Is Collective Bargaining Pareto Efficient? A Survey and Empirical Investigation

by

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1 Introduction

There are surely few economists who would deny that, even today, labour unions are very significant economic institutions. They represent a significant portion of the workforce in all developed countries, with union density rates in 2001 ranging from 12.8% in the United States to 85.1% in Iceland; Canada's union density rate climbed from 27.6% in 1963 to 36.6% in 1983, although it has since declined to a rate of 28.2% in 2002[1]. In fact, these statistics likely underestimate the importance of unions, since, in many (particularly European) countries, unions negotiate wages for many employees who are not officially members of unions[2].

Clearly, unions are important, and it is this importance that makes their consequences for efficiency so substantial. The literature on the economics of trade unions is an old one, but a quiet one through most of the 20th century, until the 1980s, when interest in the economic analysis of unions was revived[3]. Part of the impetus for this revival was a paper in 1981 by Ian McDonald and Robert Solow which formalized, algebraically and graphically, ideas which were first expressed in the context of labour markets 35 years earlier by Wassily Leontief. The standard textbook model of the labour union treats the union as a conventional monopoly seller of labour, selecting the wage while the firm chooses the level of employment - which is equivalent to the union choosing their most preferred point on the firm's labour demand curve; McDonald & Solow, however, drew from Leontief's realization that such an outcome is not Pareto efficient, to design a model in which the firm and union negotiate to an outcome in which neither party could be made better off without making the other worse off.

Further theoretical work followed that of McDonald & Solow, and a still-growing

[1] Statistics on union density are from Trade Union Density (2004). High union density rates are much more common in Europe than anywhere else; 2001 rates include 53.6% in Norway, 55.8% in Belgium, 73.8% in Denmark, 77.8% in Finland, and 78.0% in Sweden.

[2] See Economic Performance (1997).

[3] Excellent surveys of the entire field of research into the economics of unions are performed by Pencavel (1991) and Kaufman (2002).

empirical literature began to develop, a significant portion of it dedicated to testing McDonald & Solow's model against the traditional labour demand curve theory. This paper will attempt to add to that literature, by first surveying the theoretical and empirical literature on this subject, and then applying two of the most popular empirical testing procedures to a data set on employment at the Canadian Pacific Railway between 1957 and 1986.

The results of this empirical work are generally inconclusive. Use of the empirical framework proposed by Brown & Ashenfelter (1986) provides little evidence for the existence of Pareto efficient bargaining, and moderate evidence for the traditional monopoly union model, although the results may also suggest the existence of efficiency wages in some cases. An alternative approach advocated by Manning (1987) and implemented by Alogoskoufis & Manning (1991) yields indeterminate results in most cases, with numerous specifications in which neither model can be rejected; however, in some specifications of the model, there is fairly strong evidence in favour of Pareto efficiency, while in other specifications it is possible to reject both efficient bargaining and the monopoly union model. This paper, therefore, is unable to provide a definitive answer to the empirical question of the wage-employment outcome of collective bargaining.

The paper is organized as follows: Section II outlines the basic economic theory of the two principal models of union behaviour; Section III surveys the literature on empirical testing between these models; Section IV establishes the two empirical frameworks which will be employed; Section V introduces the data that will be used; Section VI will present the results and analysis of the empirical work; and section VII concludes.

2 Economic Theory of the Labour Union

It is widely acknowledged that the theoretical economic analysis of wage and employment determination in unionized labour markets originated with the work of Dunlop

(1944)[4]. His formulation of the problem assumes that the union is limited to choosing a point on the firm's labour demand curve[5]; this formed the basis of what is now commonly referred to as the Monopoly Union (MU) model, a model that would be further developed by Fellner (1947), Cartter (1959) and Oswald (1982). The following subsection will lay out the basic theoretical framework of the MU model.

2.1 Monopoly Union

In the Monopoly Union model, the union first chooses the wage, and then the firm chooses employment subject to that wage, so the model can be approached as a two-stage game. In what follows in this section, the basic notational approach of McDonald & Solow (1981), with some simplifications, will be adopted.

Let L represent employment and w the wage. In the second stage, the firm will choose L to maximize profit; let us assume that the firm has some concave revenue function $R(L)$, as a function of the employment level. The firm's profit is then $\pi = R(L) - wL$, and subject to the wage chosen by the union, the firm will choose L to satisfy:

$$\max_L \ \pi = R(L) - wL$$

$$R_L = w. \tag{1}$$

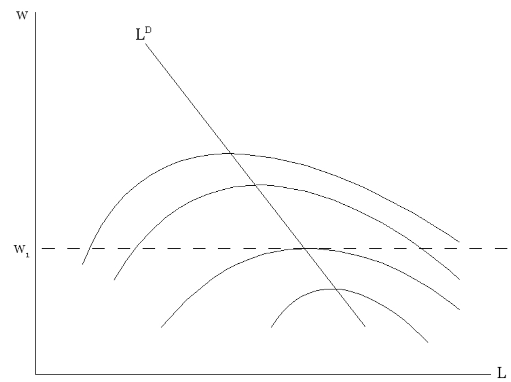
This defines the firm's labour demand curve; for any w chosen by the union, the employment level L that the firm will select is defined by (1). This result can be seen in Figure 1 below.

Defining the objective function of the union is, as Dunlop noted, rather more

[4]For a detailed discussion of the history of the economic theory of labour unions, see MaCurdy & Pencavel (1986).

[5]Perhaps the most cited passage from Dunlop's book states that "An economic theory of a trade union requires that the organization be assumed to maximize (or minimize) something ... But the model is not so easily constructed since the crucial question Whose wage bill? remains." Aside from the assertions by Ross (1948) that the trade union is a political institution that is not suited to economic analysis (he claimed that "the traditional market forces are not of compelling significance under collective bargaining. Ideas of equity and justice ... move in difference channels from supply and demand"), this assessment has been widely accepted, although, as we shall see later, Dunlop's "crucial question" of what the union maximizes remains a controversial one.

Figure 1: Labour Demand Curve



difficult. The most general way to proceed is to define a utility function for the union $U(w, L)$ (with U_w, $U_L > 0$) over the contract wage and the level of employment; McDonald & Solow impose greater structure on union preferences by assuming that all union members are identical, and that union utility can be expressed as the expected utility of an individual member given some probability of unemployment. Under this assumption, we can write $U(w, L) = N^{-1}[L(u(w))+(N-L)u(\overline{w})]$, where N represents the membership of the union, $u(.)$ is a standard concave income utility function, and $\overline{w}$ represents the generic unemployment alternative, including unemployment benefits and utility from leisure[6]. Since N and $\overline{w}$ are fixed for the purpose of union wage setting, we can redefine $U(w, L) = L[u(w) - u(\overline{w})]$. The union will select w to maximize U (however U is defined); this is equivalent to choosing w and L subject to $R_L = w$:

$$\max_{w,L} U(w, L) \; s.t. \; R_L = w$$

$$\mathcal{L} = U(w, L) + \lambda[R_L - w]$$

$$U_w - \lambda = 0$$

$$U_L + \lambda R_{LL} = 0.$$

[6]This is slightly different from the notation used by McDonald & Solow; in their initial model, they separate unemployment income from disutility of work, although they later recombine them.

Therefore:

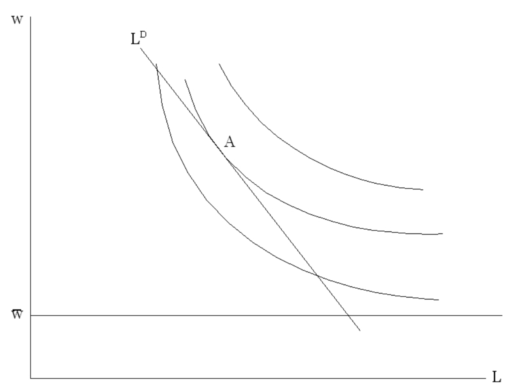
$$U_L + U_w R_{LL} = 0$$
$$\frac{-U_L}{U_w} = R_{LL}. \tag{2}$$

Or, in the case of $U(w, L) = L[u(w) - u(\overline{w})]$:

$$\frac{-[u(w) - u(\overline{w})]}{Lu_w} = R_{LL}. \tag{3}$$

This result means that the union will choose the point where the firm's labour demand curve is tangent to one of their indifference curves in (w, L) space, as at point A in Figure 2.

Figure 2: Tangency of Labour Demand Curve and Union Indifference Curve



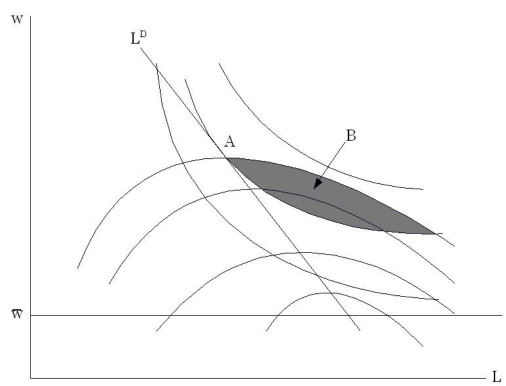
The Monopoly Union model has proven to be very popular as a description of union wage and employment outcomes, partly because the underlying game structure seems to correspond with reality; most collective bargaining processes typically do provide employers with considerable discretion over the quantity of employment[7]. However, it is not difficult to see that this outcome is not Pareto efficient; there are wage-employment combinations that lie off the labour demand curve which could leave both firm and union better off. This was first noted, in the context of labour

[7]This rationale for the popularity of the Monopoly Union model is identified by MaCurdy & Pencavel (1986), among others.

markets, by Leontief (1946), and developed further by Fellner (1947); the idea is developed in greater algebraic (as well as graphical) detail in the seminal paper by McDonald & Solow (1981).

We need only overlay Figures 1 and 2 to see this inefficiency graphically; this is done in Figure 3, and the result is a region of wage-employment combinations, labelled B, in which at least one of the firm and union can be made better off than at point A without making the other worse off. Graphically, this arises because, as Figure 1 demonstrates, the labour demand curve is defined as the locus of points at which the firm's isoprofit curve is horizontal; meanwhile, the union's indifference curve is always downward-sloping. Pareto efficiency requires tangency of the firm's isoprofit curve and the union's indifference curve, which clearly can never occur along the labour demand curve.

Figure 3: Inefficiency of Monopoly Union Outcome



As a result, an alternative model has been developed, in which the firm and union bargain to an allocation that is Pareto efficient; the rationale for such a model is that economic agents in a one-on-one negotiation would not leave unexploited gains from trade on the table[8]. This model will be referred to as the Efficient Bargaining (EB)

[8]Pencavel (1991) argues that "most economists ... are inclined to the view that union-management bargaining will not leave unexploited any opportunities to raise one party's welfare

model, and will be outlined below.

2.2 Efficient Bargaining

A Pareto efficient allocation of labour, as discussed above, will occur only when the isoprofit and union indifference curves are tangent to each other; in other words, when:

$$\frac{-U_L}{U_w} = \frac{R_L - w}{L}. \tag{4}$$

Or, in the McDonald & Solow case of $U(w, L) = L[u(w) - u(\overline{w})]$:

$$\frac{-[u(w) - u(\overline{w})]}{u_w} = R_L - w. \tag{5}$$

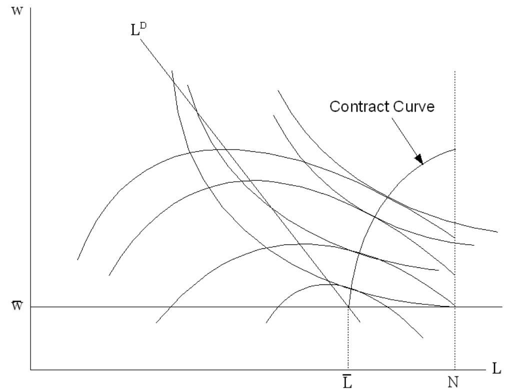
This defines a locus of Pareto efficient wage-employment combinations, which, in the economic literature, is commonly referred to as the contract curve; it is illustrated in Figure 4. In the McDonald & Solow case, we can see that the contract curve will intersect the labour demand curve only at $w = \overline{w}$, because, at any point on the labour demand curve, $R_L - w = 0$, and the left-hand side of (5) is only zero when $w = \overline{w}$. If $\overline{w}$ is the alternative wage, representing either the wage in an alternative job or the unemployment alternative (including utility from leisure), then $w = \overline{w}$ represents the competitive equilibrium.

