See Green (1991) for detailed explanation on how to interpret covariances between wage and union status.

see whether this negative covariance persists even when the full-information maximum likelihood is used in the next section.

For females, the covariance between nonunion wage and participation (σ_{26}) is 0.252 and significant at the 0.05 level. This implies that females who enter the labour market through finding jobs in the nonunion sector obtain higher wages than average nonunion females with similar characteristics. This result is often seen in the labour supply literature. The rest of covariances are found to be statistically insignificant.

The selectivity-adjusted estimates of weekly hours equations are reported in Appendix Table F.10. The estimated coefficients on logarithm of hourly earnings are now generally larger in absolute value than those in the selectivity-unadjusted estimates (2SLS), especially for union workers. Note that the positive and significant coefficients on Log-wage in the selectivity-unadjusted estimates (2SLS) for both males and females in the nonunion sector now become negative while insignificant. This provides some support for the Nakamuras' and Robinson and Tomes' conclusion. The estimated coefficient on union male head, which was negative and significant before, is now positive but insignificant. Again, larger coefficients on education and tenure variables for union workers, especially for union males, provide some evidence for that employers in the union sector extract more hours from more able workers, possibly due to union's wage standardization practice. The coefficients on industry and occupation variables are found to be very similar between the selectivity-unadjusted estimates and the selectivity-adjusted estimates.

For males, the covariance between union hours and participation (σ_{36}) is 0.693 and significant at the 0.1 level. This positive truncation means that males who participate in the union sector are the ones who have a strong tendency to work more hours than the average male worker in that sector. Therefore, only the upper section of the hours distribution is observed for union males.

For females, the covariance between nonunion hours and union status (σ_{46}) is -0.270

and significant at the 0.1 level. The negative σ_{46} means that females who enter the labour force through getting a nonunion job are the ones who tend to work more hours than the average female nonunion worker. In sum, estimates of covariances between error terms for males and females indicate that the sample selection problem should not be overlooked.

Before we compute the selectivity-adjusted union-nonunion differentials, we briefly discuss what determines the probability that an individual will work and what determines the union status of an individual.[39] Appendix Table F.8 presents the probit estimates of the participation and union status equations for males and females. For both males and females, being head of family and being better educated increase the probability that an individual will work while being single, being old and having young children reduce the probability. Coefficients on the union status equation reflect both an individual's taste for unionization and an employer's selection. For instance, the negative coefficients on university education may indicate that a lower demand for unionization among university graduates overwhelms a higher demand for those workers from an employer. One interesting observation from the estimates of the female union status equation is the relatively significant coefficients on head of family and young children. Since those variables enter the hours equations but not the wage equations, the significant coefficients on those variables provide some evidence that union status depends not only on union-nonunion wage gap but also union-nonunion hours gap.

3.6.2 Hourly Earnings, Weekly Hours and Weekly Earnings Differentials

Next, the union-nonunion hourly earnings, weekly hours and weekly earnings differentials are calculated using the same method as before. The variances of the differentials are computed from the variances of underlying coefficients obtained by White's method.

[39] A more detailed discussion will be provided in section 3.7.2.

Table 3.7 presents the results.[40]

For males, the average union-nonunion hourly earnings differential obtained from selectivity-adjusted estimates is about 34% and significant at the 0.05 level, and larger than that obtained from the OLS estimates. As Robinson (1989) noted, most researchers who used economy wide samples of workers have found larger wage differentials when they used selectivity-adjusted estimates. Therefore, our estimates for males are consistent with previous findings.

As before, union-nonunion hourly earnings are larger for construction, blue collar and part-time workers. However, the hourly earnings differential is found to be larger in the public sector than in the private sector while the reverse was true in the OLS case.

Pure, derived and total union-nonunion hours differentials for males are negative in all cases. However, pure and derived hours differentials are found to be statistically insignificant although total hours differentials show some significance. Negative total hours differentials reduce the magnitudes of weekly earnings differentials so much that the average weekly earnings differential becomes only about 4% and even becomes statistically insignificant.

The results for females are presented in table 3.8. Hourly earnings differentials for females are all positive but insignificant. At this point, it is hard to say whether union-nonunion hourly earnings differentials do not really exist or the differentials are found to be statistically insignificant because inefficient variance-covariance matrix of the estimates is used to calculate the variances of the differentials or because a lot of variability is introduced by using so many fitted terms in regression. We will come back to check the second possibility in the next section when we use maximum likelihood method.

[40]As before, wage, hours and earnings differentials are obtained by equations (3.13)-(3.17). The standard errors for the hours and earnings differentials are obtained using the δ-method. Figures in parentheses are standard errors.

Table 3.7: Union-Nonunion Hourly Earnings, Weekly Hours and Weekly Earnings Differentials by Sector for Males in 1990, Selectivity-Adjusted

		WH				
Sector	HE	Pure1	Pure2	Derv.	Total	WE
Manufact	0.314	-0.226	-0.176	-0.137	-0.313	0.0008
	(0.141)	(0.245)	(0.261)	(0.203)	(0.171)	(0.211)
Construct	0.448	-0.202	-0.147	-0.196	-0.342	0.106
	(0.153)	(0.301)	(0.335)	(0.285)	(0.177)	(0.222)
OtherInd	0.339	-0.197	-0.141	-0.148	-0.289	0.050
	(0.148)	(0.269)	(0.278)	(0.219)	(0.187)	(0.236)
BlueColr	0.398	-0.212	-0.144	-0.174	-0.318	0.080
	(0.147)	(0.292)	(0.303)	(0.254)	(0.175)	(0.232)
Mgr/Prof	0.181	-0.214	-0.186	-0.079	-0.265	-0.084
	(0.145)	(0.200)	(0.208)	(0.128)	(0.176)	(0.215)
OtherOcc	0.420	-0.192	-0.133	-0.183	-0.317	0.103
	(0.153)	(0.299)	(0.317)	(0.261)	(0.208)	(0.244)
FullTime	0.336	-0.207	-0.153	-0.147	-0.300	0.035
	(0.145)	(0.260)	(0.274)	(0.221)	(0.178)	(0.224)
PartTime	0.404	-0.227	-0.166	-0.176	-0.342	0.062
	(0.150)	(0.298)	(0.320)	(0.257)	(0.200)	(0.247)
Private	0.306	-0.227	-0.195	-0.134	-0.329	-0.023
	(0.144)	(0.245)	(0.267)	(0.199)	(0.189)	(0.226)
Public	0.460	-0.134	0.002	-0.201	-0.199	0.261
	(0.187)	(0.454)	(0.333)	(0.294)	(0.179)	(0.299)
Total	0.338	-0.208	-0.154	-0.147	-0.302	0.036
	(0.143)	(0.262)	(0.275)	(0.218)	(0.179)	(0.225)

Table 3.8: Union-Nonunion Hourly Earnings, Weekly Hours and Weekly Earnings Differentials by Sector for Females in 1990, Selectivity-Adjusted

		WH				
Sector	HE	Pure	Derv.	Total	WE	
Manufact	0.128	0.220	0.137	0.104	0.241	0.369
	(0.219)	(0.373)	(0.409)	(0.191)	(0.400)	(0.474)
Construct	0.475	-0.423	-0.532	0.386	-0.145	0.330
	(0.441)	(0.550)	(0.814)	(0.439)	(0.747)	(1.026)
OtherInd	0.124	0.210	0.149	0.101	0.250	0.374
	(0.228)	(0.356)	(0.391)	(0.197)	(0.382)	(0.483)
BlueColr	0.212	0.242	0.142	0.172	0.314	0.526
	(0.228)	(0.417)	(0.461)	(0.218)	(0.429)	(0.491)
Mgr/Prof	0.070	0.223	0.192	0.057	0.249	0.318
	(0.219)	(0.306)	(0.343)	(0.184)	(0.345)	(0.405)
OtherOcc	0.157	0.181	0.010	0.128	0.228	0.385
	(0.246)	(0.393)	(0.428)	(0.217)	(0.421)	(0.551)
FullTime	0.121	0.204	0.132	0.098	0.231	0.352
	(0.227)	(0.349)	(0.384)	(0.195)	(0.379)	(0.478)
PartTime	0.161	0.197	0.157	0.131	0.288	0.449
	(0.232)	(0.404)	(0.429)	(0.208)	(0.414)	(0.516)
Private	0.161	0.079	-0.008	0.131	0.123	0.284
	(0.243)	(0.382)	(0.389)	(0.216)	(0.407)	(0.544)
Public	0.021	0.631	0.646	0.017	0.664	0.685
	(0.273)	(0.332)	(0.411)	(0.224)	(0.401)	(0.361)
Total	0.130	0.202	0.138	0.106	0.244	0.374
	(0.229)	(0.360)	(0.395)	(0.199)	(0.388)	(0.486)

Like the selectivity-unadjusted case, pure union-nonunion hours differentials are positive but statistically insignificant in almost all cases except for the public sector. However, the average total hours differential increases dramatically from about 6% in the selectivity-unadjusted case to about 25%. As a result, the average weekly earnings differential increases by about 20 percentage point from the corresponding selectivity-unadjusted estimate. As before, the derived hours differentials are found to be statistically insignificant.

3.7 Maximum Likelihood Estimates

Although the selectivity-adjusted estimates obtained in the previous section may be consistent, they are inefficient.[41] Inefficiency occurs because (i) wage and hours equations are estimated independently of participation and union status equations and (ii) wage and hours equations themselves are estimated separately. Furthermore, the variance-covariance matrix of parameter estimates obtained by White's method is also inefficient.

In this section the participation, union status, wage and hours equations are estimated jointly by maximizing the likelihood function (3.12).[42] The obtained maximum likelihood estimates are efficient conditional on distribution assumptions.

The maximum likelihood estimates of participation and union status equations are presented in Appendix Table F.11, and the maximum likelihood estimates of hourly earnings and weekly hours equations are presented in Appendix Table F.12 and Appendix Table F.13 respectively. The maximum likelihood estimates of the variance-covariance matrix of the error terms are presented in the next section.

[41] As memtioned earlier, the consistency of the selectivity-adjusted estimates depends on the assumption that the participation decision and union status decision are independent.

[42] The estimation is done by mainly three steps. Starting from the least squares estimates obtained in the previous section, I first used the complementary Davidon-Fletcher-Powell (DFP) algorithm until the estimates do not change much and then switched to Newton-Raphson algorithm until convergence. Finally, I again used DFP algorithm to make sure that the value of log-likelihood function does not increase. Both algorithms require the first derivatives and Newton-Raphson algorithm requires the second derivatives in addition. If possible, I calculated the first derivatives analytically but in some cases I calculated them numerically. For example, consider $\partial F[a(x), b(x), c(x)]/\partial x = F_1 \cdot \partial a(x)/\partial x + F_2 \cdot \partial b(x)/\partial x + F_3 \cdot \partial c(x)/\partial x$, where F is the bivariate normal distribution function with $a(x)$ and $b(x)$, $c(x)$ is the conditional correlation coefficient, x is an unconditional correlation coefficient, $F_1 = \partial F/\partial a$ and F_2 and F_3 are similarly defined. Numerical method is used to compute F_1, F_2 and F_3 in the above example. That is, F_1 is obtained by $\frac{F[a(x)+\delta, b(x), c(x)] - F[a(x), b(x), c(x)]}{\delta}$, where δ is assumed to be 10^{-6}. Finally, the second derivatives are obtained using outer product of the first derivatives.

3.7.1 Variance-Covariance Matrix

The estimates of the variance-covariance matrix of the error terms in the system of equations are shown in table 3.9 (Note: T-statistics are in parentheses). The estimates provide important information in several aspects. First, note that standard errors of residuals in union hourly earnings and weekly hours equations (σ_1 and σ_3) are significantly smaller than those in nonunion hourly earnings and weekly hours equations (σ_2 and σ_4) respectively. Since the standard errors of the residuals can explain some of union effects on wage and hours dispersions, smaller standard errors in the union sector provide some evidence for the negative impact of unions on dispersions of wages and hours.

Second, the correlation between participation and union status (ρ_{56}) is -0.080 for males and -0.123 for females. Although these estimates are statistically insignificant, they are not negligible, especially for females. The presence of these correlations may affect the selectivity-adjusted estimates of union-nonunion wage, hours and earnings differentials obtained in the previous section since they are obtained under the assumption that this correlation is zero. The negative correlation between participation and union status indicates that workers participate in the labour market through employment in the nonunion sector. This situation is plausible if union jobs are rationed among nonunion workers to a large extent.

Third, the most interesting finding from the estimates of the variance-covariance matrix is the significant positive correlations between union hourly earnings and union weekly hours (ρ_{13}), but insignificant correlations between nonunion hourly earnings and nonunion weekly hours (ρ_{24}). This phenomenon is seen for both genders. To the extent that the error terms in hourly earnings equations reflect unmeasured workers' abilities, the positive correlation in the union sector indicates that more able workers work more hours in the union sector. If more able union workers can earn relatively more in the nonunion sector, like highly educated or highly skilled union workers, then employers in the union sector have incentives to extract more hours from those workers since the costs of using additional ability is small relative to the costs to be incurred in the nonunion sector. Under this circumstances, a positive ρ_{13} is expected in the union sector but not in the nonunion sector. This is a new finding which has not been discovered in previous studies.

An important consequence of significant correlation between union hourly earnings and weekly hours (ρ_{13}) is that the maximum likelihood estimates of the two equations will be quite different from the selectivity-unadjusted and -adjusted estimates. As we will see later, the estimates of the union weekly hours equations are most affected by the significant correlation. More importantly, these results provide a good reason for why the maximum likelihood method is preferred to the other methods.

Some of the correlation coefficients related to participation and union status are also shown to be statistically significant. For males, the correlation between union hours and union status (ρ_{35}) is negatve (-0.380) and significant at the 0.05 level, which indicates that we only observe the lower section of the union hours distribution. Like the selectivity-adjusted estimates, the correlations between union wage and participation (ρ_{16}) and nonunion wage and participation (ρ_{26}) are negative and significant. One would normally expect these correlations to be positive. This unexpected result is maybe due to a failure to control nonlabour income. Since the nonlabour income is not controlled in regression, it is possible that people with high ability accumulate more assets and hence less likely to participate in the labour market.[43] In such a case, ρ_{16} and ρ_{26} could be negative.

For females, the correlation between nonunion wage and participation (ρ_{26}) is positive

[43]This explanation is maybe consistent with the early retirement phenomenon in the past decades. Also, it is not totally unusual to find the negative correlations in the literature. For example, Zabel (1993), who used other earnings instead of nonlabour income, also found a negative correlation between the error term in participation equation and the error term in wage equation.