In Figure 4, the contract curve is drawn as upward-sloping, which is the most common depiction; however, it is not clear that this will necessarily be the case. In McDonald & Solow's expected-utility formulation, the contract curve will necessarily be upward-sloping, but other union preference structures could result in a vertical contract curve, as in an earlier paper by Hall & Lilien (1979), or even a downward-sloping curve[9].

that do not reduce the other party's welfare." However, Pencavel (1984) notes that this assumes the absence of transaction costs. Fellner (1947) explains that there may be institutional obstacles preventing union and firm from reaching efficiency, such as the firm wanting to avoid the risk inherent in specifying employment in advance.

[9] Hall & Lilien's vertical contract curve is a result of their assumption of zero income elasticity of labour supply; see McDonald & Solow (1981). McDonald & Solow (1981) demonstrate that a downward-sloping contract curve would be the result if the union acted as a commune or family. Brueckner (2001) analyses various cases in which we can specify which way the contract curve slopes.

Figure 4: Contract Curve



Additionally, if a collective bargaining agreement ends up on the contract curve, there is no clear agreement as to what point on the contract curve would result, although numerous ways of making this decision are proposed, the most popular of which is the asymmetric (or symmetric) Nash bargain[10].

The Efficient Bargaining model draws its appeal from the fact that, unlike the Monopoly Union model, it does not result in a situation of unexploited gains from trade in a bilateral negotiation. However, the main criticism of the Efficient Bargaining model is that its fundamental structure does not appear to correspond to reality as well as the Monopoly Union model does; we generally do not observe firms and unions negotiating directly over the quantity of employment as well as wages (this criticism motivates the analysis of a hybrid model, that of Kuhn (1988), in Section 4.3). On the other hand, collective bargaining does often cover issues which may proxy for employment, such as crew size, manning rules, and seniority wage structures[11].

[10]Pencavel (1991) outlines the basic idea of the asymmetric Nash bargain as being that which maximizes $(u-\overline{u})^{\alpha}(\pi-\overline{\pi})^{1-\alpha}$. Models using the two-stage collective bargaining structure proposed by Manning (1987) generally make use of an asymmetric Nash bargain over each of wage and employment. McDonald & Solow (1981), meanwhile, suggest a number of other possible methods of determining the equilibrium, including the existence of a dominant union or dominant firm, or some historically-determined "fair shares" division of surplus.

[11]McDonald & Solow (1981) suggest that, if it is not practical to specify the level of employment in a contract, manning agreements and "featherbedding" may allow for an approximation of the

The MU and EB models represent the two most popular alternative economic representations of the wage-employment outcome of collective bargaining[12], and deciding between these two models is not just an issue of curiosity; there are some clear normative implications which arise from the two models. If the Monopoly Union model is correct, employment in unionized firms will be inefficiently low and wages will be too high; in a simple efficiency analysis, unions would be socially inefficient institutions and a weakening of union power would likely enhance social welfare (assuming that non-unionized labour markets would be relatively competitive). If Efficient Bargaining is a better description of reality, these conclusions may not be true; if the contract curve is vertical, the employment level will actually be fully efficient[13], and otherwise employment will either be too high or too low for social efficiency, but will likely be less socially inefficient than the Monopoly Union outcome[14]; it is certainly the case that the policy recommendations that one would make with regard to labour markets will differ depending on which is the correct model. As a result of these normative considerations, a growing empirical literature has developed to attempt to test between these two hypotheses (and others); the following section will examine the more common empirical testing procedures used, and the findings of this literature.

efficient outcome. Johnson (1990) and Oswald (1993) both discuss the occurrence of such procedures in reality. However, as will be discussed later, several authors have cast doubt on the idea that bargaining over such measures can actually approximate an efficient outcome.

[12]Perhaps the third most popular representation is the median-voter model, which will be discussed briefly in the following section. Also, numerous papers have emphasized the role of seniority beyond a simple median-voter framework, including Frank (1985), Kuhn (1988), and Kuhn & Robert (1989), who analyse a simple two-worker example of Kuhn (1988); see Section 4.3 for a more detailed explanation of Kuhn (1988).

[13]However, it is possible that the quantities selected of other inputs could be inefficient; when the union raises wages about the competitive level, this could provide the firm with incentive to change their use of capital inputs, possibly to use relatively more capital due to its lower relative price. Hirsch & Prasad (1995), however, argue that unionized firms will in fact have a *lower* capital-labour ratio, as unions impose what they term a "union tax on capital," since the union effectively shares some of the quasi-rents that make up the normal return to capital. Manning (1987) also identifies a potential for unions to cause underinvestment in capital.

[14]Fellner (1947) identifies reasons why full social efficiency is unlikely to result. Brown & Ashenfelter (1986), Johnson (1990), and Swanson & Andrews (2007) provide a good explanation of some of the efficiency consequences of the distinction between the MU and EB models.

3 Empirical Testing Procedures

The most commonly adopted empirical procedure used to test between the MU and EB models is the one initially suggested by Brown & Ashenfelter (1986), and subsequently used, with alterations, by Card (1986), Bean & Turnbull (1988), Gavosto (1997), and Dimova (2006)[15]. This procedure is based on the results (1) and (4) above; if the MU hypothesis is correct, then we are on the labour demand curve, and it must be that $R_L = w$; if EB is correct, result (4) tells us that: $\frac{-U_L}{U_w} = \frac{R_L - w}{L}$, or

$$R_L = w - \frac{LU_L}{U_w}. \tag{6}$$

Therefore, with some assumptions about the union's utility function, the Monopoly Union model can be evaluated using a nested test. As we will see later, this test generally involves a regression of employment on (among other things) the contract wage and the alternative wage; if the MU model is correct, the coefficient on the alternative wage will be zero, whereas, if the EB model is correct, the alternative wage will have a negative coefficient (and the contract wage will have a zero coefficient if the contract curve is vertical). The exact details of the regression equations to be used will be explained in greater detail in Section 4.1.

This empirical procedure has the virtue of simplicity, but it has come under some considerable criticism. The primary criticism is about the nested nature of the test; as Martinello (1989) points out, although equations (1) and (6) are nested, the MU and EB models are inherently not nested, and there are several conditions on $U(w, L)$ which must be met for the test to work effectively[16].

[15]Brown & Ashenfelter, Bean & Turnbull, and Dimova (in an application to an economy in transition, namely Bulgaria) all find at least some evidence in favour of Efficient Bargaining, and Gavosto even finds evidence to support a vertical contract curve. Card, meanwhile, alters Brown & Ashenfelter's procedure to use a dynamic framework, with current alternative wages affecting future contract wages; he rejects both EB and MU in favour of a general contracting alternative.

[16]Specifically, union preferences must depend on alternative wages, and alternative wages cannot be weakly separable from wages and employment in the union utility function. Andrews & Harrison (1998) adds that the MU and EB models require different sets of instrumental variables for the contract wage; they also point out that, if the union does not care about employment, the contract curve will coincide with the labour demand curve, but a nested test cannot distinguish between this possibility and a Pareto inefficient result off the contract curve.

Additionally, if the null is rejected (whichever model is treated as the null), this would normally cause us to accept the alternative hypothesis, but in this case it is not clear what the alternative hypothesis would be. A number of authors have identified reasons why the wage-employment outcome could be between the strict Monopoly Union and Efficient Bargaining outcomes[17], and if this is the case, it could be that both models are incorrect, but the Brown & Ashenfelter procedure can only test between them.

Finally, Dunlop's "crucial question" of what the union maximizes remains unanswered today[18]; an empirical method like Brown & Ashenfelter's, which requires that a functional form be specified for union utility, therefore, is potentially problematic.

Several alternative testing procedures have been developed to meet these criticisms; a notable example is that of a two-stage collective bargaining game, introduced by Manning (1987). In this framework, the union and firm negotiate first over the wage, and then over employment, and the union may have different bargaining power at the two stages. This framework allows the EB and MU models to both be expressed as special cases of a more general bargaining model; if the union's employment bargaining power is q and their wage bargaining power is p, it can be shown that the Monopoly Union model implies $p = 1$ and $q = 0$ (and the related Right-To-Manage model, in which the firm sets employment but the union may not have complete power over the wage, implies $p < 1$ and $q = 0$), while the Efficient Bargaining model re-

[17]Clark (1990) and Johnson (1990) both demonstrate that bargaining measures that may appear to approximate bargaining directly over employment, such as featherbedding and agreements over crew size and work-intensity, may actually lead to outcomes that are not fully efficient. Other reasons for expecting the EB model to result in outcomes that are not Pareto efficient are discussed by Layard & Nickell (1990), Heywood (1993), Manning (1994), and Chezum & Garen (1996).

[18]Blair & Crawford (1984) demonstrate that a union's preferences, expressed through majority voting, generally will not have a von Neumann-Morgenstern representation. It is partly for this reasons that numerous papers (including Dertouzos & Pencavel (1981), Pencavel (1984), MaCurdy & Pencavel (1986) and Brown & Ashenfelter (1986)) have analysed data from the International Typographical Union; Brown & Ashenfelter suggest that problems in aggregating union preferences are less problematic when, as is the case with the ITU, union members are relatively homogenous and the union is highly democratic. An excellent survey and analysis of the difficulties of specifying and estimating union preferences is provided by Pencavel (1985), as well as Pencavel (1991). Empirical analysis of union preferences given a median-voter model is performed by Farber (1978), and for a general MU model by Dertouzos & Pencavel (1981), Pencavel (1984) and Carruth & Oswald (1985).

quires $p = q$. It is therefore possible to estimate a general bargaining equation, which nests the Monopoly Union and Efficient Bargain models as special cases and allows one to test each model against a general alternative. An additional benefit, noted by Manning, is that, if suitable proxies can be found for p and q, it is not necessary to specify a functional form for union utility, thereby avoiding the drawback faced by models such as that of Brown & Ashenfelter. This two-stage bargaining model is used empirically by Alogoskoufis & Manning (1991), Nickell & Wadhwani (1991), Vannetelbosch (1996), and Andrews & Harrison (1998)[19]; other non-nested equation models are suggested by Martinello (1989) and Christofides (1990)[20].

Meanwhile, one approach to solving the difficulties of specifying a union utility function has been to treat the union leadership as the result of a median-voter process, with union members distributed along a continuum of seniority. In such a model, as Oswald (1993) demonstrates, union indifference curves will be flat (at least starting at the employment level of the median voter)[21]; unions are indifferent to the level of employment. An empirical paper by Carruth, Findlay & Oswald (1986), however, rejects the flat indifference curve hypothesis.

Finally, a somewhat unique representation of the collective bargaining process is that of Espinosa & Rhee (1989), who model it as a dynamic repeated game. In this model, in each period, the union first chooses the wage, and then the firm chooses employment; then the game repeats in subsequent periods. In spite of the Monopoly Union structure of the game (at least in the static sense), this framework can result in a cooperative steady-state equilibrium somewhere between those predicted by the Monopoly Union and Efficient Bargaining models; if discount rates are low enough,

[19] Alogoskoufis & Manning and Vannetelbosch (the latter using a considerably more complex econometric approach) reject both the EB and MU models in favour of the general bargaining model. Nickell & Wadhwani use a model which allows for the possibility of efficiency wages, and find that their data supports that interpretation. Andrews & Harrison find insufficient evidence from their data to reject either the MU or EB model.

[20] Martinello is unable to reject either MU or EB; Christofides rejects MU in favour of some form of efficient bargaining.

[21] With flat indifference curves, Oswald shows that the contract curve would coincide with the labour demand curve.

full efficiency may even be supported as an equilibrium. De la Rica & Espinosa (1997) test between the static (Monopoly Union and Efficient Bargain) models and the dynamic framework, and find that a generalized dynamic model is supported by their data.

The empirical literature on this subject has become increasingly sophisticated, and there have been a wide variety of other innovative empirical frameworks proposed[22]. However, this paper will confine itself to examining, and attempting to reproduce, two of the simpler and most commonly used empirical procedures: the Brown & Ashenfelter procedure, and the two-stage bargaining game of Manning, using the specific empirical approach of Alogoskoufis & Manning.

4 Framework for Empirical Analysis

4.1 Brown & Ashenfelter

Brown & Ashenfelter begin by observing that a Pareto efficient contract must satisfy a condition equivalent to (6) above; to use a simplified version of their notation:

$$\frac{w - R_L}{L} = \frac{U_L}{U_w}. \tag{7}$$

They then restate this condition as:

$$R_L = w(1 + \epsilon_{w,L}) \tag{8}$$

where $\epsilon_{w,L} = \frac{-U_L}{U_w}\frac{L}{w}$ represents the elasticity of wages with respect to employment along the relevant union iso-utility locus. Meanwhile, a contract on the labour demand

[22] MaCurdy & Pencavel (1986) estimate production and utility functions, and compare the ratio of the marginal products of inputs to the ratio of prices; they find evidence in favour of the EB model, although they reject a vertical contract curve. Eberts & Stone (1986) find that the difference between the union wage and the marginal revenue product is positively related to the level of employment security provisions, which they interpret as evidence in favour of the EB model. Abowd (1989) tests whether collective bargains maximize the sum of shareholder and union wealth, and finds that, at the time of contract renegotiation, stock values move in the opposite direction from unexpected changes in labour costs, and at approximately a one-to-one rate, which is consistent with strong efficiency. Swanson & Andrews (2007) use a stochastic cost frontier approach and find that more heavily unionized industries are more likely to operate off their labour demand curve, a result that is inconsistent with the MU model.

curve will satisfy the familiar condition given by (1):

$$R_L = w. \tag{9}$$

To proceed further, some functional forms for marginal revenue product and for the union's preferences must be adopted; Brown & Ashenfelter suggest for the workers' MRP:

$$\log(R_L) = \alpha_0 + \boldsymbol{\alpha_1}\mathbf{X} - \alpha_2 \log(L) \tag{10}$$

where $\mathbf{X}$ represents a vector of variables that could affect MRP other than the employment level. For union preferences, Brown & Ashenfelter suggest two alternative structures. The first of these is a generalized Stone-Geary function[23]:

$$U(w, L) = k(w - \overline{w})^{\beta} L^{1-\beta} \tag{11}$$

where $\overline{w}$ represents the union members' alternative wage. The second functional form proposed is an expected utility function of the "typical" union member:

$$U(w, L) = \frac{L}{N} g(w) + (1 - \frac{L}{N}) g(\overline{w}) \tag{12}$$

where N represents the total union membership, and $g(.)$ is a standard concave income utility function.

It is now possible to derive equations which can be used for estimation. In the MU model, (9) is correct and we can substitute this into (10); with some rearrangement, we have:

$$\log(L) = \frac{\alpha_0}{\alpha_2} + \frac{\boldsymbol{\alpha_1}}{\alpha_2}\mathbf{X} - \frac{1}{\alpha_2}\log(w). \tag{13}$$

If the EB model is correct, we will use the condition in (8). Using a Stone-Geary union utility function, (10) becomes:

$$\log(L) = \frac{\alpha_0}{\alpha_2} + \frac{\boldsymbol{\alpha_1}}{\alpha_2}\mathbf{X} - \frac{1}{\alpha_2}\log(w - [\frac{1-\beta}{\beta}][w - \overline{w}])$$

[23] The Stone-Geary specification is commonly used for union preferences, and covers a wide range of preference structures and possible hypotheses about union preferences; for example, Andrews & Harrison (1998) note that, if $\beta = \frac{1}{2}$ (or, equivalently, if $U = k(w - \overline{w})L$), a vertical contract curve would be the result of efficient bargaining. Johnson (1990) shows that the contract curve will be negatively sloped if $\beta > \frac{1}{2}$, and positively sloped if $\beta < \frac{1}{2}$.

$$\log(L) = \frac{\alpha_0}{\alpha_2} + \frac{\boldsymbol{\alpha_1}}{\alpha_2}\mathbf{X} - \frac{1}{\alpha_2}\log[\gamma\overline{w} - (1-\gamma)w] \tag{14}$$

where $\gamma = \frac{1-\beta}{\beta}$. Using the expected utility function, Brown & Ashenfelter explain that (8) becomes:

$$R_L = w + \frac{g(\overline{w}) - g(w)}{g'(w)} \tag{15}$$

and, taking a second-order Taylor series expansion, equation (10) can be rewritten as:

$$\log(L) \approx \frac{\alpha_0}{\alpha_2} + \frac{\boldsymbol{\alpha_1}}{\alpha_2}\mathbf{X} - \frac{1}{\alpha_2}\log(\overline{w}) + \frac{\rho}{2\alpha_2}[\log(w) - \log(\overline{w})]^2 \tag{16}$$

where $\rho = \frac{-wg''(w)}{g'(w)}$ is the Arrow-Pratt measure of relative risk aversion.

Therefore, the Efficient Bargain model is represented by equation (14) in the Stone-Geary case and (16) in the expected utility case, while (13) represents the Monopoly Union model in both cases. However, upon estimating these equations, Brown & Ashenfelter find that their results are "uniformly poor," with large standard errors and parameter values that are of unexpected sign and magnitude; consequently, they decide to use a first-order approximation to equations (14) and (16), given by:

$$\log(L) \approx \frac{\alpha_0}{\alpha_2} + \frac{\boldsymbol{\alpha_1}}{\alpha_2}\mathbf{X} - \frac{\gamma}{\alpha_2}\log(\overline{w}) - \frac{1-\gamma}{\alpha_2}\log(w). \tag{17}$$

A negative coefficient on $\log(w)$ and a statistically insignificant coefficient on $\log(\overline{w})$ would be consistent with the Monopoly Union model, while a statistically significant negative coefficient on $\log(\overline{w})$ would be consistent with Efficient Bargaining; Brown & Ashenfelter divide this latter model into two alternatives, *weak efficiency*, under which there could be a significant coefficient on $\log(w)$, and *strong efficiency*, which requires a statistically insignificant coefficient on $\log(w)$ (strong efficiency implies the special case of a vertical contract curve).

As a final addition to their model, Brown & Ashenfelter relax the implicit assumption that unemployment union members can immediately obtain employment at the alternative wage, and include the natural logarithm of one minus the unemployment rate as a regressor, obtaining:

$$\log(L) \approx \frac{\alpha_0}{\alpha_2} + \frac{\boldsymbol{\alpha_1}}{\alpha_2}\mathbf{X} - \frac{\gamma}{\alpha_2}\log(\overline{w}) - \frac{1-\gamma}{\alpha_2}\log(w) - \beta\log(1-u) \tag{18}$$

where u is the unemployment rate. This variable, they explain, should have a negative coefficient if Efficient Bargaining is the correct model, and a zero coefficient under the Monopoly Union model.

4.2 Alogoskoufis & Manning

As stated above, Manning (1987) introduced the two-stage collective bargaining game model, but his paper was entirely theoretical, so this section will draw from the first attempt to use the model empirically, the paper by Alogoskoufis & Manning (1991)[24].

To begin with, the preferences of the firm and union are modelled very generally; the employer profit function is $\Pi(w, L; \mathbf{X_1}, \mathbf{X_2})$, and the union utility function is $U(w, L; \mathbf{X_3}, \mathbf{X_2})$, where w is the wage, L is employment, $\mathbf{X_1}$ is a vector of variables that only affect the profit function, $\mathbf{X_2}$ is a vector of variables that affect both profit and union utility, and $\mathbf{X_3}$ is a vector of variables that only affect union utility. Bargaining occurs in two stages, first over the wage and then over employment; the bargaining solution at each stage is an asymmetric Nash bargain, where p represents the union's bargaining power in wage negotiations and q the union's power in employment negotiations. At the second stage, once the wage has been determined, employment will be chosen to satisfy:

$$L(w; q; \mathbf{X_1}, \mathbf{X_2}, \mathbf{X_3}) = \arg\max_L \, [\Pi(w, L; \mathbf{X_1}, \mathbf{X_2})]^{1-q}[U(w, L; \mathbf{X_3}, \mathbf{X_2})]^q. \tag{19}$$

Then, moving backwards to the first stage, the wage will be chosen to satisfy:

$$w(p, q; \mathbf{X_1}, \mathbf{X_2}, \mathbf{X_3}) = \arg\max_w \, [\Pi(w, L; \mathbf{X_1}, \mathbf{X_2})]^{1-p}[U(w, L; \mathbf{X_3}, \mathbf{X_2})]^p$$

$$s.t. \; L = L(w; q; \mathbf{X_1}, \mathbf{X_2}, \mathbf{X_3}). \tag{20}$$

Equations (19) and (20) result in reduced-form wage and employment equations:

$$w = w(p, q, \mathbf{X_1}, \mathbf{X_2}, \mathbf{X_3}) \tag{21}$$

[24]However, the variables chosen in this paper will vary considerably from those used by Alogoskoufis & Manning, since they were looking at data from the U.K. aggregate labour market, rather than firm-level data.

$$L = L(p, q, \mathbf{X_1}, \mathbf{X_2}, \mathbf{X_3}). \tag{22}$$

As stated in the previous section, the MU model requires $p = 1$ and $q = 0$, while the EB model requires $p = q$. However, as Alogoskoufis & Manning comment, p and q are likely to be unobservable in any empirical setting, so (21) and (22) must be altered before they can be used empirically. Alogoskoufis & Manning suggest that we assume that p and q are functions of $\mathbf{X_4}$, a subset of $\mathbf{X_1}$, $\mathbf{X_2}$, and $\mathbf{X_3}$, and some vector $\mathbf{Z}$ of variables that do not affect profit or utility. Then, assuming that (21) and (22) are log-linear, the generally bargaining model can be written as:

$$\log(L) = \alpha_0 + \boldsymbol{\alpha_1}\mathbf{X_1} + \boldsymbol{\alpha_2}\mathbf{X_2} + \boldsymbol{\alpha_3}\mathbf{X_3} + \boldsymbol{\alpha_4}\mathbf{Z} + u_1 \tag{23}$$

$$\log(w) = \beta_0 + \boldsymbol{\beta_1}\mathbf{X_1} + \boldsymbol{\beta_2}\mathbf{X_2} + \boldsymbol{\beta_3}\mathbf{X_3} + \boldsymbol{\beta_4}\mathbf{Z} + u_2. \tag{24}$$

Finally, to allow for estimation by instrumental variables (with the contract wage as the sole endogenous explanatory variable), Alogoskoufis & Manning rewrite (23) and (24) in a form that allows employment to be expressed as a function of the wage, by replacing in the employment equation one of the elements of $\mathbf{Z}$, which they call Z_1 (making it necessary that there be at least two variables in $\mathbf{Z}$), with its solution from the wage equation:

$$\log(L) = (\alpha_0 - \gamma\beta_0) + (\boldsymbol{\alpha_1} - \gamma\boldsymbol{\beta_1})\mathbf{X_1} + (\boldsymbol{\alpha_2} - \gamma\boldsymbol{\beta_2})\mathbf{X_2} + (\boldsymbol{\alpha_3} - \gamma\boldsymbol{\beta_3})\mathbf{X_3}$$

$$+(\boldsymbol{\alpha_{4(1)}} - \gamma\boldsymbol{\beta_{4(1)}})\mathbf{Z_{(1)}} + \gamma\log(w) + (u_1 - \gamma u_2) \tag{25}$$

$$\log(w) = \beta_0 + \boldsymbol{\beta_1}\mathbf{X_1} + \boldsymbol{\beta_2}\mathbf{X_2} + \boldsymbol{\beta_3}\mathbf{X_3} + \boldsymbol{\beta_4}\mathbf{Z} + u_2 \tag{26}$$

where $\mathbf{Z}$ has been partitioned into (Z_1, $\mathbf{Z_{(1)}}$), and the parameter vectors α_4 and β_4 into (α_{41}, $\boldsymbol{\alpha_{4(1)}}$) and ($\beta_{41}$, $\boldsymbol{\beta_{4(1)}}$) respectively, and $\gamma = \frac{\alpha_{41}}{\beta_{41}}$. Since Z_1 is the only additional instrument used, this is an exactly identified model.

In this framework, if the Monopoly Union model is correct, the variables in $\mathbf{X_3}$ and $\mathbf{Z}$ only affect employment through their effect on the wage, so this implies coefficient restrictions $\boldsymbol{\alpha_3} - \gamma\boldsymbol{\beta_3} = 0$ and $\boldsymbol{\alpha_{4(1)}} - \gamma\boldsymbol{\beta_{4(1)}} = 0$. If this is the case, the coefficients on $\mathbf{X_3}$ and $\mathbf{Z_{(1)}}$ in (25) will be zero, so this allows for a simple F-test of:

$$\log(L) = (\alpha_0 - \gamma\beta_0) + (\boldsymbol{\alpha_1} - \gamma\boldsymbol{\beta_1})\mathbf{X_1} + (\boldsymbol{\alpha_2} - \gamma\boldsymbol{\beta_2})\mathbf{X_2} + \gamma\log(w) + (u_1 - \gamma u_2) \quad (27)$$

against (25).