Table 3.9: Estimates of the Variance-Covariance Matrix

Correlation	Male	Female
Union Sector		
standard dev. of wage(σ_1)	0.313(40.02)	0.307(58.70)
standard dev. of hour(σ_3)	0.294(4.40)	0.404(14.51)
union status-wage(ρ_{15})	0.005(0.04)	0.030(0.21)
participation-wage(ρ_{16})	-0.589(-4.20)	-0.047(-0.20)
union-status-hour(ρ_{35})	-0.380(-3.77)	-0.656(-9.86)
participation-hour(ρ_{36})	-0.322(-1.11)	0.060(0.08)
wage-hour(ρ_{13})	0.601(2.50)	0.282(1.47)
Nonunion Sector		
standard dev. of wage(σ_2)	0.449(47.36)	0.392(34.28)
standard dev. of hour(σ_4)	0.326(86.77)	0.485(28.84)
union status-wage(ρ_{25})	-0.183(-1.00)	0.009(0.03)
participation-wage(ρ_{26})	-0.512(-4.62)	0.273(1.64)
union status-hour(ρ_{45})	-0.079(-0.29)	-0.161(-0.61)
participation-hour(ρ_{46})	-0.204(-0.59)	-0.020(-0.05)
wage-hour(ρ_{24})	-0.029(-0.06)	-0.119(-0.32)
Participation and Union Status		
ρ_{56}	-0.080(-0.25)	-0.123(-0.19)

(0.273) and significant at the 0.1 level, while the correlation between union wage and participation is insignificant. Like males, we also observe a negative and significant correlation between union hours and union status (ρ_{35}) for females which indicates that females observed in the union sector are the ones who work less than average female union workers with similar characteristics.

In sum, there seems to be a difference in mechanisms by which individuals are selected into union and nonunion sectors, and the difference is most apparent in the correlation between union status and hours. For both males and females, individuals who enter union sector are the ones who work less than the average union worker while those who enter nonunion sector are the ones who work more than the average nonunion worker. To the extent that the error terms in the hours equations reflect taste for work, the difference in the correlations between union and nonunion workers may imply that individuals with lower taste for work enter the union sector while individuals with higher taste for work enter the nonunion sector.

3.7.2 Participation and Union Status Equations

The estimates of participation equations presented in Appendix Table F.11 are not significantly different from the probit estimates presented in Appendix Table F.8. Being head of family and being better educated increase the probability of entering labour force while being old reduces the probability. The coefficients on provincial unemployment rates are negative and significant for males. Having young children significantly reduces the probability of participating in labour market for females only. There are also regional variations in participation rates, especially for females, which may reflect regional differences in job opportunities or income assistance programs. Overall, the results are quite expected.

The estimates of union status equations presented in Appendix Table F.11 are again quite similar to the probit estimates previously obtained. The positive coefficients on Unemployment Rate imply that workers who live in regions with high unemployment rates are more likely to be union members. These findings are consistent with Perloff and Sickles (1989)'s. However, as Perloff and Sickles pointed out, the causality may run in the other direction. That is, unemployment rates may by higher in regions that are highly unionized.

The union status equations are of the reduced form, so the coefficients on the variables should be interpreted as the net effects on union status. Better educated individuals may not like unions for personal reasons or due to the lower return on education in the union sector, but employers may like to hire them on productivity grounds. As a result, the net effects of education on union status depend on these two offsetting forces. Our estimates show that the net effects of education are not significant except for male university graduates. The net effect of education for university graduates is negative (-0.201) so that they are less likely to be in the union sector. Coefficients on tenure variables can be interpreted in a similar way. Our estimates indicate that individuals with longer tenure are more likely to be union members.

As expected, individuals in the service sector have a lower probability of being unionized than those in the manufacturing sector while individuals in health, education and public administration sectors have a higher probability. White collar workers also have lower probability to be union members than blue collar workers. The firm size variables are intended to measure costs of unionization. Being employed in larger establishments reduces the costs of unionization and hence increase the probability of unionization. Significant and positive coefficients on these variables provide some evidence for this hypothesis.

3.7.3 Hourly Earnings Equations

Maximum likelihood estimates of hourly earnings equations are presented in Appendix Table F.12. For both males and females, hourly earnings increase significantly with education and tenure, and the return to education and tenure are generally smaller in the union sector for both sexes. This result has been quite robust regardless of estimation methods. There are also significant provincial, industry and occupational wage differentials. Except B.C. residents, people who live outside Ontario generally earn less than those who live in Ontario. Male workers in the construction and primary industries earn more than those in manufacturing industry while both male and female workers in the service industry earn significantly less. Professionals and managers earn considerably more than blue collar workers, especially for females. Being employed in the the public sector has a positive effect on hourly earnings but its effect is significant only for union females. Firm size variables are in general positive and significant and the sizes of coefficients are smaller in the union sector.

Although maximum likelihood estimates of the hourly earnings equations are not so much different from the OLS and selectivity-adjusted estimates, there are still some noticeable changes of coefficients on certain variables. For example, the maximum likelihood estimates for the coefficient on the public sector dummy are quite different from the corresponding selectivity-adjusted estimates for both sexes. The differences between the two sets of estimates may lead to different conclusions with regard to the impact of public sector employment on hourly earnings.

3.7.4 Weekly Hours Equations

From the maximum likelihood estimates presented in Appendix Table F.13, one can notice that the constant terms and the coefficients on log of hourly earnings in the union sector are generally larger than those in the 2SLS estimates in absolute term. On the other hand, less significant changes are seen with regard to the corresponding coefficients in the nonunion hours equations. This phenomenon is possibly due to the positive and significant correlation between hourly earnings and weekly hours in the union sector but the insignificant correlation in the nonunion sector. Since the relationship between the error term in the hourly earnings equation and the error term in the weekly hours equation is more explicitly captured in the maximum likelihood estimation than in the 2SLS estimations, we would expect that a significant correlation between the two error term will have more impact on the coefficient on log of hourly earnings in the maximum likelihood estimation.

The negative and significant coefficients on the hourly earnings for both male and female union workers indicate that hours decrease as the wage rate increases in the union sector. This result may come from the employer's hours adjustment to an increase in wage or from a joint bargaining between the union and the employer. The coefficients on the hourly earnings are insignificant for both male and female nonunion workers, which indicates that substitution and income effects offset each other when the wage rate increase for nonunion workers. This result is very similar to the corresponding selectivity-adjusted estimates. The presence of young children is a more important factor for females than for males in explaining hours determination. Provincial unemployment rates do not appear to be a significant factor.

From the coefficients on education and tenure variables, one can clearly see that coefficients on high education (post-secondary and university education) and longer tenure (more than 6 years) in the union weekly hours equations are uniformly larger than the corresponding coefficients in the nonunion weekly hours equations for both genders.[44]

[44]This does not mean that better educated and more experienced union workers work more hours than their nonunion counterparts. The average hours per week for university graduates in the union sector, for instance, are smaller than the average hours per week for those in the nonunion sector.

This pattern is much more distinct in maximum likelihood estimates than it is in the least squares estimates. Let us examine the explanation provided earlier that employers in the union sector have an incentive to extract more hours from better educated and more experienced workers because they pay less for education and experience when compared to employers in the nonunion sector. This explanation is reasonable if employers in the union sector have all the power in choosing hours, i.e., the monopoly union model. If the employer and the union determine the hours together, the explanation is less clear since the hours are determined by the worker's taste for work as well as the employer's selection of hours. One of the important findings in section 3.7.1 is that workers with lower taste for work enter the union sector. Therefore, it is difficult to think that better educated and more experienced union workers want to work more hours than their nonunion counterparts. As a result, the explanation that employers in the union sector extract more hours from the able workers seems reasonable in both monopoly union and efficient contracts models. This result and the positive correlation between hourly earnings and weekly hours in the union sector together provide strong evidence that ability, measured or unmeasured, is positively correlated with hours of work in the union sector.

Concerning industry and occupation, there appears to be no significant differences in the coefficients between union and nonunion workers except that females with service occupations (Wcolr2) work significantly fewer hours than blue collar females in the nonunion sector while this pattern is not seen in the union sector. The maximum likelihood estimates for these variables are however quite different from the previous least-squares estimates.

3.7.5 Hourly Earnings, Weekly Hours and Weekly Earnings Differentials

Using the full-information maximum likelihood estimates of the hourly earnings and weekly hours equations, union-nonunion differentials for males are calculated by the methods (3.13)-(3.17) and reported in Table 3.10. In most cases, the variances of the differentials are obtained by the δ-method. Appendix E describes the derivations of the variances of various differentials.

The estimates presented in table 3.10 are clearly different from the previous least squares estimates. Not only the pure hours differentials are positive but also they are statistically significant at better than the 0.1 level. Since we know that employers in the union sector extract more hours from better educated and more experienced workers, we calculate how much of the average pure union-nonunion hours differential is due to the differences in coefficients on education and tenure between union and nonunion workers.[45] The result is striking. Education and tenure can explain about 51% of the average pure union-nonunion hours differential. Therefore, it is reasonable to conclude that the positive union-nonunion hours differential for males is largely due to the large impact of education and tenure on hours in the union sector.[46]

The average pure union-nonunion hours differentials range from about 16% to 20% and are significant at better than 0.1 level. The average derived hours differential is about -10% and also significant at the 0.1 level. These two differentials are most significant for construction workers. The pure hours differentials for this group range from about 21% to even 30% and the derived hours differential is about -18%.

As for the economy, the total hours differential is about 9% and significant at the 0.2 level. The average total hours differential is found to be large for construction workers, part-time workers and public sector employees.

[45] The hours differential resulted from difference in coefficients on education and tenure is calculated by $\bar{X}(\Delta^u - \Delta^n)$ where X is a vector of education and tenure variables and Δ is the corresponding vector of coefficients

[46] The large impact of education and tenure on hours of work may be due to larger fixed employment costs, such as training costs, for skilled union workers than for skilled nonunion workers. The argument that fixed employment costs increase hours of work can be found in Ehrenberg (1970) and the argument that nonwage benefits, some of which are fixed employment costs, for union workers are larger than those for nonunion workers can be found in Freeman (1981).

Table 3.10: Union-Nonunion Hourly Earnings, Weekly Hours and Weekly Earnings Differentials by Sector for Males in 1990, Maximum Likelihood Estimates

		WH				
Sector	HE	Pure1	Pure2	Derv.	Total	WE
Manufact	0.163	0.116	0.147	-0.095	0.052	0.215
	(0.080)	(0.096)	(0.102)	(0.059)	(0.071)	(0.096)
Construct	0.312	0.213	0.304	-0.182	0.122	0.434
	(0.082)	(0.116)	(0.138)	(0.097)	(0.058)	(0.091)
OtherInd	0.174	0.176	0.213	-0.101	0.112	0.286
	(0.083)	(0.096)	(0.102)	(0.062)	(0.065)	(0.095)
BlueColr	0.195	0.144	0.180	-0.114	0.066	0.261
	(0.083)	(0.099)	(0.106)	(0.072)	(0.067)	(0.095)
Mgr/Prof	0.097	0.162	0.188	-0.057	0.131	0.228
	(0.079)	(0.081)	(0.084)	(0.042)	(0.063)	(0.091)
OtherOcc	0.262	0.197	0.252	-0.152	0.100	0.362
	(0.082)	(0.115)	(0.129)	(0.081)	(0.063)	(0.096)
FullTime	0.180	0.160	0.197	-0.104	0.093	0.272
	(0.078)	(0.094)	(0.100)	(0.061)	(0.062)	(0.087)
PartTime	0.230	0.198	0.243	-0.134	0.109	0.339
	(0.079)	(0.104)	(0.114)	(0.073)	(0.061)	(0.089)
Private	0.193	0.159	0.191	-0.112	0.079	0.272
	(0.071)	(0.093)	(0.102)	(0.055)	(0.053)	(0.081)
Public	0.138	0.172	0.227	-0.080	0.147	0.285
	(0.131)	(0.130)	(0.124)	(0.092)	(0.105)	(0.149)
Total	0.181	0.162	0.198	-0.105	0.093	0.275
	(0.077)	(0.094)	(0.101)	(0.061)	(0.062)	(0.089)

One may wonder why the maximum likelihood estimates of pure hours differentials are so different from the corresponding selectivity-adjusted estimates. There are several reasons why they may differ. First, as mentioned before, the selectivity-adjusted estimates are obtained under the assumption that the correlation between participation decision and union status (ρ_{56}) is zero whereas the maximum likelihood estimates are obtained without such an assumption. Second, distributional assumptions are different between the two estimation methods. That is, unlike the Heckman-Lee 2SLS estimation, maximum likelihood requires an assumption of the joint normality of the error terms in the system of equations. Besides, maximum likelihood is a nonlinear estimation.

Even though the two estimates are quite different, it does not mean that they are incompatible. Because the standard errors of the selectivity-adjusted estimates of pure hours differentials are very large, we can not reject the hypothesis that the pure hours differential is positive. In fact, the maximum likelihood estimates of pure hours differentials (Pure1 and Pure2) lie within the two standard error of the selectivity-adjusted estimates of pure hours differentials. Therefore, we cannot even reject the hypothesis that pure hours differentials are 0.162 and 0.192, which are the maximum likelihood estimates of Pure1 and Pure2, from the selectivity-adjusted estimates.

Union-nonunion hourly earnings differentials are positive as expected and statistically significant at the 0.05 level for most groups. On average, the union-nonunion hourly earnings differential is about 18% and significant at the 0.05 level. Note that this differential is larger than the one obtained from the OLS estimates but smaller than the one obtained from the selectivity-adjusted estimates. As before, part-time workers and construction workers gain most from joining the union whereas professionals and managers gain least from doing that.

Finally, union-nonunion weekly earnings differentials are also positive and significant at the 0.05 level in most cases. Notice that unlike previous cases, the earnings differentials are now larger than the wage differentials due to the positive hours differentials.

Next, union-nonunion hourly earnings, weekly hours and weekly earnings differentials for females are calculated and presented in Table 3.11. Unlike the statistically insignificant hourly earnings differentials for females obtained from the selectivity-adjusted estimates, most of the union-nonunion hourly earnings differentials are not only positive but also statistically significant at better than the 0.1 level. This result may imply that greater efficiency is obtained by full information maximum likelihood than by the extended Heckman-Lee 2SLS estimation method. The estimated hourly earnings differentials are generally larger than those obtained from the OLS and selectivity-adjusted estimates. However, the patterns of the differentials are similar: a larger earnings gain in the union sector falls to blue collar and part-time workers while workers with high-paid jobs such as managers or professionals gain relatively less. The union hourly earnings differential in the public sector is smaller than that in the private sector and statistically insignificant. This result seems more reasonable than the OLS result that the hourly earnings differential is greater in the public sector than in the private sector.[47]

Estimates in table 3.11 provide strong evidence for the positive union-nonunion hours differentials for females. Like the selectivity-adjusted estimates, the maximum likelihood estimates of pure union-nonunion hours differentials are found to be positive. Furthermore, they are generally statistically significant. On average, the pure hours differential is about 37% when evaluated at the averages of actual hourly earnings and characteristics and about 44% when evaluated at the averages of predicted hourly earnings and characteristics of nonunion females. Like before, we calculate the contribution of education and tenure to the positive union-nonunion hours differential. We find that about 33% of the average pure union-nonunion hours differential comes from the differences in the

[47] Robinson and Tomes (1984) also report that union-nonunion hourly earnings differentials are greater in the private sector than in the public sector for both males and females although their sample selection criteria are different from mine.