If the Efficient Bargaining model is correct, then $\mathbf{X_1}$, $\mathbf{X_2}$,and $\mathbf{X_3}$ determine the position of the contract curve, and $\mathbf{X_4}$ and $\mathbf{Z}$ determine the point reached by collective bargaining; therefore, if the position of the contract curve is held constant and $\mathbf{Z}$ varies, the change in employment will be related to the change in the wage only through the slope of the contract curve, γ. Therefore, variables in $\mathbf{Z}$ only affect employment through their effect on the wage, which implies coefficient restrictions $\boldsymbol{\alpha_{4(1)}} - \gamma\boldsymbol{\beta_{4(1)}} = 0$. As above, a simple F-test can be performed on:

$$\log(L) = (\alpha_0 - \gamma\beta_0) + (\boldsymbol{\alpha_1} - \gamma\boldsymbol{\beta_1})\mathbf{X_1} + (\boldsymbol{\alpha_2} - \gamma\boldsymbol{\beta_2})\mathbf{X_2} + (\boldsymbol{\alpha_3} - \gamma\boldsymbol{\beta_3})\mathbf{X_3}$$
$$+\gamma\log(w) + (u_1 - \gamma u_2) \quad (28)$$

against (25).

Using the procedure outlined above, a test of each of the Monopoly Union and Efficient Bargaining models can be made, against a general bargaining alternative in each case. As Alogoskoufis & Manning point out, (27) is a special case of (28) with $\mathbf{X_3}$ excluded, which allows us to test the MU model against the EB model; however, as they state, this suffers the same limitations as the Brown & Ashenfelter test, in that a rejection of one model does not imply acceptance of the other.

4.3 An Alternative Model of Collective Bargaining - Kuhn (1988)

Our earlier analysis identified potential weaknesses of both the Monopoly Union and Efficient Bargaining models. The MU model leads to outcomes that are not Pareto efficient, which would seem to require the existence either of transaction costs or institutional obstacles to agreement, or irrational behaviour on one or both sides of the bargaining table; meanwhile, the EB model corresponds imperfectly to a reality in which we rarely observe direct negotiation over employment. A natural question, therefore, is whether models have been proposed which combine the better features of each, allowing the firm to freely choose the quantity of employment while still achieving Pareto efficiency.

Indeed, there have been several plausible models which have incorporated these characteristics. The first of these was likely that of Hall & Lilien (1979), who demonstrate that the union, instead of just specifying a wage, could require that the total wage bill be a function of employment, in such a way that the firm's profit maximizing choice of employment would be the efficient amount. Specifically, if $R(L)$ is the firm's revenue function, and $V(L)$ is opportunity cost of labour, the efficient quantity of employment L^* would be the one at which $R_L = V_L$; if the union sets the total wage bill as $B(L)$, they know the firm will choose the quantity of employment at which $R_L = B_L$. In that case, if the union set $B_L = V_L$ at $L = L^*$, they know that the firm will choose the efficient level of employment; the firm would be free to choose any level of employment they prefer, but they would necessarily choose the efficient quantity[25].

While innovative, Hall & Lilien's model has some shortcomings; in particular, it assumes that the union cares about the total wage bill and not its distribution among members, or alternately that the union can make unlimited lump-sum transfers between union members. Neither of these assumptions seems entirely realistic; however, this critique was addressed by Kuhn (1988), who proposed a model in which the union can specify a seniority wage profile. Instead of a general wage-bill function, the union specifies the wage rate for workers at each individual position along the seniority continuum, and requires that, if the firm wishes to lay off workers, they must begin with those with the lowest level of seniority; in this way, just as in Hall & Lilien, the union defines a marginal wage as a function of employment. It is not hard to see that it would be possible for the union to achieve the efficient employment

[25]Martinello (1989) discusses an industry (the British Columbia wood products industry) in which such a situation may be the reality.

outcome by setting the marginal wage equal to the opportunity cost of labour at the efficient quantity[26]; in effect, the union can act as a first-degree price discriminating monopolist, setting a non-linear price for labour.

Kuhn's model is intuitively satisfying, but the next step must be to assess its consequences for empirical testing; we must consider how it could affect the results of the two empirical procedures we will be employing. In Brown & Ashenfelter's procedure, we are concerned with the relationship between employment on the one hand and the contract wage and alternative wage on the other hand. Of course, we would expect the marginal contract wage to be equal to the alternative wage, so if we have data on the starting wage for new employees, we could face some difficulties; fortunately, as will be discussed in Section V, our data includes the average yearly wage, which, if Kuhn's model is correct, should have no effect on employment (since it is largely determined by inframarginal employees). The Kuhn model, therefore, should result in employment varying negatively with the alternative wage, and independent of the contract wage, which happens to be the outcome that would be expected from the EB model with a vertical contract curve. As a result, we will not be able to specifically identify the Kuhn model using the Brown & Ashenfelter testing procedure; it will be indistinguishable from a vertical contract curve.

Using the Alogoskoufis & Manning procedure, the analysis is more complicated. Simplistically, it would seem that $p = 1$ and $q = 0$, which is consistent with the MU model; however, instead of the average contract wage, the union can be considered to be setting the marginal contract wage, and they should be setting it equal to the alternative wage. Envisioned this way, equations (19) and (20) become:

$$L(w_m; \mathbf{X_1}, \mathbf{X_2}) = \arg\max_{L}\ \Pi(w_m, L; \mathbf{X_1}, \mathbf{X_2}, w) \tag{29}$$

and:

$$w_m = \overline{w} \tag{30}$$

[26]Kuhn, however, assumes that the firm can shut down ex post and avoid any payments to the union, in which case employment will differ from first-best.

where w_m is the marginal contract wage, and w is the average contract wage. The reduced-form employment equation (22) becomes:

$$L = L(\overline{w}, \mathbf{X_1}, \mathbf{X_2}, w) \tag{31}$$

and the general bargaining model can be written as:

$$\log(L) = \alpha_0 + \boldsymbol{\alpha_1}\mathbf{X_1} + \boldsymbol{\alpha_2}\mathbf{X_2} + \gamma_0 \log(w) + \gamma_1 \log(\overline{w}) + u_1 \tag{32}$$

$$\log(w) = \beta_0 + \boldsymbol{\beta_1}\mathbf{X_1} + \boldsymbol{\beta_2}\mathbf{X_2} + \boldsymbol{\beta_3}\mathbf{X_3} + \boldsymbol{\beta_4}\mathbf{Z} + u_2. \tag{33}$$

It seems reasonable that the average contract wage should still be treated as endogenous. Therefore, we would like to test the Kuhn model by performing an F-test of (32) against (25), except that (32) contains $\log(\overline{w})$ as an explanatory variable; in order to perform this test, therefore, we will need to estimate (25) with $\log(\overline{w})$ as an additional regressor. Since the union wage markup percentage is already included as a variable in **Z**, there may be considerable multicollinearity, but we must keep *wmarkup* in order to have two variables in **Z**, to allow for IV estimation. The results of these tests will be reported in Section 6, and the actual table of estimates can be found in Appendix C.

5 Canadian Pacific Railway Data

The empirical work in this paper makes use of data from the Canadian Pacific Railway (CPR) in the period of 1957-86[27], including data on employment and compensation in the "running trades" (the positions of conductor, engineer, brakeman, and fireman), and data on the CPR's finances, equipment, track, and traffic. The data was collected from Statistics Canada's *Railway Transport* series; see Appendix A for further information on data sources.

[27] Prior to 1957, railway employment data reported by the Canadian government was not broken down by company, and after 1986, employment data is not listed by specific job categories. The period of 1957-86 was the only period for which data was available for specific companies and specific job categories.

The choice of the Canadian Pacific Railway for the empirical work was largely motivated by the availability of large amounts of data; the Canadian government keeps extensive records of railway activity, in the aforementioned *Railway Transport* series. Furthermore, during the 20th century, the CPR was one of Canada's largest employers, with a workforce that reached a peak of 83848 in 1952[28], and so it may be hoped that wage and employment outcomes at the CPR are somewhat representative of Canada at large during this period.

Additionally, railway unions in general are often considered to be among the strongest unions in industry, perhaps making them more able to enforce higher levels of employment[29]; the CPR appears to have been no exception, at least in its earlier years[30]. Also, very little research in this field has been done on Canadian data; Card (1990) and Wessels (1991) are among the few that have made use of Canadian data.

There are, however, several difficulties that the CPR data presents for our purposes. First of all, there were many different unions which negotiated with the CPR, which, on the surface, would seem to complicate the analysis; however, during World War II, railway unions began to negotiate jointly, a practice that persisted after the war, although unions in the running trades separated from those representing non-operating personnel[31]. Therefore, it does not seem too unreasonable to treat the

[28]By 1972, however, employment at the CPR had declined to 41189; see Lamb (1977).

[29]Brown & Ashenfelter (1986) state that railway unions are often said to be strong enough to enforce featherbedding. This strength of railway unions seems to have been the case throughout the 20th century; MacKinnon (2004) comments that railways were among the first Canadian firms to engage in collective bargaining, and by the 1920s, nearly all skilled and semi-skilled railway workers had their wages and working conditions negotiated in collective bargaining.

[30]From the early 1900s, most skilled workers at the CPR were represented by unions in collective bargaining; the four major running trades brotherhoods (see the following footnote) were among the earliest and most powerful unions in North America; see MacKinnon (2004).

[31]See Lamb (1977). For most of the 20th century, the four largest unions representing Canadian employees in the running trades were the Brotherhood of Railroad Trainmen, the Brotherhood of Locomotive Firemen and Enginemen, the Order of Railway Conductors and Brakemen (known as the Order of Railway Conductors until 1954), and the Brotherhood of Locomotive Engineers (BLE, now known as the Brotherhood of Locomotive Engineers and Trainmen). In 1969, the first three of those unions, along with the Switchmen's Union of North America, merged to form the United Transportation Union (UTU). The UTU and the BLE continued to negotiate jointly as the Canadian Council of Railway Operating Unions. See About UTU (2008), About the BLE (2008), and Ivanochko (2008).

running trade unions as effectively one union in their negotiations with the CPR.

A further, and more damaging, complication is that a similar joint negotiation practice was followed on the employer side as well; Canadian Pacific and the Crown corporation Canadian National Railway conducted collective bargaining negotiations jointly[32]. If the Monopoly Union model is correct, this should not present a problem, because collective bargaining only determines the wage, leaving the CPR free to choose employment; whatever wage is chosen, the result will still clearly be on the labour demand curve. If the Efficient Bargaining model is correct, however, the employer wage-employment bargaining strategy may be some form of compromise between the CPR and CNR, making our conclusions about the nature of the contract curve potentially invalid[33]. This clearly represents a drawback to the use of the Canadian railway data; however, it is unlikely that any other industry could present the opportunity for such detailed data as that provided by the railway industry, so we will proceed with the CPR data, but with caution, particularly when it comes to tests of the Efficient Bargaining model.

Data is available on employment and average wages for conductors, engineers, brakemen, and firemen; however, events during this period make the data on firemen unsuitable for empirical analysis. In 1957, a Royal Commission concluded that firemen were not needed on diesel locomotives[34]; attempts by the CPR to implement this ruling were met by strikes, both in early 1957 (before the report) and in May

[32]See Lamb (1977).

[33]Since Canadian National was a Crown corporation during the time period under examination, they were not subject to the same kind of profit motivation as the privately-owned CPR (indeed, the CNR was notorious for running large deficits during this period); it is therefore possible, and clearly to be hoped for in the empirical analysis that follows, that the CNR took a more passive role in collective bargaining and allowed the CPR to control the agenda, making it possible for us to presume that the CPR and the unions bargained, and the CNR effectively accepted the results of their negotiations. However, this may be too much to hope for, as it is likely that the CNR had their own objectives in collective bargaining; Bean & Turnbull (1988), for instance, in examining data from the nationalised British coal industry, suggest that the Coal Board may have had an objective function that included social variables such as unemployment.

[34]The Royal Commission's report stated that the functions of diesel firemen were either obsolete or could easily be duplicated by other employees, and that there was no evidence to support the unions' claim that they helped to prevent accidents; see Financial Times (1958).

1958[35]. Eventually, a compromise was reached, in which all firemen with seniority prior to April 1, 1956 received job security, but those firemen would not be replaced when their positions became vacant[36]. As a result, the numbers of firemen in both passenger and freight service declined rapidly throughout the period being studied, due, one would expect, entirely to the process of existing firemen retiring and not being replaced; as a result, there does not seem to be any useful economic information contained in the data on firemen, so their employment data will be excluded from the empirical analysis.

We therefore have data on six different employment categories: conductors, engineers and brakemen, in each of freight and passenger service. However, while freight data is available for the entire 1957-86 period, whereas CPR passenger data is only available in any consistent form until 1975. In 1976, VIA Rail was formed as the new passenger division of CNR, and in 1978, VIA became an independent Crown corporation, and also completed taking over operation of CPR passenger service[37]. Additionally, even prior to the inauguration of VIA Rail, CPR significantly reduced their passenger service due to unprofitability[38], causing a rapid decline in employment that was not matched on the freight side. Upon estimation of both the Brown & Ashenfelter and Alogoskoufis & Manning models using passenger data, it was found that many coefficient estimates were in the opposite direction from that which would be expected, and often very few coefficients were significant; whether simply as a result of the smaller sample size, or other factors, estimation using passenger data produced poor results, and so the decision was made to exclude it from examination and focus only on freight data.

One other important consideration of using post-war railway data is the possibility that the North American railway sector was declining during this period; after all, the period of 1957-86 (and indeed the entire post-war 20th century) saw a dramatic

[35]See Lamb (1977).
[36]See Lamb (1977)
[37]See Thompson (2003) and VIA Rail (2008).
[38]See Lamb (1977).

increase in the use of air transportation for both passengers and freight[39], at the same time that long-distance automobile transportation was becoming more practical with the construction of multi-lane expressways across North America. It seems natural that the railways would decline in the face of this added competition, and it is often believed that unions care more about wages when the sector is steady or growing, and more about employment when the sector is in decline[40]. It would seem, therefore, that railway unions would be likely to place a fairly high weight on employment; if the EB model is correct, therefore, it should be particularly easy for us to detect this, at least using the Brown & Ashenfelter model[41].

However, we must exercise caution before making such an assumption; while examination of data on passenger rail travel clearly indicates a rapid decline, the same cannot be said about CPR rail freight data. Figures 5 through 7 demonstrate that real freight revenue, tonnes of freight carried, and tonne-km for freight carried by the CPR all increased fairly steadily throughout the period of 1957-86; it may be that a smaller proportion of freight in Canada was being carried by rail, but in absolute terms the amount of rail freight underwent a steady increase. Meanwhile, Figure 8 illustrates that employment at the CPR did not decline significantly during this period (the number of brakemen does fluctuate considerably, and declined noticeably around 1960 and during the early 1980s, but numbers of conductors and engineers were fairly steady), and Figures 9 and 10 show that the union wage markup at the CPR also did not undergo a systematic decline during the period in question.

[39]For instance, historical data on U.S. air traffic estimate that revenue passenger ton-miles increased from about 3.2 billion in 1958 to about 37.9 billion in 1986, while revenue freight ton-miles increased from 677 million to 11.0 billion during the same period; see Air Carrier Traffic Statistics (2008).

[40]One possible way to justify such a set of union preferences would a median-voter framework, in which union members care only about wages when their own job is secure, but are much more concerned about preserving employment when they are in danger of being layed off, as described in Oswald (1993). A somewhat more general explanation of this shifting rate of substitution between wages and employment, using an insider-outsider approach, is presented by Carruth & Oswald (1987).

[41]In the Brown & Ashenfelter case, a greater weight on employment will result in a larger value for γ, and therefore a larger coefficient on $\overline{w}$ and a smaller one on w. The much more general framework used by Alogoskoufis & Manning makes it difficult to make any predictions.

Figure 5: Real Freight Revenue

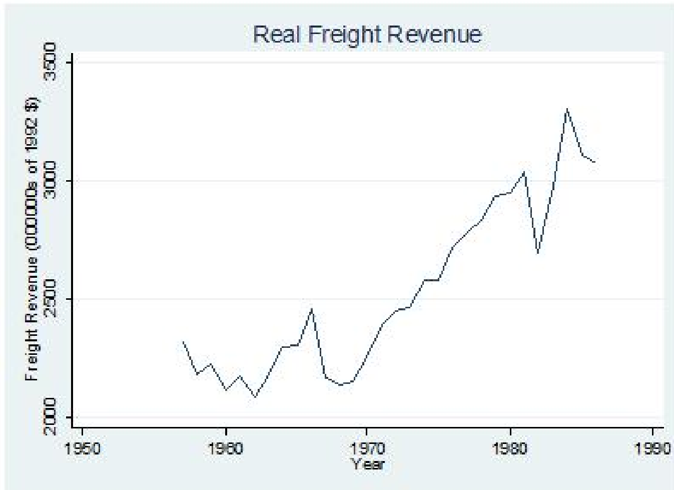


Figure 6: Tonnes of Freight Carried

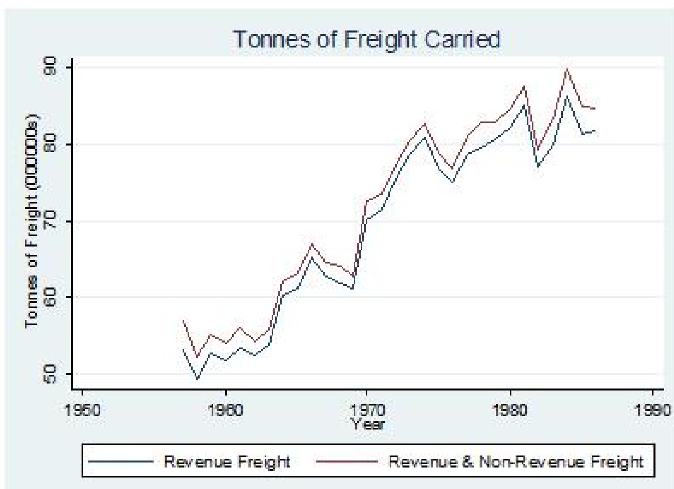


Figure 7: Tonne-Km of Freight

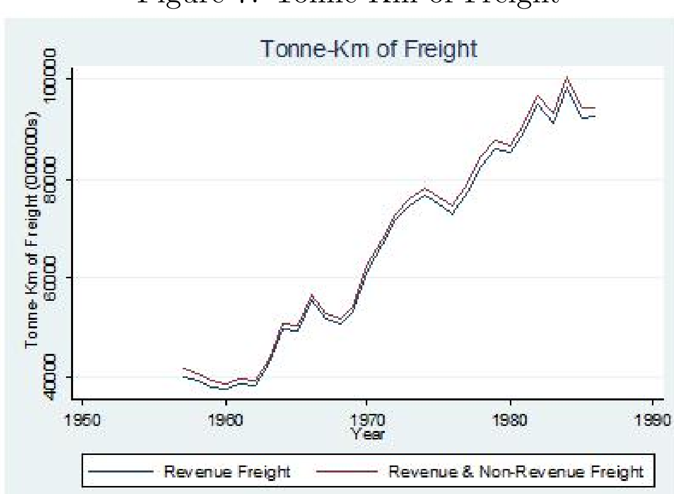


Figure 8: Freight Employment

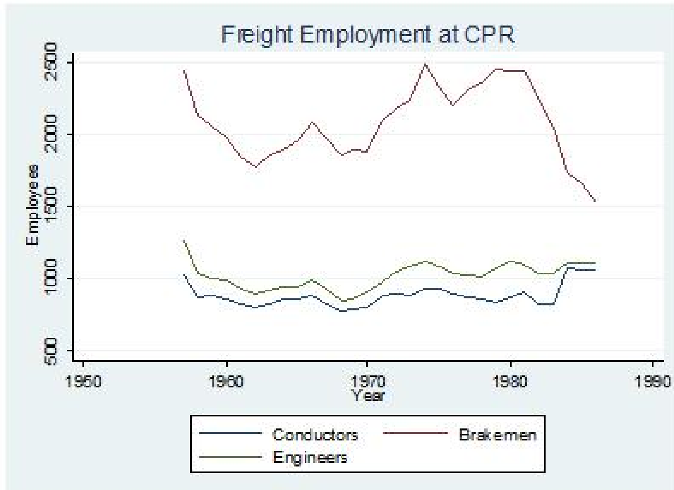


Figure 9: Union Wage Markup over Manufacturing Wage

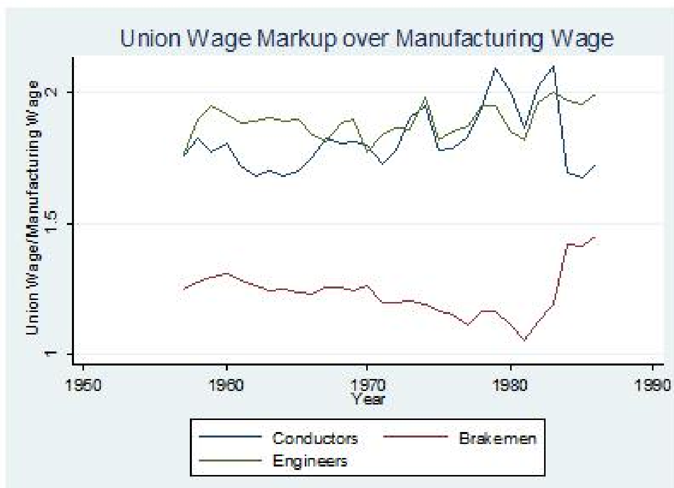


Figure 10: Union Wage Markup over Industrial Composite Wage

The railway unions, of course, represented employees in both freight and passenger service, so it probably remains the case that the decline in passenger service influenced the unions towards placing a higher weight on employment for all employees; however, the argument presented here is simply that such an effect may have been smaller than would initially appear.

It is unclear whether it is appropriate to use fixed effects panel data estimation with the CPR data; this has been the practice in numerous empirical papers, including Brown & Ashenfelter, but they had data from individual union locals, which they used as the cross-sectional categories. In our case, we could treat the employment categories of conductor, engineer and brakeman as separate cross-sectional categories, but it is not clear that we should expect them to have the same slope coefficients. For the Brown & Ashenfelter model, a pooled IV regression including interaction terms between all explanatory variables and dummies for employment category was estimated for freight employees; a test of the hypothesis that the coefficients on all these interaction terms are zero produced a p-value of 0.0248 for freight employees (and 0.0000 for OLS), suggesting that panel data estimation may not be appropriate. The same test using the Alogoskoufis & Manning model produced a p-value of 0.0000 (and 0.0000 as well for OLS); see Appendix B for further detail of the specification tests. Therefore, fixed effects instrument variables estimation will not be used; individual IV regressions for each category (with the contract wage treated as endogenous in all cases) will be reported instead.

For both the Brown & Ashenfelter and Alogoskoufis & Manning models, the quantity of employment used for each job category is that reported in *Railway Transport*, which is typically the average of the monthly employment numbers. Data on specific wage rates are not available, so the contract wage will be represented by the average yearly earnings in each job category.

6 Empirical Findings

6.1 Brown & Ashenfelter

Estimation for the Brown & Ashenfelter model will use equations (17) and (18), ie. with and without the log of one minus the unemployment rate as an additional regressor. Two different (although highly correlated, with a correlation coefficient around 0.998) measures are available for the alternative wage, the average yearly earnings in manufacturing (AYEM) and the industrial composite average (AYEIC); separate regressions will be run using each of these two measures. The variables in **X** are shown in Table 1 below; we have followed Brown & Ashenfelter's lead in including linear and quadratic time trends. Data was available on tonnes and tonne-km of revenue freight, and the same for all freight (revenue and non-revenue), but these four variables were highly collinear, so the decision was made to only include one of them; tonne-km of revenue and non-revenue freight seemed most likely to directly affect the demand for labour.

Table 1: Variables Included in Vector **X**

Description	Labelled as
linear time trend	TREND
quadratic time trend	TSQ
natural log of lagged employment	L_{-1}
natural log of real freight revenue	REV
natural log of total km of track operated	TRACK
natural log of tonne-km of revenue & non-revenue freight	TONNEKM
natural log of car-km	CARKM
natural log of train-km	TRAINKM
natural log of freight hours of service	HOURS

We will also follow Brown & Ashenfelter in using current and lagged values of the consumer price index and lagged values of the contract wage as additional instruments for the current contract wage. As stated in Section 4, we are most interested in the coefficient on $\overline{w}$; a significant negative coefficient is evidence in favour of Efficient Bargaining, and if in addition the coefficient on w is not significant, this would be evidence of strong efficiency. When $\log(1-u)$ is included in the regression (ie. when (18) is estimated), a significant negative coefficient on it would also be evidence in favour of the EB model.

Results from IV estimation of (17) can be found in Table 2. The results for conductors and brakemen are strongly inconsistent with the EB model; $\log(\overline{w})$ is insignificant for conductors, and significantly positive for brakemen. The evidence, therefore, is in favour of the MU model for conductors; for brakemen, it is hard to determine what may be going on, as neither the EB nor MU models suggest any reason for a positive coefficient on $\log(\overline{w})$. Exactly this result, however, was observed by Brown & Ashenfelter, although they could not identify a convincing reason for this effect; Nickell & Wadhwani (1988) and Nickell & Wadhwani (1991) argue that such a result may be indicative of efficiency wages, since a decrease in the alternative wage would lead to increased effort, which would allow the same amount to be produced with fewer workers.