Table 3.11: Union-Nonunion Hourly Earnings, Weekly Hours and Weekly Earnings Differentials by Sector for Females in 1990, Maximum Likelihood Estimates

		WH				
Sector	HE	Pure1	Pure2	Derv.	Total	WE
Manufact	0.184	0.246	0.305	-0.074	0.231	0.414
	(0.109)	(0.265)	(0.250)	(0.047)	(0.241)	(0.267)
Construct	0.491	0.514	0.620	-0.198	0.422	0.913
	(0.284)	(0.272)	(0.278)	(0.124)	(0.245)	(0.337)
OtherInd	0.194	0.385	0.454	-0.078	0.376	0.569
	(0.106)	(0.229)	(0.206)	(0.048)	(0.195)	(0.232)
BlueColr	0.229	0.260	0.327	-0.093	0.234	0.463
	(0.118)	(0.286)	(0.270)	(0.059)	(0.260)	(0.286)
Mgr/Prof	0.174	0.297	0.366	-0.072	0.295	0.469
	(0.115)	(0.227)	(0.196)	(0.053)	(0.184)	(0.217)
OtherOcc	0.205	0.442	0.508	-0.083	0.425	0.630
	(0.104)	(0.235)	(0.221)	(0.043)	(0.208)	(0.234)
FullTime	0.189	0.351	0.424	-0.076	0.347	0.536
	(0.104)	(0.229)	(0.205)	(0.463)	(0.194)	(0.221)
PartTime	0.220	0.440	0.489	-0.089	0.400	0.621
	(0.106)	(0.249)	(0.227)	(0.050)	(0.215)	(0.241)
Private	0.205	0.374	0.439	-0.083	0.357	0.562
	(0.098)	(0.223)	(0.209)	(0.041)	(0.197)	(0.221)
Public	0.163	0.361	0.434	-0.066	0.368	0.531
	(0.173)	(0.296)	(0.257)	(0.079)	(0.247)	(0.298)
Total	0.196	0.371	0.438	-0.079	0.359	0.555
	(0.105)	(0.230)	(0.210)	(0.047)	(0.198)	(0.225)

coefficients on education and tenure. Even though this figure is lower than 51% obtained for males, education and tenure are still an important factor in explaining the positive hours differential for females.

Maximum likelihood estimates for the pure union hours differentials are larger for part-time workers than for full-time workers while there is no significant difference between private and public sector females. The pure hours differentials for females with professional occupations and working in manufacturing and public sectors are found to be statistically insignificant.

Maximum likelihood estimates for derived hours differentials are found to be quite large. This is mainly due to the large coefficient on the hourly earnings in the union hours equation and the relatively large union-nonunion wage differential. The derived hours differentials obtained by maximum likelihood are negative and significant at better than the 0.1 level whereas the corresponding selectivity-unadjusted and -adjusted estimates are not statistically insignificant. The derived hours differential is the largest in absolute value for part-time females since these workers gain the largest hourly earnings differential when they enter the union sector.

Due to the negative derived hours differentials, total union-nonunion hours differentials are smaller than the pure hours differentials. However, total hours differentials are still positive and significant at the 0.1 level in most groups. On average, the total hours differential is about 36%.

Finally, the union-nonunion weekly earnings differentials are positive and significant at the 0.05 level. The average earnings differential is about 56%. As before, the earnings differential is larger than the wage differentials, so it is reasonable to conclude that unionization increases earnings differentials more than wage differentials. This result is consistent with our earlier findings.

3.8 Applications

In this section, we examine three related issues to which our results may be applied. The first part of this section deals with the male-female earnings differentials, the second part deals with the impact of unionization on male-female earnings differentials, and the last part deals with the union effects on hours dispersion.

3.8.1 Male-Female Earnings Differentials

Most studies dealing with male-female earnings differentials base their analyses on estimates of wage equations that are estimated independently from hours equations. However, as we have seen in the previous sections, the estimates of wage equations change a lot depending on whether the wage equations are estimated jointly with hours equations or they are estimated independently from hours equations. This is especially true in the union sector since wage and hours might be determined jointly by collective bargaining. As a result, we expect that the sizes of the standard decomposition terms might change depending on different sets of estimates used. We examine this possibilty in this section.

Consider an economy segmented in two sectors, union and nonunion sectors. The expected wages for an average male and an average female may be written as

$$EW_j = Prob(U_j = 1)\bar{W}_j^u + Prob(U_j = 0)\bar{W}_j^n \quad (j = m, f) \tag{3.22}$$

where $\bar{W}_j^u$ and $\bar{W}_j^n$ are the average union and nonunion wages for gender j measured in logarithm and U_j is the dummy indicating union status of gender j. For notational simplicity, let $Prob(U_j = 1) = \alpha_j$. The male-female wage differential is then written as

$$\begin{aligned} EW_m - EW_f &= (\alpha_m - \alpha_f)(\bar{W}_m^u - \bar{W}_m^n) \\ &+ (\alpha_f)(\bar{W}_m^u - \bar{W}_f^u) + (1 - \alpha_f)(\bar{W}_m^n - \bar{W}_f^n) \end{aligned} \tag{3.23}$$

The first line of (3.23) measures the contribution of the difference in union densities between males and females to the male-female wage differential. The second line of (3.23) represents the sum of weighted male-female wage differentials in union and nonunion sectors. Although it is possible that the difference in union densities between two genders can be decomposed as the difference in characteristics and the difference in coefficients, we only focus on decomposing male-female wage differentials in union and nonunion sectors because our purpose is to compare the sizes of decomposition terms obtained from the estimates of wage equations that are estimated independently from hours equations with those obtained from the estimates of wage equations that are estimated jointly with hours equations. [48]

Following Oaxaca (1973), the male-female wage differentials in union and nonunion sectors are decomposed into two parts:

$$Difference\ in\ Characteristics = (\bar{Z}^j_m - \bar{Z}^j_f)\hat{\Gamma}^j_m \tag{3.24}$$

$$Difference\ in\ Coefficients = (\hat{\Gamma}^j_m - \hat{\Gamma}^j_f)\bar{Z}^j_f \tag{3.25}$$

These two terms are then obtained using the OLS estimates, selectivity-adjusted estimates and maximum likelihood estimates respectively. The results are presented in table 3.12.[49] The three sets of estimates show significant differences, especially for the term due to difference in coefficients, although the proportions of the decomposition terms are roughly the same in each case. For the union sector, the maximum likelihood estimate for the difference in coefficients (=0.209) is larger than the OLS estimate (=0.179) but smaller than the selectivity-adjusted estimate (=0.279). For the nonunion sector, the corresponding maximum likelihood estimate (=0.292) is the largest and the OLS estimate (=0.229) is the smallest. On average, the corresponding maximum likelihood estimate

[48]To decompose the difference in union densities between males and females, one can linearize the probability of becoming a union member using the Taylor approximation. For details, see Doiron and Riddell (1993).

[49]In table 3.12, OLS=Ordinary Least Squares, Sel-Adj=Selectivity Adjusted and ML=Maximum Likelihood. Figures in (3a)-(3c) are obtained using female union density as a weight. A complete decomposition will include the term due to difference in male-female union density. The size of the term is 0.013. All differences are measured in logarithm.

Table 3.12: Estimates of Decomposition Terms of the Male-Female Wage Differential.

	OLS	Sel-Adj	ML
Union Sector			
(1a) Due to Differences in Characteristics	0.022	0.032	0.025
(1b) Due to Differences in Coefficients	0.179	0.279	0.209
(1c) Due to Both	0.201	0.311	0.233
Nonunion Sector			
(2a) Due to Differences in Characteristics	0.091	0.096	0.104
(2b) Due to Differences in Coefficients	0.229	0.272	0.292
(2c) Due to Both	0.320	0.368	0.396
Both Sectors			
(3a) Due to Differences in Characteristics	0.064	0.071	0.072
(3b) Due to Differences in Coefficients	0.209	0.275	0.259
(3c) Due to Both	0.273	0.345	0.331

(=0.259) is between the OLS estimate (=0.209) and selectivity-adjusted estimate (0.275).

Among the three sets of the estimates, selectivity-adjusted estimates appear to be least convincing. Unlike the OLS and ML estimates, male-female wage differentials are larger in the union sector than in the nonunion sector. This result contradicts our expectations that females in the union sector are less discriminated against than females in the nonunion sector.

One of the important implications of results presented in table 3.12 is that the OLS estimate of the difference in coefficients, often called the discriminatory or unexplained part, is not reduced even when wage equations are jointly estimated with hours equations. Therefore, the large discriminatory part in male-female wage differential appears to be persistent regardless of different estimation techniques used.

3.8.2 The Impact of An Increase in Female Union Density on Male-Female Earnings Differentials

A recent study by Doiron and Riddell (1993) explores a possibility that an increase in union density of females relative to a small decline in that of males may have contributed to the narrowing of the male-female wage differential in Canada. Because union workers on average earn more than nonunion workers per hour, an average wage for females would increase as the union density of females increases, and hence would reduce the male-female wage differential.

In this section we examine how an increase in female union density affects the male-female earnings differential. Our earlier results suggest that unionization leads to an increase in hours of work for females in addition to an increase in wages. Therefore, a shift of female workers from the nonunion sector to the union sector will increase their average earnings more than their average wage. As a result, it will reduce the male-female earnings differential more than the male-female wage differential.

To truly tackle this issue, we need more than one data set. For example. Doiron and Riddell used three different data sets (1981, 1984 and 1988) to capture the changes in male and female union densities over time. Since this is not possible here, we focus on how a small increase in female union density would affect the male-female wage and earnings differentials. Specifically, we compute the changes in male-female wage and earnings differentials when female union density increases by one percentage point holding male union density constant. During the last two decades, female union density has gradually increased, but male union density has not changed much. Thus, our assumption of constant male union density is not so unrealistic.

The male-female earnings differential can be expressed like equation (3.23) in the previous section except for that union and nonunion wages are replaced by union and

Table 3.13: The Changes of the Male-Female Wage and Earnings Differentials With One Percentage Point Increase of Female Union Density

	Wage Differential	Earnings Differential
Due to Differences in Union Densities	-.0022	-.0017
Due to Differences in Characteristics	-.0008	-.0010
Due to Differences in Coefficients	-.0008	-.0027
Total	-0.46%	-0.79%

nonunion earnings respectively. The standard decomposition methods can also be applied to the earnings differential in a straightforward way. Like the male-female wage differential, the male-female earnings differential can be written as

$$\begin{aligned} EY_m - EY_f &= (\alpha_m - \alpha_f)(\bar{Y}_m^u - \bar{Y}_m^n) \\ &+ (\alpha_f)(\bar{Y}_m^u - \bar{Y}_f^u) + (1 - \alpha_f)(\bar{Y}_m^n - \bar{Y}_f^n) \end{aligned} \tag{3.26}$$

where Y denotes weekly earnings (wage rate times times hours of work).

Using maximum likelihood estimates, we obtain the changes of male-female wage and earnings differentials when female union density increases by one percentage point. These changes are also decomposed by (3.24) and (3.25). Table 3.13 presents the results.[50]

The results indicate that one percentage point increase in female union density reduces the male-female earnings differential by 0.79% and the male-female wage differential by 0.46%. The reduction of the earnings differential is mainly achieved through the reduction of differences in coefficients whereas the reduction of the wage differential is mainly achieved through the reduction of the gap between male and female union densities.

The upshot of the results presented in table 3.13 is that an increase in female union density reduces the earnings differential more than the wage differential. The difference between the total changes (-0.33%=-0.79%+0.46%) comes from the reduction in the

[50]The changes of the decomposition terms in the table are measured in logarithm, but total changes are converted into percentage.

Table 3.14: Differences in Variances of Log of Hourly Earnings and Weekly Hours Between Union and Nonunion Males and Females.

	Males	Females
Hourly Earnings		
Union	0.117	0.161
Nonunion	0.284	0.217
Difference	-0.167	-0.056
F-Statistics	2.43	1.35
Weekly Hours		
Union	0.074	0.124
Nonunion	0.086	0.201
Difference	-0.012	-0.077
F-Statistics	1.16	1.62

male-female hours differentials as a result of an increase in female union density. This result suggests that some of the decrease in male-female hours differential during the past two to three decades may be attributed to an increase in female union density as well.

3.8.3 Union Effects on Wage and Hours Dispersion

It is well known that wages are less dispersed in the union sector than in the nonunion sector. The evidence for the U.S. can be found in Freeman (1980,1982), and the evidence for Canada can be found in Meng (1990) and Lemieux (1993). Table 3.14 presents the variances of the log of hourly earnings and weekly hours for males and females by union status calculated from our data set. As expected, for both males and females, the variances of log of hourly earnings are smaller in the union sector. By the F test, the differences are significant at the 0.01 level for males and at the 0.05 level for females. In addition, weekly hours are also less dispersed in the union sector. The F statistics for the differences are significant at better than the 0.10 level for males and at better than the 0.05 level for females.

There are several reasons why the variances of wages and hours might be smaller in the union sector. First, the smaller variances may be due to more homogeneous characteristics among union workers. Second, unions may try to standardize wages and hours for workers with similar charactersitics. Finally, unions may reduce employers' subjectivity in determining wages and hours for their members.

This section uses maximum likelihood estimates to identify which of the three factors is most responsible for smaller variances of wages and hours in the union sector. Recall the weekly hours equations (3.6) and (3.7) presented in section 3.3. Following Freeman (1980)'s methodology, the difference in the variance of log of hourly earnings in the two sectors is decomposed as

$$\Gamma_u[VC(Z_u) - VC(Z_n)]\Gamma_u' \tag{3.27}$$

and

$$\Gamma_u VC(Z_n)\Gamma_u' - \Gamma_n VC(Z_n)\Gamma_n' \tag{3.28}$$

where VC denotes a variance-covariance matrix of a vector Z_j, where Z_j is a vector of all variables appeared in the hours equation of sector j. The difference in the variance of log of weekly hours is similarly decomposed. Note that all the union coefficients in (3.27) can be replaced by nonunion coefficients, and all the variance and covariance matrixes of nonunion characteristics in (3.28) can be replaced by those of union characteristics. The decomposition term (3.27) is the difference in variances attributable to differences in characteristics and the decomposition term (3.28) is the difference in variances attributable to differences in coefficients. The decomposition term (3.28) provides one possible measure of union effects on wage dispersion. Holding the variances and covariances of characteristics constant, unions can affect the distribution of wages and hours through influencing the coefficients in wage and hours equations.

Remaining differences in wages and hours dispersions can be attributed to differences

Table 3.15: Estimates of the Decomposition Terms in the Differences in Variances of Hourly Earnings and Weekly Hours between Union and Nonunion Sectors

	Males	Females
Wages		
Due to Differences in Characteristics	-0.011(-0.025)	0.012(0.013)
Due to Differences in Coefficients	-0.040(-0.026)	-0.015(-0.016)
Due to Difference in Variances of Residuals	-0.104	-0.060
Total Difference	-0.155	-0.063
Hours		
Due to Differences in Characteristics	-0.041(0.014)	-0.004(0.016)
Due to Differences in Coefficients	0.070(0.015)	0.004(-0.016)
Due to Difference in Variances of Residuals	-0.020	-0.072
Total Difference	0.009	-0.072

in variances of error terms in wage and hours equations. The difference in variances of error terms may reflect some of the differences in determining wages and hours between the two sectors that are not captured by regression coefficients. Therefore, these differences provide another measure of union impacts on wages and hours dispersions.

Table 3.15 presents maximum likelihood estimates of the decomposition terms for males and females respectively.[51] Concerning the wage dispersion for males, our results are consistent with those obtained by previous studies where least square estimates are generally used.[52] For example, Freeman (1980) and Meng (1990) found that some of the lower dispersion of wage for males in the union sector is due to more homogeneous characteristics in that sector. They also found that more significant sources of the lower dispersion of wages in the union sector are due to smaller coefficients and smaller variance

[51]Note: The first estimates in the table are obtained using methods (3.27) and (3.28). The second estimates in parentheses are obtained using alternative methods where union coefficients in (3.27) are replaced by nonunion coefficients and the variances and covariances matrixes of nonunion characteristics in (3.28) are replaced by those of union characteristics. All differences are measured in logarithm.