In only one case, specifically for engineers and using average manufacturing earnings, does $\log(\overline{w})$ have a significant negative coefficient, and even then only at the 10% level. However, there is some evidence that the regression equations for engineers may be misspecified in some way, as the Sargan test using both AYEM and AYEIC cannot reject the overidentifying restrictions. As well, it is hard to explain why $\log(w)$ would have a positive coefficient. Revised regressions for engineers were performed after removing two of the additional three instruments (CPI and lagged CPI, the two least significant extra instruments in a regression of $\log(w)$ on all instruments), but the results are largely the same; $\log(w)$ still has positive (although not significant) coefficients, and $\log(\overline{w})$ has negative (and insignificant) coefficients.

Next, estimation of (18) was performed; the results can be found in Table 3. The coefficients on $\log(w)$ and $\log(\overline{w})$ are generally similar in magnitude and direction to those from estimation of (17); the coefficients on $\log(1-u)$ are negative in all but one case, but only significant once. The results for conductors, consistent with

Table 2: IV Estimation of (17)

	Conductors		Engineers		Brakemen	
	AYEM	AYEIC	AYEM	AYEIC	AYEM	AYEIC
$\log(w)$	-0.887***	-0.847***	0.776	0.287	-0.824***	-0.829***
	(0.074)	(0.060)	(0.490)	(0.352)	(0.166)	(0.179)
$\log(\overline{w})$	0.079	0.183	-0.900*	-0.333	0.982***	0.924**
	(0.224)	(0.249)	(0.514)	(0.548)	(0.266)	(0.453)
TREND	0.034***	0.029***	-0.008	-0.001	0.034**	0.039*
	(0.010)	(0.011)	(0.025)	(0.022)	(0.015)	(0.020)
TSQ	-0.00008	-0.00005	0.0002	0.00008	-0.0009**	-0.001**
	(0.0002)	(0.0002)	(0.0005)	(0.0005)	(0.0004)	(0.0005)
L_{-1}	0.049	0.038	0.252**	0.201**	0.337***	0.367***
	(0.049)	(0.045)	(0.107)	(0.083)	(0.080)	(0.092)
REV	0.380***	0.395***	0.019	0.163	0.226	0.261
	(0.130)	(0.131)	(0.310)	(0.272)	(0.178)	(0.239)
TRACK	2.745***	2.525***	0.247	0.486	0.534	0.323
	(0.419)	(0.537)	(0.987)	(1.022)	(0.880)	(1.124)
TONNEKM	0.124	0.145	-0.173	-0.005	0.164	0.166
	(0.090)	(0.091)	(0.251)	(0.209)	(0.138)	(0.171)
CARKM	-0.553**	-0.572**	0.763	0.118	-1.060**	-1.152**
	(0.263)	(0.257)	(0.884)	(0.704)	(0.422)	(0.502)
TRAINKM	0.960***	0.928***	0.385	0.707*	1.388***	1.462***
	(0.178)	(0.169)	(0.510)	(0.406)	(0.267)	(0.306)
HOURS	-0.142**	-0.123**	-0.200	-0.189*	-0.096	-0.132
	(0.059)	(0.061)	(0.132)	(0.113)	(0.092)	(0.115)
Constant	-28.327***	-27.491***	-13.209	-15.045*	-11.248	-8.209
	(3.882)	(4.608)	(8.811)	(8.874)	(7.706)	(9.602)
R^2	0.980	0.978	0.905	0.936	0.979	0.966
N	29	28	29	28	29	28
p-value of regression	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	0.0115	0.0110	0.0247	0.0201	0.0178	0.0205
Wu-Hausman F	0.037	0.043	8.048	2.788	0.345	0.022
(p-value)	(0.850)	(0.839)	(0.012)	(0.116)	(0.565)	(0.884)
Sargan $\chi^2(2)$	11.295	10.553	0.545	3.949	6.552	11.281
(p-value)	(0.004)	(0.005)	(0.761)	(0.139)	(0.038)	(0.004)

Standard errors are in parentheses. * represents significant at 10%, ** at 5%, and *** at 1%. Data on AYEIC is unavailable for 1986, leading to an N of 28 for freight data. The Wu-Hausman F-stat is for a test of the hypothesis that $\log(w)$ is exogenous. The Sargan χ^2 statistic is for a test of overidentifying restrictions.

Table 3: IV Estimation of (18)

	Conductors		Engineers		Brakemen	
	AYEM	AYEIC	AYEM	AYEIC	AYEM	AYEIC
$\log(w)$	-0.882***	-0.842***	0.223	-0.129	-0.768***	-0.774***
	(0.076)	(0.056)	(0.262)	(0.251)	(0.162)	(0.178)
$\log(\overline{w})$	0.028	-0.034	-0.426	0.034	0.954***	0.768
	(0.217)	(0.256)	(0.317)	(0.421)	(0.260)	(0.486)
$\log(1-u)$	-0.377	-0.787*	0.655	-0.057	-0.628	-0.554
	(0.403)	(0.450)	(0.600)	(0.820)	(0.519)	(0.749)
TREND	0.042***	0.050***	-0.004	0.012	0.045***	0.054**
	(0.012)	(0.016)	(0.023)	(0.030)	(0.017)	(0.027)
TSQ	-0.0003	-0.0005	0.0002	-0.0002	-0.001***	-0.001**
	(0.0003)	(0.0003)	(0.0005)	(0.0007)	(0.0004)	(0.0006)
L_{-1}	0.075	0.078*	0.176**	0.175**	0.348***	0.387***
	(0.050)	(0.045)	(0.074)	(0.071)	(0.080)	(0.092)
REV	0.394***	0.490***	0.234	0.333	0.216	0.326
	(0.128)	(0.132)	(0.206)	(0.254)	(0.172)	(0.248)
TRACK	2.699***	2.714***	0.753	0.609	0.348	0.376
	(0.418)	(0.520)	(0.686)	(0.896)	(0.858)	(1.175)
TONNEKM	0.076	0.082	0.112	0.142	0.078	0.128
	(0.102)	(0.092)	(0.167)	(0.159)	(0.154)	(0.183)
CARKM	-0.576**	-0.683***	0.008	-0.517	-1.113***	-1.275**
	(0.260)	(0.254)	(0.553)	(0.600)	(0.407)	(0.501)
TRAINKM	1.027***	1.071***	0.693*	1.064***	1.545***	1.603***
	(0.202)	(0.191)	(0.367)	(0.398)	(0.270)	(0.329)
HOURS	-0.127**	-0.108*	-0.280***	-0.225**	-0.066	-0.125
	(0.060)	(0.057)	(0.099)	(0.095)	(0.092)	(0.115)
Constant	-27.650***	-28.625***	-16.537***	-14.816*	-9.483	-8.417
	(3.928)	(4.397)	(6.332)	(7.593)	(7.467)	(9.926)
R^2	0.980	0.980	0.949	0.954	0.981	0.967
N	29	28	29	28	29	28
p-value of regression	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	0.0113	0.0104	0.0181	0.0171	0.0172	0.0203
$\chi^2(2)$ (p-value)	0.88	3.46	2.68	0.01	16.87	4.60
for test of MU	(0.644)	(0.177)	(0.262)	(0.994)	(0.000)	(0.100)
Wu-Hausman	0.001	0.426	2.239	0.421	0.004	0.076
F (p-value)	(0.980)	(0.525)	(0.155)	(0.527)	(0.952)	(0.787)
Sargan $\chi^2(2)$	13.587	11.567	6.124	8.731	15.175	19.960
(p-value)	(0.001)	(0.003)	(0.047)	(0.013)	(0.001)	(0.000)

Standard errors are in parentheses. * represents significant at 10%, ** at 5%, and *** at 1%. Data on AYEIC is unavailable for 1986, leading to an N of 28 for freight data. The Wu-Hausman F-stat is for a test of the hypothesis that $\log(w)$ is exogenous. The Sargan chi-squared statistic is for a test of overidentifying restrictions. The "test of MU" refers to a test of the hypothesis of zero coefficients on $\log(\overline{w})$ and $\log(1-u)$.

the MU model for (17), now suggest the possibility of weak efficiency, with negative coefficients on $\log(1-u)$; meanwhile, the results for brakemen still seem to support a possible efficiency wage interpretation, while the results for engineers are inconclusive. This time, however, the Sargan test statistics universally reject the overidentifying restrictions at the 5% level.

For each regression in Table 3, exogeneity of $\log(w)$ cannot be rejected (as well as every regression but one in Table 2); therefore, it seems sensible to compute OLS estimates as well. The results of OLS estimation of (18) can be found in Table 4. The results are broadly similar, as one would expect; the data on conductors and brakemen still support the MU model and efficiency wages respectively, although the coefficients on $\log(1-u)$ are negative in each case, but not significant. The results for engineers remain inconclusive.

Therefore, the summary of results using the Brown & Ashenfelter procedure is that there is no strong evidence in favour of the EB model (although, given the often-negative coefficients on $\log(1-u)$, a larger sample size might find sufficient evidence), and some evidence in favour of the MU model, although efficiency wages may also be a possible explanation in some cases. On the whole, the results are fairly inconclusive.

6.2 Alogoskoufis & Manning

Estimation for the Alogoskoufis & Manning model will use equations (25) and (26). The variables included in $\mathbf{X_1}$, $\mathbf{X_2}$, $\mathbf{X_3}$ and $\mathbf{Z}$ are listed below in Table 5. As for the Brown & Ashenfelter test, two different measures are used to represent the alternative wage; the same variables used in Brown & Ashenfelter will be used again, with some additions, as seen below.

Table 4: OLS Estimation of (18)

	Conductors		Engineers		Brakemen	
	AYEM	AYEIC	AYEM	AYEIC	AYEM	AYEIC
$\log(w)$	-0.884***	-0.877***	-0.114	-0.285	-0.758***	-0.819***
	(0.064)	(0.053)	(0.235)	(0.243)	(0.155)	(0.184)
$\log(\overline{w})$	0.032	-0.023	-0.205	0.108	0.957**	0.771
	(0.255)	(0.345)	(0.371)	(0.557)	(0.348)	(0.662)
$\log(1-u)$	-0.381	-0.875	0.292	-0.367	-0.621	-0.585
	(0.520)	(0.591)	(0.718)	(1.001)	(0.687)	(1.015)
TREND	0.042**	0.053**	0.013	0.024	0.045*	0.054
	(0.017)	(0.021)	(0.026)	(0.036)	(0.023)	(0.036)
TSQ	-0.0003	-0.0006	-0.0001	-0.0005	-0.001**	-0.001
	(0.0004)	(0.0005)	(0.0006)	(0.0008)	(0.0005)	(0.0008)
L_{-1}	0.075	0.072	0.156	0.175*	0.352***	0.368***
	(0.065)	(0.060)	(0.093)	(0.096)	(0.086)	(0.105)
REV	0.393**	0.485**	0.362	0.424	0.216	0.323
	(0.162)	(0.177)	(0.245)	(0.314)	(0.231)	(0.338)
TRACK	2.697***	2.740***	1.039	0.719	0.312	0.522
	(0.556)	(0.700)	(0.847)	(1.196)	(0.994)	(1.516)
TONNEKM	0.075	0.079	0.170	0.171	0.080	0.118
	(0.136)	(0.124)	(0.208)	(0.210)	(0.206)	(0.247)
CARKM	-0.577	-0.717*	-0.472	-0.793	-1.120*	-1.236*
	(0.349)	(0.338)	(0.617)	(0.692)	(0.536)	(0.669)
TRAINKM	1.030***	1.131***	1.012**	1.248**	1.549***	1.583***
	(0.250)	(0.241)	(0.409)	(0.458)	(0.358)	(0.443)
HOURS	-0.127	-0.116	-0.282**	-0.227*	-0.067	-0.121
	(0.081)	(0.076)	(0.125)	(0.128)	(0.124)	(0.156)
Constant	-27.628***	-28.629***	-17.548**	-15.070	-9.185	-9.644
	(5.222)	(5.922)	(7.994)	(10.227)	(8.858)	(12.826)
R^2	0.980	0.980	0.955	0.955	0.981	0.967
N	29	28	29	28	29	28
p-value of regression	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	0.0153	0.0141	0.0229	0.0230	0.0232	0.0277
F-stat (p-value) for test of MU	0.29 (0.754)	1.29 (0.304)	0.24 (0.792)	0.10 (0.901)	4.67 (0.025)	1.29 (0.303)

Standard errors are in parentheses. * represents significant at 10%, ** at 5%, and *** at 1%. Data on AYEIC is unavailable for 1986, leading to an N of 28 for freight data. The "test of MU" refers to a test of the hypothesis of zero coefficients on $\log(\overline{w})$ and $\log(1-u)$.

Table 5: Variables Included in Vectors $\mathbf{X_1}$, $\mathbf{X_2}$, $\mathbf{X_3}$ and $\mathbf{Z}$

Variables Included in Vectors $\mathbf{X_1}$ and $\mathbf{X_2}$ (ie. affecting profit function)	
Description	Labelled as
linear time trend	TREND
quadratic time trend	TSQ
natural log of lagged employment	L_{-1}
natural log of real freight revenue	REV
natural log of total km of track operated	TRACK
natural log of tonne-km of revenue & non-revenue freight	TONNEKM
natural log of car-km	CARKM
natural log of train-km	TRAINKM
natural log of freight hours of service	HOURS
Variables Included in Vector $\mathbf{X_3}$ (ie. affecting utility function but not profit function)	
unemployment rate	u
natural log of UI replacement ratio	UI
Variables Included in Z (ie. affecting neither the utility function nor the profit function)	
union wage markup, $\frac{w-\overline{w}}{\overline{w}}$, using AYEM and AYEIC	$wmarkup$
CPR strike in last 3 years; 1 = strike, 0 = no strike	STRIKE

The one variable in $\mathbf{Z}$ which will be removed from the employment equation (and therefore serve as Z_1, the single additional instrument) will be STRIKE. Results from IV estimation can be found in Table 6.

For each regression, the value of the χ^2 test statistics and p-values are given for the test of the MU model (for which the coefficients on $\mathbf{X_3}$ and $\mathbf{Z}$ are zero, as in (27)) and the test of the EB model (for which the coefficients on $\mathbf{Z}$, or more precisely on $Z_{(1)}$, are zero, as in (28). A test statistic is also calculated for the test of (27) against (28), the simple nested test of the MU model against the alternative of the EB model, for comparison.

The results for conductors are mixed; when AYEM is used to represent the alternative wage in the specification of $wmarkup$, neither the MU or EB model can be rejected, and the simple nested test cannot reject MU in favour of EB. However, when AYEIC is used, both the MU and EB models are close to rejection at the 5% level, and can both be rejected at the 10% level.

Table 6: IV Estimation of (25)

	Conductors		Engineers		Brakemen	
	AYEM	AYEIC	AYEM	AYEIC	AYEM	AYEIC
$\log(w)$	-1.415***	-1.774***	-0.963**	-1.266**	-0.688	-0.318
	(0.391)	(0.507)	(0.461)	(0.581)	(0.676)	(0.840)
TREND	0.063***	0.091***	0.046*	0.067**	0.074***	0.063
	(0.020)	(0.026)	(0.026)	(0.031)	(0.028)	(0.039)
TSQ	-0.0006	-0.001**	-0.0008	-0.001*	-0.002***	-0.001*
	(0.0004)	(0.0005)	(0.0005)	(0.0006)	(0.0005)	(0.0007)
L_{-1}	0.086	0.093*	0.086	0.077	0.292***	0.348***
	(0.059)	(0.054)	(0.053)	(0.058)	(0.078)	(0.079)
REV	0.595***	0.764***	0.605***	0.757***	0.476*	0.402
	(0.190)	(0.202)	(0.223)	(0.257)	(0.253)	(0.317)
TRACK	3.390***	4.219***	1.505**	2.217**	1.905	1.008
	(0.655)	(0.942)	(0.721)	(1.041)	(1.282)	(1.580)
TONNEKM	0.135	0.110	0.313**	0.320**	0.109	0.120
	(0.117)	(0.104)	(0.128)	(0.125)	(0.174)	(0.180)
CARKM	-0.723**	-0.943***	-1.111**	-1.337***	-1.218***	-1.259**
	(0.311)	(0.307)	(0.445)	(0.454)	(0.459)	(0.509)
TRAINKM	1.003***	1.223***	1.178***	1.312***	1.569***	1.579***
	(0.223)	(0.224)	(0.262)	(0.275)	(0.313)	(0.340)
HOURS	-0.179**	-0.180**	-0.217***	-0.201**	-0.155	-0.134
	(0.086)	(0.076)	(0.084)	(0.081)	(0.116)	(0.123)
u	0.005	0.015**	0.0002	0.006	0.010	0.008
	(0.005)	(0.006)	(0.005)	(0.007)	(0.007)	(0.010)
UI	0.046	0.027	0.193***	0.196***	0.009	0.014
	(0.033)	(0.031)	(0.040)	(0.042)	(0.051)	(0.054)
$wmarkup$	0.330	0.458*	0.335	0.419	-0.194	-0.392
	(0.229)	(0.256)	(0.207)	(0.268)	(0.477)	(0.631)
Constant	-30.836***	-38.327***	-13.933***	-19.524**	-20.095*	-12.970
	(5.241)	(7.115)	(5.148)	(7.449)	(9.819)	(12.026)
R^2	0.975	0.975	0.976	0.974	0.975	0.968
N	29	28	29	28	29	28
p-value of regression	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	0.0127	0.0177	0.0125	0.0128	0.0195	0.0201

$\chi^3(3)$ (p-value) for zero coefficients on $\mathbf{X_3}$, $\mathbf{Z}$	3.94 (0.269)	7.14 (0.068)	26.11 (0.000)	23.59 (0.000)	3.96 (0.265)	3.71 (0.295)
$\chi^2(1)$ (p-value) for zero coefficients on $\mathbf{Z}$	2.07 (0.150)	3.20 (0.074)	2.60 (0.107)	2.45 (0.118)	0.16 (0.685)	0.38 (0.535)
$\chi^2(2)$ (p-value) for test of MU against EB	2.45 (0.294)	5.14 (0.077)	22.49 (0.000)	21.64 (0.000)	3.25 (0.197)	3.06 (0.217)
Wu-Hausman F (p-value)	1.573 (0.230)	2.436 (0.143)	0.328 (0.576)	0.564 (0.466)	2.384 (0.145)	0.188 (0.672)

Standard errors are in parentheses. * represents significant at 10%, ** at 5%, and *** at 1%. Data on AYEIC is unavailable for 1986, leading to an N of 28 for freight data. The Wu-Hausman F-stat is for a test of the hypothesis that $log(w)$ is exogenous.

In contrast, the estimates for engineers provide a much more definite result. For both specifications of *wmarkup*, the MU model can be soundly rejected, and the EB model cannot be rejected; as one might expect, the nested test strongly rejects the MU model in favour of the EB model. Therefore, it would seem that the data on engineers provides some support for the EB model, and a clear rejection of the MU model.

Finally, the results for brakemen are inconclusive, just as for conductors when using AYEM. Neither model can be rejected, although it can be noted that the p-values for the EB test are larger than those for the MU test, which can perhaps be interpreted as minimal evidence in favour of EB.

As for the Brown & Ashenfelter model, Wu-Hausman tests are performed for each regression, and in every single case the hypothesis that $\log(w)$ is exogenous cannot be rejected. Therefore, there is good reason to also perform OLS estimation; since an additional instrument for $\log(w)$ is no longer needed, we can now include STRIKE as one of the explanatory variables in the employment equation.

OLS estimates can be found in Table 7. There are some slight changes to the results; for conductors, it is now the case that neither model can be rejected even at the 10% level for both specifications of the alternative wage. In the case of engineers, it still appears that the data generally supports the EB model over the MU model, although now we are (marginally) unable to reject the MU model at the 5% level

Table 7: OLS Estimation of (25)

	Conductors		Engineers		Brakemen	
	AYEM	AYEIC	AYEM	AYEIC	AYEM	AYEIC
$\log(w)$	-0.746**	-0.637	-0.566*	-0.527	0.695	0.359
	(0.261)	(0.419)	(0.299)	(0.568)	(0.469)	(0.984)
TREND	0.034*	0.038	0.025	0.030	0.018	0.032
	(0.018)	(0.024)	(0.022)	(0.034)	(0.026)	(0.053)
TSQ	-0.0002	-0.0004	-0.0004	-0.0006	-0.0009*	-0.001
	(0.0004)	(0.0005)	(0.0004)	(0.0007)	(0.0005)	(0.001)
L_{-1}	0.039	0.041	0.055	0.044	0.231*	0.317*
	(0.069)	(0.064)	(0.095)	(0.098)	(0.109)	(0.148)
REV	0.328*	0.392*	0.453**	0.494*	0.082	0.188
	(0.165)	(0.186)	(0.186)	(0.265)	(0.232)	(0.409)
TRACK	2.031**	1.703	0.744	0.625	-1.251	-0.518
	(0.777)	(1.064)	(0.848)	(1.394)	(1.346)	(2.466)
TONNEKM	0.141	0.156	0.322*	0.346*	0.175	0.143
	(0.140)	(0.129)	(0.180)	(0.187)	(0.207)	(0.272)
CARKM	-0.538	-0.674*	-0.924*	-1.090*	-0.947*	-1.083
	(0.346)	(0.335)	(0.473)	(0.545)	(0.519)	(0.738)
TRAINKM	0.946***	1.067***	1.080**	1.198**	1.555***	1.521***
	(0.262)	(0.254)	(0.304)	(0.356)	(0.354)	(0.491)
HOURS	-0.093	-0.091	-0.179*	-0.159	-0.083	-0.100
	(0.084)	(0.079)	(0.096)	(0.101)	(0.123)	(0.166)
u	0.002	0.007	-0.003	0.0007	0.006	0.003
	(0.006)	(0.007)	(0.006)	(0.009)	(0.007)	(0.013)
UI	0.044	0.024	0.188***	0.187***	-0.019	0.005
	(0.038)	(0.036)	(0.050)	(0.054)	(0.054)	(0.073)
$wmarkup$	-0.061	-0.116	0.142	0.065	-1.249***	-0.929
	(0.158)	(0.214)	(0.176)	(0.289)	(0.380)	(0.799)
STRIKE	0.014	0.017	0.009	0.013	0.034	0.014
	(0.011)	(0.011)	(0.016)	(0.018)	(0.022)	(0.031)
Constant	-21.381***	-20.088**	-9.396	-8.724	0.275	-2.425
	(6.843)	(8.541)	(7.490)	(10.915)	(10.758)	(18.796)
R^2	0.983	0.984	0.978	0.977	0.985	0.969
N	29	28	29	28	29	28
p-value of regression	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	0.0151	0.0137	0.0169	0.0177	0.0220	0.0289

F-stat (p-value) for zero coefficients on $\mathbf{X_3}$, $\mathbf{Z}$	0.75 (0.572)	1.37 (0.299)	4.03 (0.022)	3.17 (0.050)	3.52 (0.035)	0.80 (0.548)
F-stat (p-value) for zero coefficients on $\mathbf{Z}$	0.82 (0.461)	1.31 (0.302)	1.07 (0.369)	0.67 (0.528)	5.60 (0.016)	0.79 (0.473)
F-stat (p-value) for test of MU against EB	0.70 (0.510)	0.70 (0.510)	6.93 (0.007)	6.93 (0.007)	0.91 (0.423)	0.91 (0.423)

Standard errors are in parentheses. * represents significant at 10%, ** at 5%, and *** at 1%. Data on AYEIC is unavailable for 1986, leading to an N of 28 for freight data.

using the AYEIC form of alternative wages. For brakemen, neither model can be rejected using AYEIC, but both models can now be rejected at the 5% level using AYEM.

Finally, tests of the model of Kuhn (1988), as outlined in Section 4.3, were performed. The results of these regressions can be found in Appendix C. As can be seen there, we are able to reject Kuhn's model at the 1% level for engineers, while for conductors we can reject it once at the 1% level and once at the 10% level. For brakemen, however, we are unable to reject Kuhn's model of non-linear union wages. It should be acknowledged that Alogoskoufis & Manning's empirical framework is not designed for a test of Kuhn's hypothesis, but all the same we have at least some evidence against the Kuhn model.

As with the results from estimation of the Brown & Ashenfelter model, our findings are not conclusive in any direction. The data on conductors and brakemen provide evidence in at least some specifications that both of our principle models may be incorrect, although in most cases we are unable to reject either model. However, for engineers (for whom the results of the Brown & Ashenfelter model were highly inconclusive, and suggestive of misspecification), there does appear to be some moderately strong evidence in favour of the Efficient Bargaining model.

7 Conclusions

This paper has surveyed and analysed the theoretical and empirical literature on the wage-employment outcomes of collective bargaining, and applied two of the most popular empirical testing procedures to a data set on employment in the running trades at the Canadian Pacific Railway from 1957 to 1986. The estimation results using these two procedures are generally inconclusive; an application of the Brown & Ashenfelter method indicates a small amount of evidence in favour of the MU model, whereas the Alogoskoufis & Manning procedure provides weak support for the EB model. This paper, therefore, provides no definite answers, and it seems clear that more work is needed on this subject.