[52]Unfortunately, most studies I am aware of in this area focus on males. Therefore, I am unable to compare my results for females with others.

of the residual in the union wage equation. The same pattern is observed in table 3.15.

Concerning the hours dispersion, there is no strong evidence that the smaller variance of hours in the union sector is due to more homogeneous characteristics in that sector. The sign of the estimate of the difference in characteristics varies as the different weights are used. Moreover, the estimate of the difference in coefficients is positive for males, which means that if male union workers have the same characteristics as male nonunion workers, they in fact work longer hours. This result may suggest that although unions do standardize wages among their members, they do not standardize hours. Finally, the most significant source of a narrower dispersion of hours in the union sector is a smaller variance of residual in the union hours equation. This may indicate that unions are successful in reducing the degree of employers' arbitrary determination of hours.

In sum, there is strong evidence that unions reduce wage dispersion, but a rather weak evidence that unions reduce hours dispersion.

3.9 Conclusion

In this chapter we examined union-nonunion wage, hours and earnings differentials in Canada. We particularly focussed on union-nonunion hours and earnings differentials since this subject has not received much attention in Canada. In estimating the union-nonunion differentials, we used three different estimation techniques in order to test the robustness of the estimates. The main estimates of union-nonunion differentials for males and females are summarized here.

1) Union-nonunion hours differentials for males are ambiguous. The average pure union hours differential for males is about -2% and statistically significant when obtained from the selectivity-unadjusted estimates. But, the differential becomes statistically insignificant when obtained from the extended Heckman-Lee 2SLS estimation method and

becomes even positive (16%) and statistically significant when calculated from maximum likelihood estimates.

2) Union-nonunion pure hours differentials for females are found to be positive in all the estimation methods used and generally found to be statistically significant. The average pure union hours differentials range from 6% to 56% depending on estimation methods. Maximum likelihood estimates for this differential are found to be larger than least squares estimates. Total union hours differentials for females range from 7% to 56% and are statistically significant as well.

3) As expected, union-nonunion wage and earnings differentials are positive and statistically significant for both males and females. The average wage and earnings differentials for males range from 14% to 34% and 4% to 28% respectively. The average wage and earnings differentials for females range from 10% to 20% and 18% to 56 % respectively. The larger union earnings differential for females are due to larger positive union hours differentials.

The implications of the larger union earnings differentials for females on male-female earnings differentials are discussed in section 3.8.2. The main finding of that section is that an increase in female union density reduces the male-female weekly earnings differential more than the male-female hourly earnings differential. This result makes sense since an increase in female union density would reduce the male-female hours differential due to positive union hours effects for females, and hence would reduce the male-female weekly earnings differential more.

This chapter also finds an interesting result that employers in the union sector tend to extract more hours from able workers. This result is consistent with a hypothesis that employers in the union sector have an incentive to do that because returns to more able worker are lower in the union sector.

One can argue that the positive union-nonunion hours differentials we obtained in this study, especially for females, may be due to omitted variables such as absenteeism rates, fringe benefits and work schedules in the hours equations. Allen (1984) found that absenteeism rates are higher in the union sector than in the nonunion sector and Freeman (1981) found that union workers receive larger fringe benefits than their nonunion counterparts do. Since both absenteeism and fringe benefits are known to be positively correlated with hours of work, at least in theory, a failure to control for absenteeism rates and fringe benefits in the hours equations may lead to positive union-nonunion hours differentials.[53]

The positive union-nonunion hours differentials may also come from a failure to control for work schedules in the hours equations. A recent study by Kostiuk (1990) reports that a larger percentage of union workers than nonunion workers are working on shift work schedules in the United States. A study by Northrup (1989) also reports that twelve-hour shift work schedules have been successfully adopted in the chemical industries in the United States that are highly unionized. So far, the effects of absenteeism, fringe benefits and work schedules on the union-nonunion hours differential are unknown. These issues certainly deserve more attention in the future.

[53]A large portion of fringe benefits can be thought of as fixed costs of employment. The theoretical prediction that absenteeism and fixed costs increase hours of work is shown in Ehrenberg (1970).

Chapter 4

Conclusion

The economic impact of the union has been an important subject for economists. We are interested in unions for various reasons. Do unions distort the efficiency of the labour market? If so, how much? Do unions increase or reduce inequality between individuals in our society? Do unions have a positive or negative impact on productivity and profitability? Are quit rates higher or lower in the union sector? Do unions encourage or discourage absenteeism? These are the some of questions that economists try to answer and policy makers are also interested in.

However, despite the considerable amount of research done on unionism, not many people have raised the question, "Do unions increase or reduce hours of work?" In general perception, unions are believed to reduce hours of work. However, whether the hours of work are in fact lower in the union sector depends also on the firm's reaction to the union demand for shorter hours. If unionized firms face high employment costs (such as high recruiting and training costs), and hence have an incentive to substitute hours for employment, it is not clear that we should expect the hours of work to be lower in the union sector. Also, as we have seen in chapter 2, if the union cares more about employment than each member's utility, the union impact on hours is ambiguous even in the absence of such fixed costs of employment. As Pencavel (1991) pointed out, we know very little about union impact on hours of work.

The purpose of this thesis is twofold. First, it summarizes previous theoretical union models which normally assume fixed hours of work and extends them to allow the possibility that both the union and the firm can bargain over hours as well as wages and employment. By doing so, it obtains some predictions on union impacts on wages, hours and employment. Second, this thesis develops an empirical framework which allows one to examine the union wage, hours and earnings effects simultaneously. The empirical results obtained in this thesis are very diverse. There are considerable variations in the union-nonunion hours differential between gender, industry and occupation.

In conclusion, we briefly summarize the main results of this thesis:

1. The three union models (monopoly union, right to manage and efficient contracts models), incorporated with hours of work, predict that union effects on hours and employment are generally ambiguous, but union effect on wages is positive. However, in some special cases, it is possible to determine the union effects on hours and employment. For example, if the union's objective function is assumed to be utilitarian and if the union and the firm bargain over the three variables jointly, both wage rates and employment rise, but hours decrease in the union sector.

2. In the efficient contracts model the slope of the contract curve in wage-employment space obtained without assuming fixed hours is quite different from the one obtained with assuming fixed hours. In particular, if the union cares relatively less about employment than the utility gains of its members, it is shown that the contract curve does not necessarily have a negative slope in contrast to the one shown in Pencavel (1991).

3. Like several others, we show that at the bargaining equilibrium union workers would like to work more hours at the negotiated wage rate. This has two implications. First, it means that a usual assumption of fixed working hours or the assumption that workers can choose the number of hours they would like to work may be

inappropriate in the unionized sector. Second, it also means that some of the higher wages that union workers receive could be the compensating wages for the unsatisfactory hours set by unions and firms.

4. Empirically, union-nonunion hours differentials for males are ambiguous. Although the selectivity-unadjusted estimates indicate that union workers work less than nonunion workers with similar characteristics, maximum likelihood estimates indicate the opposite.

5. However, union-nonunion hours differentials for females are found to be positive in all cases and generally found to be statistically significant.

6. The positive union-nonunion hours differentials for both males and females are largely due to larger coefficients on education and tenure in the union hours equation and the positive correlation between the union wage and hours equations. This provides some evidence for that employers in the union sector extract more hours from more able workers since they pay less for education and experience than their counterparts in the nonunion sector.

7. As expected, union-nonunion wage and earnings differentials are positive and statistically significant for both males and females. However, due to smaller union-nonunion hours differentials for males, the average union-nonunion earnings differential for females is larger than the average union-nonunion earnings differential for males.

8. An increase in female union density reduces the male-female earnings differential more than the male-female wage differential. This result makes sense since an increase in female union density would reduce the male-female hours differential

due to larger positive union hours effects for females, and hence would reduce the male-female earnings differential more.

9. There is strong evidence that unions reduce wage dispersion, but only weak evidence that unions reduce hours dispersion.

There are several ways to extend this thesis both theoretically and empirically. First, one could possibly examine union effects on wages, hours and employment in a general equilibrium model in order to obtain a more complete picture of the union impacts on economy. Second, empirically, it may be desirable to control for absenteeism, work schedules and nonwage benefits in hours equations in order to obtain true union-nonunion hours differential. Since workers in the union sector are more likely to work on the shift work schedules, have higher absence rates, and receive larger nonwage benefits, all of which are believed to lead to longer hours of work, it could be due to the omission of such variables in the hours equations that we obtain positive union-nonunion hours differentials.

Differentials in wage, hours, earnings and employment between union and nonunion sectors indicate that unions change the use of production factors in order to create wage and earnings premiums for their members. Those differentials may be considered as a measure of inefficiency, technical or allocative, caused by unions. On the other hand, the union-nonunion differentials may lead to greater equality in the income distribution. As is seen in chapter 4 in this thesis, low income groups such as part-time workers gain most from unionization in terms of wage and earnings. Also, the male-female differential in earnings is reduced because of the larger union-nonunion hours differential for females. The overall impacts of unions on our society are therefore not clear-cut.

What unions represent is an issue that has not been settled to date. Some people argue that the union represents its members' opinions while others argue that the union simply represents its leader's opinions. Both views seem too extreme. If we take the first view, the union should not care about the size of membership and if we accept the second view, the union should only act in order to maximize its leader's pecuniary and non-pecuniary benefits. We do not observe these two extreme cases in the real world. One thing we do know, however, is that unions can effectively alter employment conditions of workers and their impacts on our society are hardly negligible. This leads us to study what unions do, but also leads us to think about what unions can do to improve the welfare of our society.

Appendix A

Proof to Chapter 2

Proof of $\frac{dW}{dH} < 0$ and $\frac{dN}{dH} < 0$ When $k \leq 1$

First, we show how to obtain $\frac{dW}{dH}$. Equations (2.23) and (2.24) can be simplified as follows:

$$G' = \frac{U_2}{U_1} \tag{A1}$$

$$U - \bar{U} = kU_1 H(W - G') \tag{A2}$$

Substituting (A1) into (A2), we obtain

$$U - \bar{U} = k(U_1 WH - HU_2) > 0 \tag{A3}$$

The inequality of the right hand side of (A3) is very important to determine the signs of $\frac{dW}{dH}$ and $\frac{dN}{dH}$. Let F be the function such that

$$F(W, H; \bar{U}) = U(WH, T - H) - \bar{U} - kU_1(WH, T - H)WH + kU_2(WH, T - H)H \tag{A4}$$

Using the implicit function theorem, we can compute

$$\frac{dW}{dH} = -\frac{F_H}{F_W} \tag{A5}$$

where

$$F_H = (1 - k)(WU_1 - U_2) - kH(U_{11}W^2 - 2U_{12}W + U_{22}) \tag{A6}$$

and

$$F_w = (1 - k)HU_1 + kH^2(U_{12} - WU_{11}) \tag{A7}$$

Hence,

$$\frac{dW}{dH} = -\frac{(1-k)(WU_1 - U_2) - kH(U_{11}W^2 - 2U_{12}W + U_{22})}{(1-k)HU_1 + kH^2(U_{21} - U_{11}W)} \tag{2.25}$$

With the results above, it is straightforward to obtain $\frac{dN}{dH}$ Since actual calculation is long and tedious, but straightforward, we are not presenting the steps of calculation. Instead, we focus on how to calculate $\frac{dN}{dH}$. (Please contact the author for detailed calculations.)

Taking total differential of equation (A1) yields

$$G''HdN = [\frac{U_1(WU_{12}-U_{22})-U_2(WU_{11}-U_{12})}{U_1{}^2} - G''N]dH + \frac{H(U_1U_{21}-U_2U_{11})}{U_1{}^2}dW \qquad (A8)$$

Then, after dividing (A8) by dH and rearranging terms, we obtain

$$\frac{dN}{dH} = -\frac{G''N}{G''H} + \frac{U_1(WU_{12}-U_{22})-U_2(WU_{11}-U_{12})}{G''U_1{}^2H} + \frac{H(U_1U_{12}-U_2U_{11})}{G''U_1{}^2H}\frac{dW}{dH} \qquad (A9)$$

By substituting the results for $\frac{dW}{dH}$ into (A7) and rearranging the terms, we obtain

$$\frac{dN}{dH} = -\frac{N}{H} + \frac{kH(WU_1-U_2)(U_{11}U_{22}-U_{12}{}^2)-(1-k)(U_{22}U_1{}^2-2U_{12}U_1U_2+U_{11}U_2{}^2)}{U_1{}^2G''H[kH(U_{21}-U_{11}W)+(1-k)U_1} \qquad (2.26)$$

Now, we prove $\frac{dW}{dH} < 0$ and $\frac{dN}{dH} < 0$ when $k \leq 1$. From the assumption of the concavity of U we know that $U_{11}U_{22} - U^2{}_{12} \geq 0$, and since a concave function is a quasi-concave function it is true that $U_{22}U_1{}^2 - 2U_{12}U_1U_2 + U_{11}U_2{}^2 \leq 0$. The production function G is assumed to be strongly concave, so $G'' < 0$. We also know that $WU_1 - U_2 > 0$ from (2.24). Therefore, we only need to know the signs of $U_{11}W^2 - 2U_{12}W + U_{22}$ and $U_{21} - U_{11}W$ to determine the signs of $\frac{dW}{dH}$ and $\frac{dN}{dH}$.

Recall that the worker's labour supply curve is characterized by

$$WU_1(WH, T-H) - U_2(WH, T-H) = 0 \qquad (A10)$$

Applying the implicit function theorm to (A10), one can show

$$\frac{dH}{dW} = -\frac{U_1}{W^2U_{11}-2WU_{12}+U_{22}} + \frac{H(U_{12}-WU_{11})}{W^2U_{11}-2WU_{12}+U_{22}} \qquad (A11)$$

Equation (A11) is nothing but the Slutsky equation. The first part of the right hand side of (A11) is the substitution effect and the second part is the income effect. The denomination of the right hand side of (A11) is the second order condition of the worker's utility maximization problem, so it is negative. Hence, the substitution effect is positive as expected. We also know that if leisure is a normal good (hours are an inferior good), the income effect is negative. Therefore, $U_{12} - WU_{11}$ must be positive. With these results and $k \leq 1$, we obtain that $\frac{dW}{dH} < 0$ and $\frac{dN}{dH} < 0$.