A Definition and Sources of Variables Used in Empirical Analysis

Table 8: Summary Statistics

Variables	Mean	Standard Deviation	Minimum	Maximum
Conductors				
Employment (L)	874.87	78.50	769	1063
Contract wage (w)	50547.95	10589.00	35106.47	68302.80
Engineers				
Employment (L)	1011.60	93.05	844	1272
Contract wage (w)	52403.75	9515.67	35199.43	64305.94
Brakemen				
Employment (L)	2082.47	260.55	1522	2490
Contract wage (w)	33935.65	5790.57	24899.61	46583.18
General				
Alternative wage ($\overline{w}$), AYEM	27716.58	4652.25	19963.07	33234.54
Alternative wage ($\overline{w}$), AYEIC	26157.33	4150.14	19289.77	31224.76
Strike in last 3 years (STRIKE); during the sample period, there were strikes in 1957, 1958, 1966, and 1973	0.333	0.474	0	1
Real freight revenue (REV)	$2.53\text{x}10^9$	$3.57\text{x}10^8$	$2.09\text{x}10^9$	$3.30\text{x}10^9$
Total km of track operated (TRACK)	36987.67	1569.15	33458	39026.11
Tonne-km of revenue & non-revenue freight (TONNEKM)	$6.71\text{x}10^{10}$	$2.07\text{x}10^{10}$	$3.86\text{x}10^{10}$	$1.01\text{x}10^{11}$
Car-km (CARKM)	$2.63\text{x}10^9$	$3.63\text{x}10^8$	$2.02\text{x}10^9$	$3.10\text{x}10^9$
Train-km (TRAINKM)	$4.12\text{x}10^7$	2615965	$3.69\text{x}10^7$	$4.91\text{x}10^7$
Freight hours of service (HOURS)	1172165	165556.6	964879	1575767
Unemployment rate (u)	6.885	2.245	3.6	12.008
Average yearly UI compensation	9387.88	2913.62	5964.80	13122.67

A.1 Employment (L)

Employment numbers for all categories of employment were taken from the annual Statistics Canada (formerly Dominion Bureau of Statistics) publication *Railway Transport*; data was taken from *Part II: Financial and Employment Statistics* in 1957, *Part VI: Employment Statistics* during 1958-81, and from the single volume *Railway Transport in Canada: General Statistics* during 1982-86.

A.2 Contract Wage (w)

Dollar amounts of total annual compensation for all workers in each category of employment were taken from *Railway Transport*, the same volumes as for employment; these dollar amounts were then divided by the number of employees in the employment category to obtain average yearly earnings, and the resulting figures were deflated using the Consumer Price Index, series V735319 from Statistics Canada's online CANSIM database (taking the yearly average of the monthly numbers).

A.3 Alternative Wage ($\overline{w}$)

For average earnings in manufacturing, the average weekly earnings were taken from two separate sources; for the period of 1957-75, series E90 of Statistics Canada's *Historical Statistics of Canada* (at http://www.statcan.ca/bsolc/english/bsolc?catno =11-516-X) was used, and for 1976-86, data was taken from series V75265 from CANSIM (the yearly average of the monthly numbers). For the industrial composite, series E49 from *Historical Statistics of Canada* was used for 1957-75, and series V75249 from CANSIM for 1976-85 (the yearly average of the monthly numbers). These series for average weekly earnings were then multiplied by 50 to obtain an estimate of average yearly earnings, and deflated using the Consumer Price Index.

A.4 Unemployment Rate (u)

Data on unemployment was taken from series D233 from *Historical Statistics of Canada* for 1957-75, and from series V2062815 from CANSIM for 1976-86 (using the yearly average of the monthly numbers).

A.5 Financial, Track and Operating Statistics

All data in this section was taken from the *Railway Transport* series. Data on freight revenue (REV) came from *Part II: Financial and Employment Statistics* in 1957, *Part II: Financial Statistics* during 1958-81, and the single volume *Railway Transport in Canada: General Statistics* during 1982-86; they were then deflated using the Consumer Price Index. Data on total km of track operated (TRACK) came from *Part III: Equipment, Track and Fuel Statistics* during 1957-81, and *Railway Transport in Canada: General Statistics* during 1982-86. Data on tonne-km of freight (TONNEKM), passenger-km (PASSKM), car-km (CARKM), train-km (TRAINKM) and freight hours of train service (HOURS) came from *Part IV: Operating and Traffic Statistics* during 1957-81, and *Railway Transport in Canada: General Statistics* during 1982-86.

A.6 Unemployment Insurance

Data on the average weekly compensation from unemployment insurance was taken from series V384424 from CANSIM, and deflated using the Consumer Price Index. To obtain the UI replacement ratio (UI), this series was then divided by the series for the real contract wage w.

A.7 Strike in Last 3 Years (STRIKE)

Data on the occurrence of strikes at the CPR was collected from Lamb (1977).

B Specification Tests

B.1 Brown & Ashenfelter

If fixed effects panel data estimation was to be used, the procedure of Brown & Ashenfelter would have been followed in using all the variables in $\mathbf{X}$, but with category-specific linear time trends (although a common quadratic time trend). Therefore, the pooled IV regression took the form of:

$$\log(L) = \beta_0 + \beta_1 C + \beta_2 E + \boldsymbol{\beta_3}\mathbf{X} + \boldsymbol{\beta_4}\mathbf{X}C + \boldsymbol{\beta_5}\mathbf{X}E + \beta_6 \log(\overline{w}) + \beta_7 C \log(\overline{w}) + \beta_8 E \log(\overline{w})$$
$$+\beta_9 \log(w) + \beta_{10} C \log(w) + \beta_{11} E \log(w) \qquad (34)$$

where C is a dummy variable equal to 1 for conductors and 0 otherwise, and E likewise for engineers, and where each of the terms with $\log(w)$ was treated as endogenous. Since the fixed effects framework would allow for category-specific fixed effects and linear time trends, a test was then performed on the hypothesis that $\boldsymbol{\beta_4}$, $\boldsymbol{\beta_5}$, β_7, β_8, β_{10} and β_{11} were zero *except* for the linear time trend interaction terms; this test resulted in a test statistic of $\chi^2(20) = 34.20$, and a p-value of 0.0248, as reported in Section 5. The same test performed on an OLS estimation of (29) resulted in a test statistic of $F(20, 51) = 5.14$, and a p-value of 0.0000.

B.2 Alogoskoufis & Manning

The test regressions for Alogoskoufis & Manning were performed in essentially the same way as for Brown & Ashenfelter; a pooled IV regression of the form:

$$\log(L) = \beta_0 + \beta_1 C + \beta_2 E + \boldsymbol{\beta_3}\mathbf{X_1} + \boldsymbol{\beta_4}\mathbf{X_1}C + \boldsymbol{\beta_5}\mathbf{X_1}E + \boldsymbol{\beta_6}\mathbf{X_2} + \boldsymbol{\beta_7}\mathbf{X_2}C + \boldsymbol{\beta_8}\mathbf{X_2}E + \boldsymbol{\beta_9}\mathbf{X_3}$$
$$+\boldsymbol{\beta_{10}}\mathbf{X_3}C + \boldsymbol{\beta_{11}}\mathbf{X_3}E + \boldsymbol{\beta_{12}}\mathbf{Z_{(1)}} + \boldsymbol{\beta_{13}}\mathbf{Z}_{(1)}C + \boldsymbol{\beta_{14}}\mathbf{Z}_{(1)}E + \beta_{15}\log(w) + \beta_{16} C \log(w)$$
$$+\beta_{17} E \log(w) \qquad (35)$$

was run, where each of the terms with $\log(w)$ was treated as endogenous. Once again, a test was performed on the hypothesis that $\boldsymbol{\beta_4}$, $\boldsymbol{\beta_5}$, $\boldsymbol{\beta_7}$, $\boldsymbol{\beta_8}$, $\boldsymbol{\beta_{10}}$, $\boldsymbol{\beta_{11}}$, $\boldsymbol{\beta_{13}}$, $\boldsymbol{\beta_{14}}$, β_{16} and β_{17} were zero *except* for the linear time trend interaction terms. The test statistic was $\chi^2(24) = 110.84$, for a p-value of 0.0000, and the same test performed on an OLS estimation of (30) resulted in a test statistic of $F(26, 42) = 4.87$, for a p-value of 0.0000[42].

[42] The F-statistic has 26 numerator degrees of freedom, not 24, because in an OLS regression Z_1 no longer has to be excluded from (30) to serve as the extra instrument.

C Tests of Kuhn (1988)

Initially, IV estimation of (25) including $\log(\overline{w})$ produced poor results due to severe multicollinearity; in fact, in one case, the regression package was unable to perform the regression due to the severity of the multicollinearity. It was then decided to switch the roles of *wmarkup* and STRIKE; STRIKE was inserted into regression equation (25), while *wmarkup* served as the additional instrument. Estimation of this revised model produced the results found below in Table 9.

Table 9: IV Estimation of (25) including $\log(\overline{w})$

	Conductors		Engineers		Brakemen	
	AYEM	AYEIC	AYEM	AYEIC	AYEM	AYEIC
$\log(w)$	-0.866***	-0.870***	-0.301**	-0.400***	-0.845***	-0.839***
	(0.057)	(0.042)	(0.129)	(0.131)	(0.119)	(0.155)
$\log(\overline{w})$	0.162	0.430	-0.275	-0.139	1.337***	0.823
	(0.220)	(0.303)	(0.232)	(0.400)	(0.330)	(0.678)
TREND	0.032**	0.029*	0.025*	0.031	0.029	0.051
	(0.013)	(0.017)	(0.015)	(0.024)	(0.019)	(0.034)
TSQ	-0.0002	-0.0003	-0.0004	-0.0006	-0.001***	-0.001**
	(0.0003)	(0.0003)	(0.0003)	(0.0005)	(0.0004)	(0.0006)
L_{-1}	0.036	0.032	0.055	0.045	0.251***	0.344***
	(0.048)	(0.043)	(0.066)	(0.067)	(0.080)	(0.099)
REV	0.310***	0.323**	0.455***	0.498***	0.131	0.300
	(0.119)	(0.131)	(0.129)	(0.181)	(0.171)	(0.278)
TRACK	1.958***	1.323*	0.766	0.649	-0.801	0.305
	(0.543)	(0.710)	(0.594)	(0.967)	(0.977)	(1.647)
TONNEKM	0.141	0.162*	0.321**	0.346***	0.168	0.130
	(0.097)	(0.085)	(0.125)	(0.128)	(0.153)	(0.190)
CARKM	-0.525**	-0.623***	-0.926**	-1.093***	-1.021***	-1.203**
	(0.240)	(0.225)	(0.328)	(0.372)	(0.381)	(0.505)
TRAINKM	0.944***	1.045***	1.082***	1.200***	1.574***	1.568***
	(0.181)	(0.169)	(0.211)	(0.242)	(0.262)	(0.340)
HOURS	-0.089	-0.077	-0.180***	-0.160**	-0.075	-0.110
	(0.058)	(0.053)	(0.067)	(0.069)	(0.092)	(0.117)
u	0.002	0.005	-0.002	0.0009	0.008	0.007
	(0.004)	(0.005)	(0.004)	(0.006)	(0.005)	(0.008)
UI	0.043	0.023	0.188***	0.187***	-0.013	0.010
	(0.027)	(0.024)	(0.035)	(0.036)	(0.040)	(0.051)
STRIKE	0.015*	0.021***	0.009	0.013	0.029*	0.005
	(0.008)	(0.008)	(0.011)	(0.012)	(0.016)	(0.021)

Constant	-20.897*** (4.747)	-17.436*** (5.641)	-9.587* (5.247)	-8.920 (7.605)	-2.343 (7.912)	-7.845 (12.839)
R^2	0.983	0.985	0.979	0.977	0.983	0.967
N	29	28	29	28	29	28
p-value of regression	0.000	0.000	0.000	0.000	0.000	0.000
RMSE	0.0104	0.0091	0.0118	0.0121	0.0163	0.0202
$\chi^2(3)$ (p-value) for zero coefficients on $\mathbf{X_3}$, $\mathbf{Z}$	6.50 (0.090)	12.75 (0.005)	32.46 (0.000)	27.10 (0.000)	5.19 (0.158)	0.92 (0.820)
Wu-Hausman F (p-value)	1.002 (0.335)	2.315 (0.154)	0.401 (0.538)	0.029 (0.867)	4.679 (0.050)	2.523 (0.138)

Standard errors are in parentheses. * represents significant at 10%, ** at 5%, and *** at 1%. Data on AYEIC is unavailable for 1986, leading to an N of 28 for freight data. The Wu-Hausman F-stat is for a test of the hypothesis that $log(w)$ is exogenous.

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