Appendix B

Figures for Chapter 2

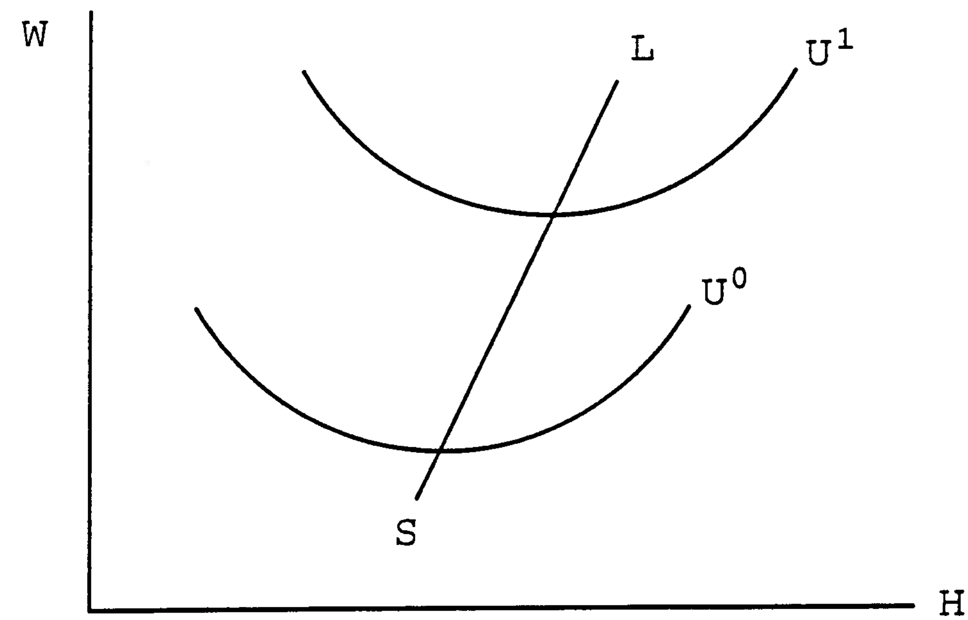

Figure B.1: Indifference Curves and The Associated Labour Supply Curve

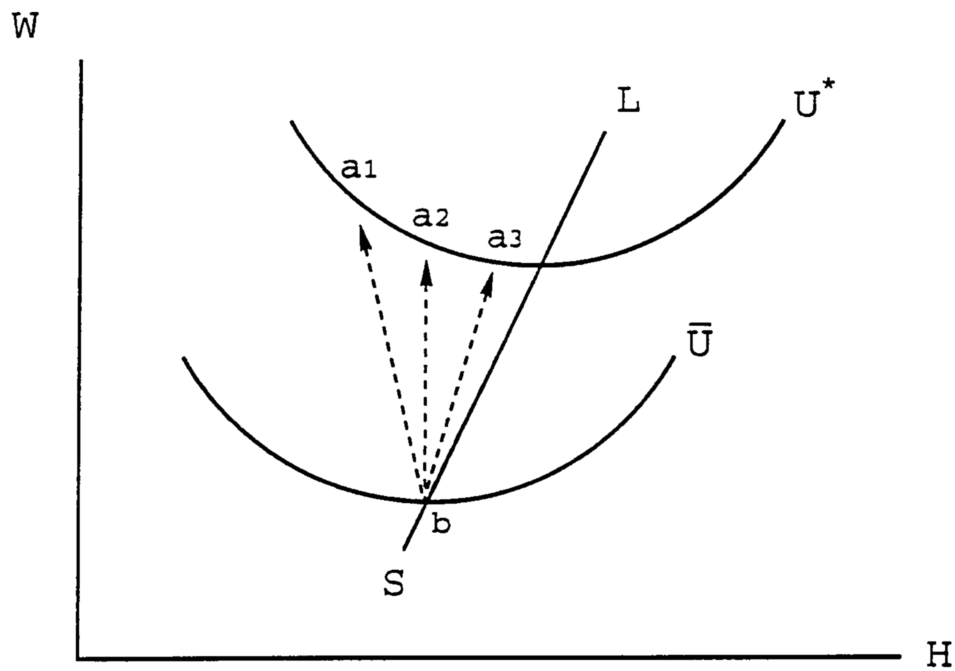

Figure B.2: Possible Equilibrium Outcomes under the Monopoly Union Model

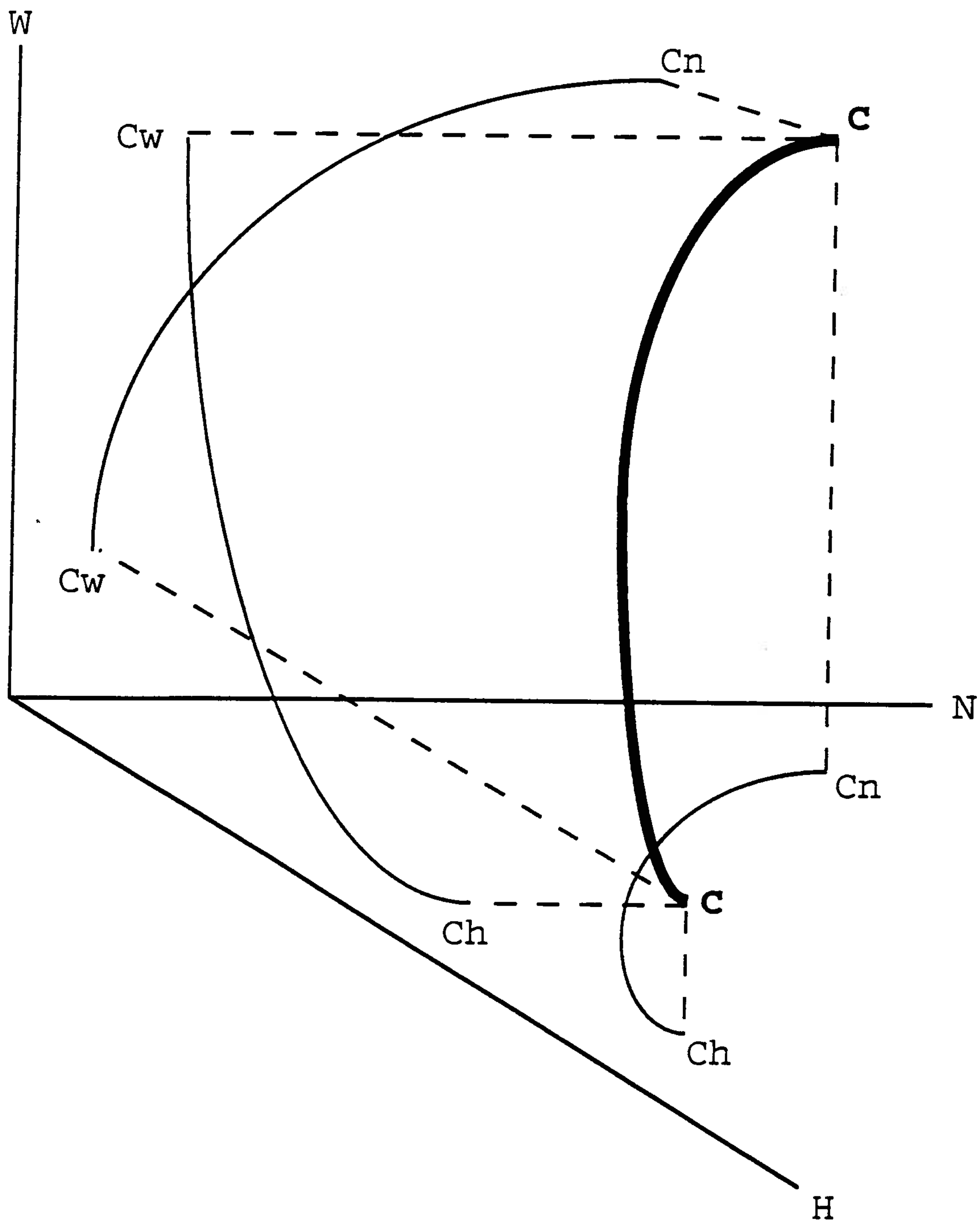

Figure B.3: A Representation of the Contract Curve in Wage-Hours-Employment Space

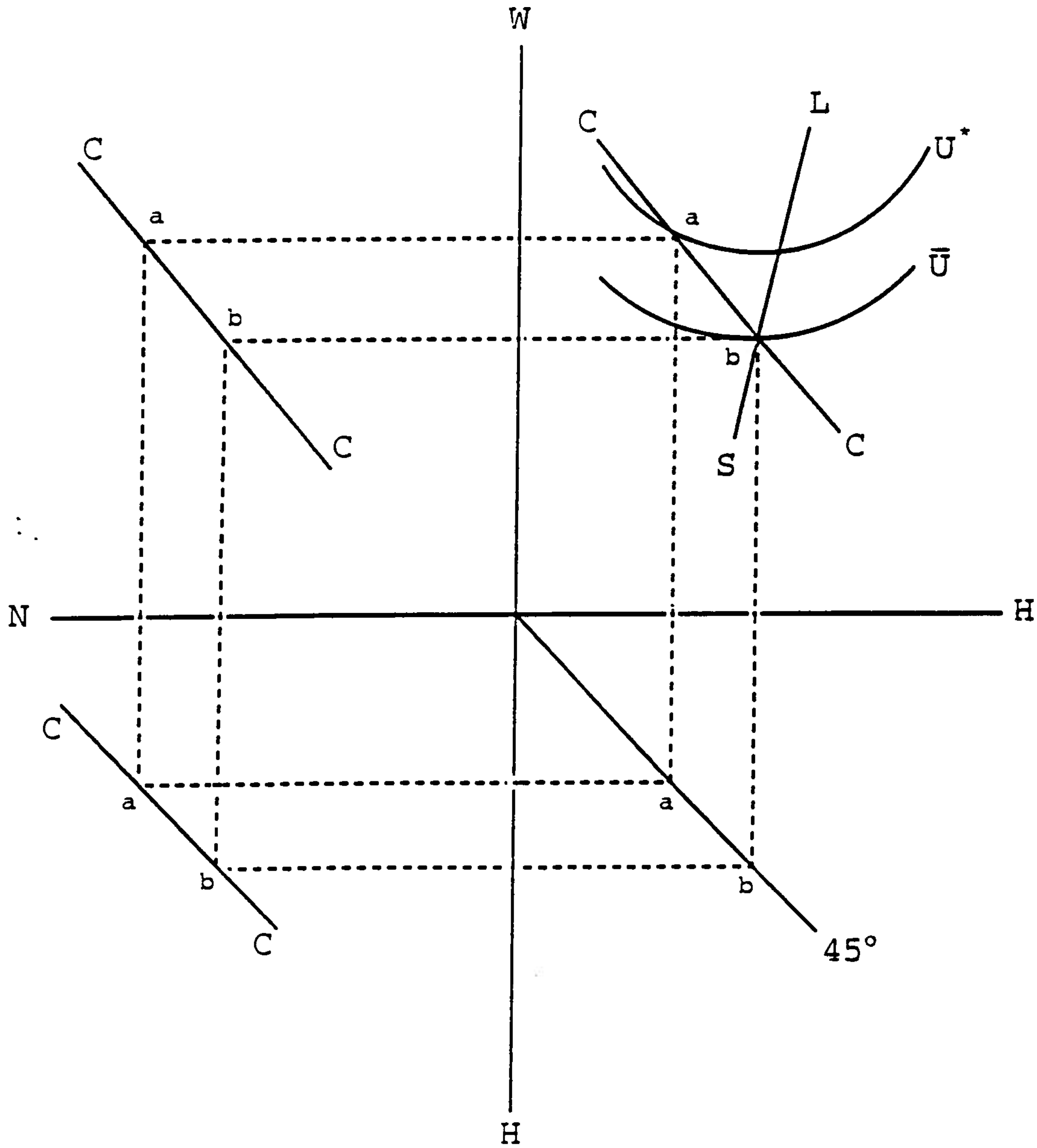

Figure B.4: Optimal Outcomes under the Efficient Contracts Model

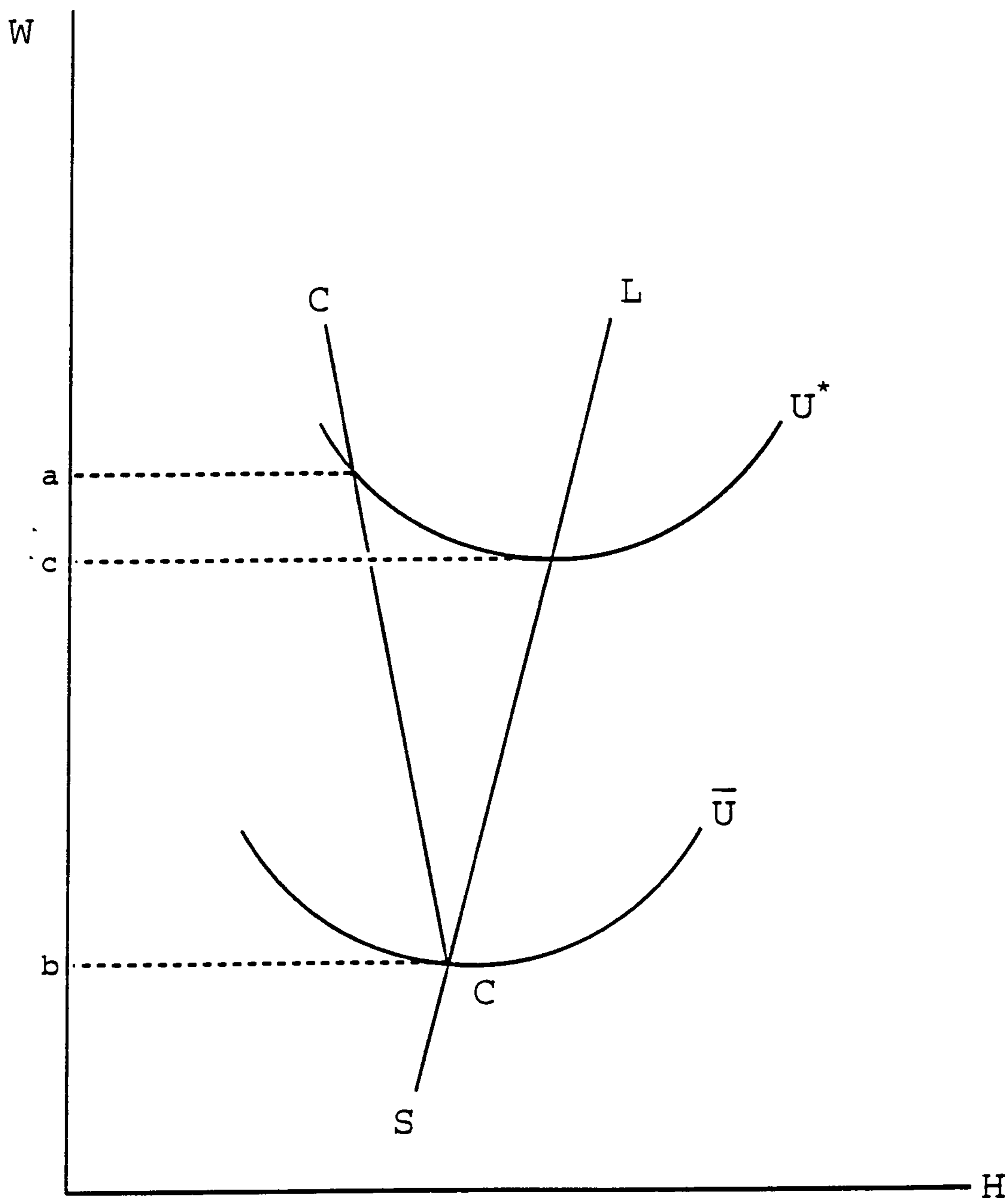

Figure B.5: Compensating Wage Differentials for Union Workers

Appendix C

The Specification of the Likelihood Function in Chapter 3

Under the joint normality assumption of the error terms in the six equations described in section 3.3, I specify the likelihood function as follows.

The contribution to the likelihood function of a nonworker is

$$F(-S\Phi) \tag{B1}$$

where F is the standard univariate normal distribution.

The contribution to the likelihood function of a union worker is

$$\frac{f\left(\frac{e_1}{\sigma_1}, \frac{e_3}{\sigma_3}, r_{13}\right)}{\sigma_1 \sigma_3} \cdot F\left[\frac{(Q\Lambda + \mu_{5,13})}{\sigma_{5,13}}, \frac{(S\Phi + \mu_{6,13})}{\sigma_{6,13}}, \rho_{56,13}\right] \tag{B2}$$

where f is the standard bivariate normal density function with the correlation coefficient r_{ij} and F is the standard bivariate normal distribution function with the correlation coefficient $\rho_{ij,km}$. $\mu_{i,jk}$ is the mean of e_i conditional on e_j and e_k, $\sigma_{i,jk}$ is the standard deviation of e_i conditional on e_j and e_k and $\rho_{ij,km}$ is the correlation coefficient between e_i and e_j conditional on e_j and e_m.

Finally, the contribution of the likelihood function of a nonunion worker is

$$\frac{f\left(\frac{e_2}{\sigma_2}, \frac{e_4}{\sigma_4}, r_{24}\right)}{\sigma_2 \sigma_4} \cdot F\left[\frac{(-Q\Lambda - \mu_{5,24})}{\sigma_{5,24}}, \frac{(S\Phi + \mu_{6,24})}{\sigma_{6,24}}, -\rho_{56,24}\right] \tag{B3}$$

where $\mu_{i,jk}$, $\sigma_{i,jk}$ and $\rho_{ij,km}$ are defined as above.

The formulas for the conditional means, standard deviations and correlation coefficients are obtained using the properties of conditional normal densities. For all i, j, k and m,

$$\begin{aligned}
\mu_{i,jk} &= r_{ij,k} e_j + r_{ik,j} e_k \\
\sigma_{i,jk} &= \left(1 - R^2{}_{i,jk}\right)^{1/2}
\end{aligned}$$

$$\rho_{ij,km} = \frac{r_{ij} - r_{jk}r_{i,km}\sigma_k - r_{jm}r_{i,mk}\sigma_m}{\sigma_{i,km}\sigma_{j,km}}$$

where

$$r_{ij,k} = \frac{r_{ij} - r_{ik}r_{jk}}{(1 - r^2{}_{jk})\sigma_j}$$

$$R^2{}_{i,jk} = \frac{r^2{}_{ij} - 2r_{ij}r_{ik}r_{jk} + r^2{}_{ik}}{1 - r^2{}_{jk}}$$

Note that the above formulas are obtained with the assumption that $\sigma_5 = \sigma_6 = 1$.

Appendix D

Variances of Error Terms in the Extended H-L Model in Chapter 3

Since the derivation procedures for obtaining the variances of u_{ki} in equations (3.18)-(3.21) are similar, I only present how the variance of u_{1i} is obtained. Readers can verify the variances of other u_{ki} by following the procedure presented below.

Let $W_1 = \frac{f(Q_i\Lambda)}{F(Q_i\Lambda)}$, $W_2 = \frac{f(S_i\Phi)}{F(S_i\Phi)}$. Suppressing the subscript i, we can write

$$u_1 = e_1 - \sigma_{15}W_1 - \sigma_{16}W_2 \qquad (C1)$$

Note that $E(u_1|P = 1, U = 1) = 0$. Hence,

$$Var(u_1|P = 1, U = 1) = E(u_1{}^2|P = 1, I = 1) \qquad (C2)$$

By substituting (C1) into (C2), obtain

$$E(u_1{}^2|P = 1, U = 1) = E[(e_1 - \sigma_{15}W_1 - \sigma_{16}W_2)^2|P = 1, U = 1] \qquad (C3)$$

The right hand side of (C3) involves $E(e_1|P = 1, U = 1)$ and $E(e_1{}^2|P = 1, U = 1)$. Since $E(e_1|P = 1, U = 1) = \sigma_{15}W_1+\sigma_{16}W_2$, we only need to find out $E(e_1{}^2|P = 1, U = 1)$. Let $\mu = E(e_1{}^2|P = 1, U = 1)$, $a = Q\Lambda$ and $b = S\Phi$.

$$\begin{aligned}
\mu &= \int_{-\infty}^{+\infty} e_1{}^2 f(e_1|P = 1, U = 1)de_1 \\
&= \frac{\int_{-\infty}^{+\infty}\int_{-b}^{+\infty}\int_{-a}^{+\infty} e_1{}^2 f(e_1, e_5, e_6)de_5 de_6 de_1}{F(a)F(b)} \\
&= \frac{\int_{-b}^{+\infty}\int_{-a}^{+\infty} f(e_5, e_6)\int_{-\infty}^{+\infty} e_1{}^2 f(e_1|e_5, e_6)de_1 de_5 de_6}{F(a)F(b)} \qquad (C4)
\end{aligned}$$

where $f(\cdot)$ and $F(\cdot)$ are appropriate normal density and distribution functions. From the properties of condition normal density functions, we know

$$Var(e_1|e_5, e_6) = \sigma_1{}^2(1 - R^2{}_{1,56}) = \sigma_1{}^2(1 - r^2{}_{15} - r^2{}_{16}) \qquad (C5)$$

$$E(e_1|e_5, e_6) = (\sigma_{15}e_5 + \sigma_{16}e_6) \qquad (C6)$$

where r_{jk} is the correlation coefficient between e_j and e_k. Using (C5) and (C6),

$$E(e_1{}^2|e_5, e_6) = \sigma_1{}^2(1 - r^2{}_{15} - r^2{}_{16}) + (\sigma_{15}e_5 + \sigma_{16}e_6)^2 \qquad (C7)$$

By substituting (C7) into (C4), we obtain

$$\begin{aligned} \mu &= \sigma_1{}^2(1 - r^2{}_{15} - r^2{}_{16}) \\ &+ \frac{\sigma_{15}{}^2 \int_{-b}^{+\infty}\int_{-a}^{+\infty} e_5{}^2 f(e_5)f(e_6)de_5de_6}{F(a)F(b)} \\ &+ \frac{2\sigma_{15}\sigma_{16} \int_{-b}^{+\infty}\int_{-a}^{+\infty} e_5e_6 f(e_5)f(e_6)de_5de_6}{F(a)F(b)} \\ &+ \frac{\sigma_{25}{}^2 \int_{-b}^{+\infty}\int_{-a}^{+\infty} e_6{}^2 f(e_5)f(e_6)de_5de_6}{F(a)F(b)} \qquad (C8) \end{aligned}$$

Applying integration by part to (C8) and using the definitions of W_1 and W_2, (C8) can be simplified as

$$\mu = \sigma_1{}^2 - a\sigma^2{}_{15}W_1 - b\sigma^2{}_{16}W_2 + 2\sigma_{15}\sigma_{16}W_1W_2 \qquad (C9)$$

Finally, by substituting (C9) into (C3) and simplifying the terms, the variance of u_1 can be found as

$$\text{Var}(u_1|\text{U=1,P=1}) = \sigma_1{}^2 - \sigma_{15}{}^2W_1(Q\Lambda + W_1) - \sigma_{16}{}^2W_2(S\Phi + W_2) \qquad (C10)$$

Now, let $W_3 = \frac{f(Q_i\Lambda)}{F(Q_i\Lambda)-1}$ and W_1 and W_2 be defined as same as before. Then,

$$\text{Var}(u_2|\text{U=0,P=1}) = \sigma_2{}^2 - \sigma_{25}{}^2W_3(Q_i\Lambda + W_3) - \sigma_{26}{}^2W_2(S\Phi + W_2) \qquad (C11)$$

$$\text{Var}(u_3|\text{U=1,P=1}) = \sigma_3{}^2 - \sigma_{35}{}^2W_1(Q_i\Lambda + W_1) - \sigma_{36}{}^2W_2(S\Phi + W_2) \qquad (C12)$$

$$\text{Var}(u_4|\text{U=0,P=1}) = \sigma_4{}^2 - \sigma_{45}{}^2W_3(Q_i\Lambda + W_3) - \sigma_{46}{}^2W_2(S\Phi + W_2) \qquad (C13)$$

Appendix E

Variances of Union-Nonunion Differentials in Chapter 3

The variances of the union-nonunion hourly earnings and weekly hours differentials presented in columns (1) and (2) in Table 3.5 are obtained by the methods shown in the footnote of section 3.5.3. The variances of the rest of union-nonunion differentials are obtained by the δ-method. Since the derivation procedures of these differentials are similar, I will only demonstrate how the variance of the pure weekly hours differential presented in column (3) is obtained. The following procedure can be directly applied to deriving the variances of the remaining differentials.

Denote the union-nonunion pure weekly hours differential as PWHD. Then, from equation (3.17) in section 3.5.3,

$$PWHD = \bar{Z}\hat{\Gamma}^n(\hat{\gamma}^u - \hat{\gamma}^n) + \bar{X}(\hat{\Delta}^u - \hat{\Delta}^n). \qquad (D1)$$

Applying the δ-method, the variance of PWHD can be shown as

$$\frac{\partial PWHD}{\partial \Theta} VC(\Theta) \frac{\partial PWHD'}{\partial \Theta} \qquad (D2)$$

where Θ is the vector of ($\hat{\Gamma}^n$,$\hat{\gamma}^u$, $\hat{\gamma}^n$, $\hat{\Delta}^u$,$\hat{\Delta}^n$), $\frac{\partial PWHD}{\partial \Theta}$ is a row vector of first partial derivatives of PWHD with respect to Θ and VC(Θ) is the variance-covariance matrix of Θ.

Note that the variance-covariance matrix of Θ involves covariances between the estimates of nonunion hourly earnings equations ($\hat{\Gamma}^n$) and the estimates of nonunion weekly hours equations ($\hat{\gamma}^n$, $\hat{\Delta}^n$). This is not the case when the variance of the pure weekly hours differential is obtained using the OLS and selectivity-adjusted estimates, because such covariances are not available from those estimates.

Appendix F

Appendix Tables for Chapter 3

Note 1: Excluded variables in estimation are: Age 34-54 years, Non-Single, High School Education, Ontario, Tenure 1-5 years, Manufacturing Industry, Blue Collar Occupation, Private Sector and Small Firm Size.

Note: In Tables 9 and 10 Select1 is the inverse of Mill's ratio obtained from the participation equation, i.e., $\frac{f(S_i\hat{\Phi})}{F(S_i\hat{\Phi})}$. Select2 is the inverse of Mill's ratio obtained from the union status equation. It is defined as $\frac{f(Q_i\hat{\Lambda})}{F(Q_i\hat{\Lambda})}$ for union workers and $\frac{f(Q_i\hat{\Lambda})}{F(Q_i\hat{\Lambda})-1}$ for nonunion workers.

Note 3: T-statistics are presented in parentheses.

Table F.1: Definitions of the Variables

Variable	Definitions
Unioncov	Covered by collective bargaining or member of a union =1; other =0
Head	Head of a family =1; other =0
Chd05	Number of own children of age between 0 an 5
Unempl	Provincial unemployment rates by sex in April 1990
A2024	Age 20 to 24 =1; other =0
A2534	Age 25 to 34 =1; other =0
A5564	Age 55 to 64 =1; other =0
Single	Single =1; other =0
Highschl	Some secondary education or graduated from highschool =1; other=0
Postsecd	Some post-secondary, post-secondary cert. or diploma or trades cert. or diploma =1; other =0
Univgrad	University degree =1; other =0
Atlantic	Resided in P.E.I., Newfoundland, Nova Scotia or New Brunswick =1; other =0
Quebec	Resided in Quebec =1; other =0
Ontario	Resided in Ontario =1; other =0
Prairie	Resided in Manitoba or Saskatchewan =1; other =0
Alberta	Resided in Alberta =1; other =0
Ten01	Tenure less than 1 year =1; other =0
Ten610	Tenure 6 to 10 years =1; other =0
Ten1120	Tenure 11 to 20 years =1; other =0
Ten20ov	Tenure 20 years over =1; other =0
Primind	Forestry or Mining =1; other =0
Constrct	Construction =1; other =0
Service	Trade, Finance or Service =1; other =0
Trcmut	Transportation, Communication or Utilities =1; other =0
Healeduc	Health or Education =1; other =0
Pubadm	Public Administration =1; other =0
Wcolr1	Managerial or Professional =1; other =0
Wcolr2	Clerical, sales or service =1; other =0
Public	Public sector =1; other =0
Medfirm	Number of employees between 100 and 499 =1; other =0
Bigfirm	Number of employees more than 500 =1; other =0

Table F.2: Sample Means of The Variables

Variable	Male			Female		
	Union	Nonunion	Nonworker	Union	Nonunion	Nonworker
Head	0.846	0.803	0.751	0.298	0.284	0.196
Chd05	0.294	0.305	0.279	0.251	0.206	0.406
Unempl	8.231	7.997	8.950	7.453	7.163	7.796
A2024	0.050	0.107	0.102	0.051	0.114	0.073
A2534	0.302	0.350	0.274	0.334	0.335	0.266
A5564	0.108	0.085	0.302	0.079	0.084	0.279
Single	0.176	0.235	0.286	0.146	0.197	0.114
Element	0.076	0.067	0.170	0.050	0.049	0.169
Postsecd	0.339	0.329	0.237	0.382	0.377	0.229
Univgrad	0.161	0.187	0.126	0.236	0.122	0.077
Atlantic	0.070	0.075	0.105	0.070	0.070	0.100
Quebec	0.301	0.236	0.383	0.306	0.223	0.332
Prairie	0.059	0.069	0.057	0.071	0.067	0.059
Alberta	0.063	0.105	0.065	0.082	0.093	0.073
BC	0.128	0.105	0.105	0.116	0.125	0.125
Ten01	0.208	0.322		0.248	0.333	
Ten610	0.134	0.134		0.141	0.118	
Ten1120	0.233	0.127		0.202	0.099	
Ten20ov	0.144	0.072		0.070	0.029	
Primind	0.037	0.038		0.006	0.005	
Constrct	0.082	0.108		0.002	0.031	
Service	0.101	0.458		0.122	0.633	
Trcmut	0.173	0.079		0.078	0.031	
Healeduc	0.167	0.032		0.512	0.166	
Pubadm	0.170	0.034		0.146	0.024	
Wcolr1	0.233	0.355		0.471	0.303	
Wcolr2	0.208	0.248		0.408	0.621	
Public	0.381	0.063		0.461	0.065	
Medfirm	0.170	0.127		0.212	0.122	
Bigfirm	0.632	0.329		0.593	0.341	
Union Membership	0.458			0.398		
Participation Rate		0.841			0.643	
NO. of Observations	1547	1797	647	1236	1740	1799

Table F.3: Construction of the Sample Data Set

Reason for Exclusion	Male	Female
1. Full-Time Student at Any Time During the Sample Year	4059	4133
2. Age 16-19	497	359
3. Age 64 Over	1665	2059
4. Disabled	2251	2450
5. Self-Employed or Non-Paid Family Members	3903	1773
6. Agricultural Sector Workers	384	312
7. Workers Who Don't Know the Size of Their Company	2202	1899
9. Total Excluded	14961	12985
10. Original Sample	30921	32086
11. Final Sample (10. - 9.)	15960	19101
12. 25% Random Sample of the Final Sample:		
a) Workers	3344	2976
b) Non-Workers	647	1799
c) Total	3991	4775

Table F.4: Sample Sizes by Sex and Sector

	Male		Female	
Sector	Union	Nonunion	Union	Nonunion
Manufact	411	389	121	184
Construct	101	220	4	50
OtherInd	1035	1188	1111	1506
BlueColr	906	856	126	153
Mgr/Prof	375	573	625	455
OtherOcc	266	368	485	1132
FullTime	1488	1711	933	1276
PartTime	59	86	303	464
Private	912	1651	598	1601
Public	635	146	638	139
Total	1547	1797	1236	1740

Table F.5: The OLS Estimates of Hourly Earnings Equations

Variable	Male		Female	
	Union	Nonunion	Union	Nonunion
A2024	-0.224(-5.88)	-0.203(-4.95)	-0.201(-4.61)	-0.119(-3.46)
A2534	-0.063(-3.33)	-0.047(-1.92)	0.030(1.42)	0.052(2.26)
A5564	0.033(1.26)	-0.117(-2.94)	-0.033(-0.96)	-0.005(-0.15)
Single	-0.027(-1.22)	-0.191(-6.93)	-0.066(-2.50)	0.029(1.11)
Element	-0.127(-4.17)	-0.045(-0.99)	0.026(0.60)	-0.190(-4.02)
Postsecd	0.120(6.80)	0.121(4.90)	0.127(5.55)	0.098(4.47)
Univgrad	0.320(11.37)	0.275(8.59)	0.337(11.54)	0.283(8.45)
Atlantic	-0.241(-7.84)	-0.349(-8.55)	-0.181(-5.05)	-0.276(-6.94)
Quebec	-0.096(-5.15)	-0.066(-2.49)	-0.024(-1.12)	-0.049(-1.89)
Prairie	-0.097(-2.92)	-0.142(-3.33)	-0.119(-3.31)	-0.193(-4.80)
Alberta	-0.075(-2.33)	0.003(0.09)	-0.062(-1.83)	-0.042(-1.19)
BC	0.023(0.95)	-0.018(-0.49)	0.074(2.52)	-0.006(-0.18)
Ten01	0.028(1.30)	-0.098(-3.83)	-0.046(-1.99)	-0.049(-2.19)
Ten610	0.032(1.28)	0.086(2.56)	0.072(2.58)	0.069(2.16)
Ten1120	0.089(4.08)	0.182(5.19)	0.137(5.33)	0.151(4.29)
Ten20ov	0.135(5.09)	0.259(5.71)	0.130(3.40)	0.264(4.43)
Primind	0.109(2.63)	0.205(3.58)	-0.092(-0.83)	0.206(1.46)
Constrct	0.209(6.54)	0.155(3.94)	0.415(1.85)	-0.002(-0.04)
Service	-0.079(-2.59)	-0.085(-3.00)	-0.031(-0.63)	-0.131(-3.74)
Trcmut	-0.001(-0.04)	0.074(1.69)	0.194(3.71)	0.121(1.95)
Healeduc	-0.086(-2.73)	-0.121(-1.95)	0.076(1.66)	-0.076(-1.78)
Pubadm	-0.042(-1.21)	-0.045(-0.51)	0.107(2.01)	0.022(0.26)
Wcolr1	0.021(0.77)	0.199(6.66)	0.199(4.11)	0.321(7.10)
Wcolr2	0.011(0.50)	-0.022(-0.71)	0.040(0.87)	0.136(3.22)
Public	0.065(2.68)	0.013(0.19)	0.069(2.98)	0.049(0.93)
Medfirm	0.056(2.19)	0.095(2.88)	0.099(3.55)	0.051(1.62)
Bigfirm	0.052(2.43)	0.106(4.16)	0.133(5.51)	0.141(6.35)
Constant	2.698(91.89)	2.534(68.54)	2.176(56.72)	2.090(45.69)
R^2	0.299	0.361	0.449	0.284
No of Obs	1547	1797	1236	1740

Table F.6: The Selectivity-Unadjusted Estimates of Weekly Hours Equations, Males

Variable	OLS Union	OLS Nonunion	2SLS Union	2SLS Nonunion
Logwage	-0.005(-0.20)	-0.042(-2.64)	-0.008(-1.36)	0.014(2.29)
Head	-0.045(-2.17)	-0.006(-0.31)	-0.047(-2.27)	-0.005(-0.26)
Chd05	-0.006(-0.49)	-0.005(-0.41)	-0.006(-0.50)	-0.006(-0.44)
Unempl	-0.047(-0.69)	0.027(0.40)	-0.050(-0.73)	0.027(0.40)
A2024	0.020(0.55)	0.016(0.57)	0.013(0.36)	0.033(1.16)
A2534	-0.018(-0.98)	-0.004(-0.20)	-0.018(-1.00)	-0.001(-0.03)
A5564	-0.037(-1.53)	-0.047(-1.75)	-0.036(-1.48)	-0.042(-1.54)
Single	-0.121(-5.61)	-0.042(-2.02)	-0.116(-5.30)	-0.037(-1.80)
Element	0.012(0.43)	-0.058(-1.91)	0.011(0.40)	-0.060(-1.98)
Postsecd	0.010(0.61)	-0.010(-0.62)	0.011(0.69)	-0.017(-1.03)
Univgrad	0.101(3.75)	0.005(0.25)	0.104(4.01)	-0.015(-0.67)
Atlantic	0.100(1.42)	-0.029(-0.43)	0.084(1.18)	0.022(0.32)
Quebec	0.052(1.46)	-0.006(-0.16)	0.052(1.46)	-0.001(-0.02)
Prairie	0.052(1.50)	-0.052(-1.57)	0.035(0.97)	-0.016(-0.45)
Alberta	0.098(3.17)	-0.005(-0.20)	0.085(2.62)	0.017(0.60)
BC	0.027(0.95)	-0.033(-1.11)	0.023(0.81)	-0.024(-0.81)
Ten01	-0.033(-1.65)	0.002(0.14)	-0.032(-1.63)	0.008(0.45)
Ten610	0.009(0.42)	0.015(0.67)	0.010(0.45)	0.007(0.31)
Ten1120	0.001(0.05)	-0.046(-1.93)	-0.001(-0.03)	-0.058(-2.43)
Ten20ov	-0.003(-0.11)	0.009(0.30)	-0.002(-0.09)	-0.007(-0.23)
Primind	0.042(1.11)	0.106(2.75)	0.038(1.00)	0.104(2.68)
Constrct	0.018(0.65)	0.058(2.22)	0.022(0.79)	0.050(1.89)
Service	-0.081(-2.95)	-0.003(-0.16)	-0.076(-2.72)	0.002(0.11)
Trcmut	0.051(2.09)	0.007(0.23)	0.055(2.22)	-0.001(-0.02)
Healeduc	-0.017(-0.59)	-0.098(-2.34)	-0.016(-0.55)	-0.087(-2.07)
Pubadm	0.052(1.64)	0.109(1.85)	0.055(1.74)	0.113(1.92)
Wcolrl	-0.069(-2.86)	0.021(1.02)	-0.071(-2.93)	0.001(0.04)
Wcolr2	-0.024(-1.17)	-0.016(-0.79)	-0.023(-1.12)	-0.021(-1.02)
Public	-0.063(-2.83)	-0.137(-3.09)	-0.063(-2.86)	-0.134(-3.01)
Constant	3.781(47.88)	3.842(63.32)	3.800(71.32)	3.681(70.26)
R^2	0.073	0.040	0.074	0.039
No of Obs	1547	1797	1547	1797

Table F.7: The Selectivity-Unadjusted Estimates of Weekly Hours Equations, Females

	OLS		2SLS	
Variable	Union	Nonunion	Union	Nonunion
Logwage	0.075(2.34)	-0.029(-1.13)	-0.001(-0.13)	0.036(4.48)
Head	0.061(2.64)	0.076(3.13)	0.068(2.96)	0.091(3.73)
Chd05	-0.039(-2.00)	-0.137(-6.32)	-0.037(-1.89)	-0.133(-6.17)
Unempl	0.051(0.35)	0.205(1.32)	0.053(0.36)	0.237(1.53)
A2024	-0.036(-0.73)	0.076(2.03)	-0.051(-1.03)	0.098(2.65)
A2534	0.062(2.53)	0.106(4.10)	0.065(2.61)	0.107(4.16)
A5564	-0.121(-3.16)	-0.022(-0.57)	-0.125(-3.25)	-0.024(-0.62)
Single	0.079(2.49)	0.053(1.76)	0.072(2.28)	0.023(0.75)
Element	0.024(0.50)	-0.105(-2.08)	0.025(0.51)	-0.089(-1.77)
Postsecd	0.045(1.72)	0.002(0.11)	0.056(2.15)	-0.010(-0.42)
Univgrad	0.018(0.51)	-0.047(-1.29)	0.045(1.35)	-0.077(-2.14)
Atlantic	-0.006(-0.04)	-0.176(-1.33)	-0.024(-0.19)	-0.110(-0.83)
Quebec	-0.085(-1.31)	-0.071(-1.02)	-0.089(-1.37)	-0.072(-1.05)
Prairie	0.013(0.30)	-0.147(-3.02)	0.001(0.02)	-0.071(-1.41)
Alberta	0.005(0.09)	-0.042(-0.83)	-0.003(-0.06)	0.010(0.20)
BC	-0.035(-0.62)	-0.147(-2.51)	-0.031(-0.55)	-0.157(-2.68)
Ten01	-0.005(-0.20)	0.006(0.23)	-0.009(-0.35)	0.009(0.39)
Ten610	0.059(1.88)	0.030(0.87)	0.065(2.06)	0.028(0.81)
Ten1120	0.111(3.84)	0.045(1.21)	0.123(4.24)	0.034(0.91)
Ten20ov	0.137(3.19)	0.048(0.75)	0.148(3.47)	0.023(0.36)
Primind	0.257(2.06)	-0.071(-0.47)	0.250(2.00)	-0.056(-0.37)
Constrct	-0.182(-0.73)	-0.155(-2.31)	-0.157(-0.63)	-0.159(-2.38)
Service	-0.098(-1.79)	-0.095(-2.53)	-0.100(-1.82)	-0.090(-2.43)
Trcmut	-0.037(-0.62)	-0.226(-3.39)	-0.019(-0.33)	-0.223(-3.37)
Healeduc	-0.108(-2.09)	-0.193(-4.25)	-0.101(-1.95)	-0.182(-4.03)
Pubadm	-0.002(-0.03)	0.172(1.84)	0.009(0.15)	0.180(1.95)
Wcolr1	-0.125(-2.26)	-0.021(-0.42)	-0.113(-2.04)	-0.049(-1.02)
Wcolr2	-0.086(-1.66)	-0.181(-4.00)	-0.084(-1.63)	-0.191(-4.27)
Public	-0.023(-0.90)	-0.175(-3.14)	-0.017(-0.67)	-0.181(-3.27)
Constant	3.377(30.66)	3.634(34.02)	3.549(39.57)	3.433(35.37)
R^2	0.103	0.119	0.099	0.129
No of Obs	1236	1740	1236	1740

Table F.8: The Probit Estimates of Participation and Union Status Equations

	Participation		Union Status	
Variable	Male	Female	Male	Female
Head	0.258(3.81)	0.340(6.80)	-0.052(-0.70)	0.087(1.30)
Chd05	-0.190(-4.12)	-0.479(-13.77)	-0.041(-0.88)	0.087(1.55)
Unempl	-0.300(-1.41)	0.003(0.01)	0.298(1.18)	0.349(0.82)
A2024	0.035(0.34)	0.164(2.03)	-0.192(-1.65)	-0.110(-0.92)
A2534	0.057(0.86)	0.161(3.14)	0.066(0.99)	0.065(0.91)
A5564	-0.957(-13.07)	-0.923(-15.75)	0.005(0.05)	-0.153(-1.47)
Single	-0.413(-5.62)	-0.175(-2.68)	0.080(0.99)	-0.171(-1.95)
Element	-0.157(-1.83)	-0.456(-6.37)	-0.198(-1.87)	0.171(1.32)
Postsecd	0.238(3.94)	0.419(9.09)	0.014(-0.24)	0.046(0.68)
Univgrad	0.196(2.56)	0.606(9.16)	-0.245(-2.66)	-0.087(-0.93)
Atlantic	-0.107(-0.47)	-0.350(-1.51)	-0.166(-0.64)	-0.226(-0.63)
Quebec	-0.260(-2.24)	-0.281(-2.29)	0.289(2.19)	0.225(1.19)
Prairie	-0.016(-0.13)	0.035(0.37)	-0.057(-0.45)	0.077(0.58)
Alberta	-0.050(-0.46)	-0.036(-0.37)	-0.342(-3.12)	-0.202(-1.40)
BC	-0.090(-0.86)	-0.190(-3.59)	0.321(2.87)	0.224(1.39)
Ten01			-0.178(-2.57)	-0.177(-2.52)
Ten610			0.125(1.49)	0.093(1.01)
Ten1120			0.170(2.09)	0.269(3.01)
Ten20ov			0.191(1.91)	0.252(1.79)
Primind			-0.0002(-0.001)	0.281(0.81)
Constrct			0.196(2.05)	-1.400(-4.13)
Service			-0.454(-5.66)	-0.708(-6.62)
Trcmut			0.087(0.91)	0.255(1.72)
Healeduc			1.358(11.66)	0.602(5.24)
Pubadm			0.367(2.48)	0.285(1.71)
Wcolrl			-1.150(-13.92)	-0.629(-4.91)
Wcolr2			-0.516(-6.69)	-0.653(-5.58)
Public			1.056(9.56)	0.937(10.15)
Medfirm			0.707(8.70)	0.611(7.39)
Bigfirm			0.959(14.75)	0.666(9.92)
Constant	1.376(9.39)	0.519(3.59)	-0.766(-4.23)	-0.625(-2.55)
Log-Likelihood	-1582	-2682	-1557	-1298
No of Obs	3991	4775	3344	2976

Table F.9: The Selectivity-Adjusted Estimates of Hourly Earnings Equations

Variable	Male		Female	
	Union	Nonunion	Union	Nonunion
A2024	-0.206(-4.03)	-0.177(-3.30)	-0.199(-2.46)	-0.119(-2.26)
A2534	-0.059(-2.33)	-0.047(-1.34)	0.033(1.19)	0.051(1.33)
A5564	0.184(1.86)	0.017(0.15)	-0.011(-0.17)	-0.137(-2.03)
Single	0.025(0.62)	-0.152(-2.91)	-0.072(-1.84)	0.033(0.72)
Element	-0.088(-2.02)	0.004(0.04)	0.045(0.69)	-0.246(-4.79)
Postsecd	0.091(2.63)	0.095(2.67)	0.116(3.38)	0.150(4.05)
Univgrad	0.300(7.27)	0.275(5.19)	0.322(7.07)	0.343(5.35)
Atlantic	-0.189(-5.01)	-0.313(-4.75)	-0.171(-4.80)	-0.321(-8.93)
Quebec	-0.045(-1.21)	-0.061(-1.15)	-0.013(-0.32)	-0.060(-1.16)
Prairie	-0.085(-2.46)	-0.134(-3.27)	-0.115(-3.13)	-0.187(-5.01)
Alberta	-0.061(-1.66)	0.031(0.79)	-0.062(-1.68)	-0.054(-1.36)
BC	0.038(1.17)	-0.041(-0.72)	0.085(1.88)	-0.009(-0.20)
Ten01	0.030(0.84)	-0.082(-2.38)	-0.049(-1.30)	-0.061(-1.79)
Ten610	0.030(0.82)	0.075(1.35)	0.072(2.29)	0.078(1.76)
Ten1120	0.088(2.93)	0.162(3.38)	0.139(3.85)	0.172(3.02)
Ten20ov	0.131(3.34)	0.234(4.02)	0.134(2.16)	0.288(3.66)
Primind	0.105(2.95)	0.207(4.28)	-0.087(-0.64)	0.209(2.08)
Constrct	0.212(4.08)	0.146(3.42)	0.374(1.42)	-0.070(-0.64)
Service	-0.070(-1.13)	-0.046(-1.13)	-0.045(-0.44)	-0.175(-2.63)
Trcmut	-0.008(-0.21)	0.060(0.82)	0.202(2.72)	0.132(1.81)
Healeduc	-0.098(-1.52)	-0.293(-2.81)	0.090(1.27)	-0.038(-0.56)
Pubadm	-0.049(-1.04)	-0.091(-0.82)	0.115(1.55)	0.021(0.18)
Wcolr1	0.029(0.50)	0.306(4.76)	0.185(2.41)	0.286(3.98)
Wcolr2	0.014(0.34)	0.028(0.54)	0.025(0.32)	0.094(1.26)
Public	0.059(1.22)	-0.120(-1.17)	0.081(1.13)	0.169(1.16)
Medfirm	0.050(1.00)	0.030(0.55)	0.110(1.67)	0.097(1.30)
Bigfirm	0.046(0.85)	0.017(0.27)	0.145(2.12)	0.175(3.25)
Select1	-0.408(-1.81)	-0.361(-1.45)	-0.053(-0.64)	0.252(3.16)
Select2	-0.016(-0.17)	-0.224(-2.15)	0.031(0.19)	0.158(0.81)
Constant	2.784(23.42)	2.483(31.77)	2.173(11.27)	2.056(15.01)
R^2	0.303	0.364	0.449	0.290
No of Obs	1547	1797	1236	1740

Table F.10: The Selectivity-Adjusted Estimates of Weekly Hours Equations

	Male		Female	
Variable	Union	Nonunion	Union	Nonunion
Logwage	-0.437(-0.71)	-0.041(-0.04)	0.813(1.52)	-0.088(-0.33)
Head	0.021(0.69)	-0.053(-1.11)	0.048(0.79)	0.105(1.35)
Chd05	-0.047(-2.24)	0.024(0.80)	0.011(0.13)	-0.210(-1.78)
Unempl	-0.131(-2.19)	0.081(1.25)	0.091(1.04)	0.166(1.39)
A2024	-0.058(-0.48)	0.012(0.06)	0.083(0.87)	0.093(1.68)
A2534	-0.032(-0.64)	-0.014(-0.25)	0.026(0.67)	0.121(2.72)
A5564	-0.267(-1.42)	0.148(0.93)	-0.039(-0.20)	-0.141(-0.52)
Single	-0.209(-2.35)	0.025(0.16)	0.133(2.79)	0.045(0.88)
Element	-0.080(-1.29)	-0.016(-0.21)	0.066(0.62)	-0.213(-1.39)
Postsecd	0.104(1.37)	-0.047(-0.47)	-0.077(-0.82)	0.050(0.35)
Univgrad	0.278(1.37)	-0.024(-0.82)	-0.028(-1.32)	0.041(0.49)
Atlantic	0.005(0.04)	-0.013(-0.39)	0.127(1.12)	-0.206(0.27)
Quebec	-0.031(-0.65)	0.033(0.45)	-0.041(-0.64)	-0.126(-1.26)
Prairie	0.014(0.26)	-0.051(-0.36)	0.104(1.29)	-0.150(-2.08)
Alberta	0.067(1.71)	0.003(0.01)	0.040(0.77)	-0.031(-0.66)
BC	0.023(0.43)	-0.025(-0.43)	-0.067(-1.00)	-0.186(-2.60)
Ten01	-0.015(-0.27)	0.005(0.05)	0.019(0.55)	0.018(0.55)
Ten610	0.022(0.69)	0.010(0.13)	0.012(0.24)	0.030(0.62)
Ten1120	0.037(0.66)	-0.052(-0.28)	0.020(0.26)	0.010(0.17)
Ten20ov	0.051(0.62)	0.002(0.01)	0.044(0.49)	0.007(0.07)
Primind	0.089(1.22)	0.105(0.48)	0.035(3.33)	-0.081(-0.47)
Constrct	0.108(0.89)	0.055(0.37)	-0.601(-0.10)	-0.027(-0.35)
Service	-0.098(-0.95)	-0.001(-0.01)	-0.131(-1.40)	-0.021(-0.47)
Trcmut	0.049(1.75)	0.002(0.03)	-0.172(-1.52)	-0.253(-2.73)
Healeduc	-0.080(-0.97)	-0.116(-0.33)	-0.124(-2.11)	-0.256(-3.52)
Pubadm	0.026(0.48)	0.107(0.81)	-0.060(-0.71)	0.154(1.06)
Wcolr1	-0.039(-0.68)	0.026(0.07)	-0.315(-2.00)	0.064(0.50)
Wcolr2	-0.007(-0.18)	-0.016(-0.29)	-0.162(-1.93)	-0.102(-1.30)
Public	-0.053(-1.14)	-0.147(-0.64)	-0.025(-0.50)	-0.362(-2.88)
Select1	0.693(2.09)	-0.483(-1.15)	-0.172(-0.53)	0.233(0.53)
Select2	-0.039(-0.73)	-0.009(-0.15)	0.140(0.90)	-0.270(-1.78)
Constant	4.911(2.78)	3.919(1.47)	1.661(1.23)	3.470(6.55)
R^2	0.078	0.040	0.101	0.132
No of Obs	1547	1797	1236	1740

Table F.11: The ML Estimates of Participation and Union Status Equations

	Participation		Union Status	
Variable	Male	Female	Male	Female
Head	0.268(3.71)	0.223(4.22)	-0.051(-0.57)	0.011(0.12)
Chd05	-0.169(-3.78)	-0.429(-12.55)	0.043(0.91)	0.155(0.97)
Unempl	-0.324(-2.68)	0.053(0.36)	0.384(2.54)	0.338(1.45)
A2024	0.092(0.89)	0.106(1.23)	-0.201(-1.58)	-0.030(-0.23)
A2534	0.031(0.46)	0.091(1.72)	-0.044(-0.63)	-0.014(-0.17)
A5564	-0.980(-13.78)	-0.974(-16.24)	-0.038(-0.22)	0.098(0.25)
Single	-0.419(-5.38)	-0.001(-0.02)	0.094(0.92)	-0.138(-1.36)
Element	-0.165(-2.07)	-0.472(-6.72)	-0.070(-0.64)	0.187(0.78)
Postsecd	0.179(2.96)	0.441(9.60)	-0.027(-0.41)	0.065(0.39)
Univgrad	0.472(5.11)	0.772(10.57)	-0.201(-2.06)	-0.063(-0.25)
Atlantic	-0.039(-0.26)	-0.355(-2.52)	-0.254(-1.48)	-0.212(-0.83)
Quebec	-0.255(-2.55)	-0.307(-3.45)	0.275(2.45)	0.226(1.37)
Prairie	0.062(0.61)	0.026(0.36)	-0.057(-0.57)	0.035(0.36)
Alberta	-0.069(-0.69)	-0.081(-1.03)	-0.364(-3.63)	-0.200(-1.68)
BC	-0.106(-1.00)	-0.226(-2.52)	0.268(2.35)	0.155(1.04)
Ten01			-0.200(-2.73)	-0.230(-3.29)
Ten610			0.030(0.34)	0.102(1.05)
Ten1120			0.146(1.75)	0.227(2.34)
Ten20ov			0.174(1.67)	0.202(1.22)
Primind			-0.043(-0.38)	0.233(0.90)
Constrct			0.056(0.54)	-0.652(-1.86)
Service			-0.522(-5.86)	-0.472(-3.76)
Trcmut			0.087(0.85)	0.230(1.37)
Healeduc			1.228(10.85)	0.763(5.61)
Pubadm			0.241(1.67)	0.294(1.65)
Wcolr1			-1.054(-13.14)	-0.548(-3.84)
Wcolr2			-0.489(-5.85)	-0.633(-4.79)
Public			0.986(9.16)	0.894(9.61)
Medfirm			0.800(9.73)	0.683(7.56)
Bigfirm			1.018(15.47)	0.784(10.78)
Constant	1.372(11.16)	0.488(5.26)	-0.770(-4.64)	-0.733(-1.79)
No of Obs	3991	4775	3344	2976

Table F.12: The ML Estimates of Hourly Earnings Equations

Variable	Male Union	Male Nonunion	Female Union	Female Nonunion
A2024	-0.245(-6.03)	-0.199(-4.22)	-0.155(-3.32)	-0.097(-2.37)
A2534	-0.084(-4.07)	-0.043(-1.49)	-0.009(-0.38)	0.038(1.55)
A5564	0.050(1.61)	-0.030(-0.72)	-0.080(-1.61)	-0.087(-1.59)
Single	-0.009(-0.30)	-0.115(-3.32)	-0.040(-1.32)	0.014(0.43)
Element	-0.101(-3.05)	-0.041(-0.85)	-0.056(-1.12)	-0.192(-3.39)
Postsecd	0.073(3.67)	0.096(3.27)	0.088(2.81)	0.113(4.22)
Univgrad	0.281(9.24)	0.239(6.49)	0.315(7.81)	0.337(8.29)
Atlantic	-0.186(-6.93)	-0.257(-7.33)	-0.137(-4.39)	-0.266(-7.68)
Quebec	-0.046(-1.49)	-0.056(-1.27)	0.038(1.14)	-0.089(-2.30)
Prairie	-0.065(-2.16)	-0.137(-3.43)	-0.091(-3.04)	-0.172(-5.08)
Alberta	-0.040(-1.22)	0.009(0.24)	-0.043(-1.31)	-0.048(-1.39)
BC	0.041(1.17)	0.032(0.69)	0.111(2.58)	-0.050(-1.28)
Ten01	-0.004(-0.18)	-0.082(-2.91)	-0.029(-1.13)	-0.043(-1.74)
Ten610	0.028(1.02)	0.105(2.64)	0.067(1.89)	0.105(3.21)
Ten1120	0.084(3.42)	0.123(3.48)	0.110(3.70)	0.190(5.19)
Ten20ov	0.115(3.75)	0.198(3.78)	0.165(4.44)	0.194(2.97)
Primind	0.085(2.29)	0.146(3.03)	-0.165(-1.95)	0.262(2.17)
Constrct	0.196(5.25)	0.112(2.06)	0.340(1.34)	-0.034(-0.49)
Service	-0.095(-2.36)	-0.058(-1.55)	-0.093(-1.62)	-0.142(-2.97)
Trcmut	0.002(0.05)	-0.018(-0.39)	0.117(1.95)	0.034(0.60)
Healeduc	-0.097(-2.22)	-0.197(-2.15)	0.017(0.34)	-0.073(-1.13)
Pubadm	-0.023(-0.59)	-0.089(-0.96)	0.045(0.76)	0.058(0.67)
Wcolr1	0.065(1.77)	0.152(3.06)	0.232(4.98)	0.275(4.91)
Wcolr2	0.008(0.29)	-0.082(-2.03)	0.064(1.37)	0.091(1.74)
Public	0.032(1.02)	0.105(1.22)	0.073(2.20)	0.085(0.90)
Medfirm	0.046(1.56)	0.084(1.83)	0.108(3.01)	0.062(1.42)
Bigfirm	0.062(2.08)	0.125(2.69)	0.124(3.58)	0.123(2.76)
Constant	2.741(49.57)	2.530(40.35)	2.212(26.59)	2.065(27.39)
Log-Likelihood	-39671		-49326	
No of Obs	1547	1797	1236	1740

Table F.13: The ML Estimates of Weekly Hours Equations

	Male		Female	
Variable	Union	Nonunion	Union	Nonunion
Logwage	-0.582(-1.68)	-0.019(-0.06)	-0.404(-1.61)	0.128(0.27)
Head	-0.004(-0.14)	0.001(0.05)	0.061(1.33)	0.105(2.65)
Chd05	-0.007(-0.44)	0.002(0.11)	-0.067(-0.91)	-0.125(-2.73)
Unempl	-0.016(-0.46)	0.003(0.05)	0.065(0.61)	0.149(1.65)
A2024	-0.152(-1.60)	0.013(0.17)	-0.042(-0.56)	0.117(1.59)
A2534	-0.041(-1.04)	0.009(0.32)	0.050(1.44)	0.100(2.42)
A5564	0.009(0.21)	-0.056(-1.71)	-0.107(-0.56)	-0.088(-0.80)
Single	-0.092(-2.78)	-0.029(-0.60)	0.070(1.22)	0.041(0.73)
Element	-0.016(-0.32)	0.029(0.80)	-0.011(-0.09)	-0.077(-0.65)
Postsecd	0.039(1.10)	-0.033(-0.78)	0.067(0.81)	0.013(0.19)
Univgrad	0.198(1.84)	-0.025(-0.28)	0.162(1.05)	-0.146(-0.87)
Atlantic	-0.051(-0.60)	0.012(0.11)	-0.100(-0.81)	-0.061(-0.42)
Quebec	-0.042(-0.96)	-0.009(-0.17)	-0.095(-1.24)	-0.053(-0.64)
Prairie	-0.021(-0.48)	-0.041(-0.67)	-0.040(-0.80)	-0.125(-1.32)
Alberta	0.073(1.83)	0.026(0.74)	-0.017(-0.33)	-0.014(-0.29)
BC	0.011(0.32)	-0.008(-0.20)	-0.010(-0.14)	-0.154(-2.54)
Ten01	0.023(0.89)	0.001(0.04)	0.009(0.30)	0.037(1.20)
Ten610	0.022(0.68)	0.000(-0.01)	0.050(1.15)	-0.007(-0.12)
Ten1120	0.040(0.91)	-0.002(-0.04)	0.145(2.86)	0.044(0.45)
Ten20ov	0.054(0.95)	0.019(0.24)	0.166(2.37)	0.048(0.37)
Primind	0.141(3.12)	0.090(1.31)	0.171(0.80)	-0.012(-0.06)
Constrct	0.178(2.52)	0.039(0.67)	0.073(0.51)	-0.163(-1.58)
Service	-0.034(-0.63)	-0.007(-0.19)	-0.020(-0.26)	-0.074(-0.85)
Trcmut	0.036(1.02)	0.072(1.70)	-0.044(-0.48)	-0.274(-3.21)
Healeduc	-0.131(-2.01)	-0.170(-1.32)	-0.210(-2.92)	-0.258(-2.30)
Pubadm	-0.013(-0.26)	0.141(1.77)	-0.058(-0.68)	0.035(0.30)
Wcolr1	0.070(1.47)	0.025(0.30)	0.071(0.77)	-0.043(-0.24)
Wcolr2	0.013(0.35)	-0.015(-0.41)	-0.005(-0.07)	-0.192(-1.79)
Public	-0.076(-2.32)	-0.224(-4.49)	-0.080(-2.20)	-0.217(-2.49)
Constant	5.405(5.55)	3.782(4.57)	4.684(7.71)	3.268(3.46)
Log-Likelihood	-39671		-49326	
No of Obs	1547	1797	1236	1740

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