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Substitutability of Capital-Labour in the Presence of Unions in the US Postal Services Industry

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Abstract: *This paper studies the effects of labour unions on elasticity of substitution between production inputs in the US Postal Service industry. The study uses data from the National Income Product Account (NIPA) and the Current Population Survey (CPS). The paper estimates elasticity substitution between production labour, non-production labour, and capital using CES production functions and translog cost function. The CES production function is estimated by using seemingly unrelated non-linear least square regression of inverse labour demand on the union density and input prices. In the translog cost function, seemingly unrelated linear regression is employed to run regression of cost share of operation labour and cost share of non-operation labour on union density and input prices. Further, the paper uses an instrumental variable of union density in the federal sector to solve the endogeneity of the union density. The analysis indicates that the labour union did not reduce elasticity substitution between production inputs. However, the union was able to maintain inelastic substitution between production labour and capital and between non-production labour and capital. The results of this study suggest that the strength of production labour and non-production labour to remain inelastic to substitute with capital was due to low competitive industry.*

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1. Introduction

Recently, The American Postal Workers Union revised several important sections in their Collective Bargaining Agreement (2006-2010) regarding implementation of technological or mechanisation changes in the postal service industry. One of the sections stated that "The Union party" must be

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informed as far in advance as practicable, but no less than 30 days in advance, of implementation of technological or mechanisation changes which affect jobs including new or changed jobs in the area of wages, hours or working conditions[1].

Introducing and implementing new technology at one point became a threat to labours' job security and salary. Economic theory suggests that unions could contribute both to the conduciveness and to the detriment of economic welfare. To the same extent that unions secure monopoly power for workers, they may also cause inefficiency in a firm's production – in particular, the firm's decisions in production or operations are subject to the union's strength. The stronger the union, the less flexibility the firm has in making decisions.

Freeman and Medoff (1982) argued that unions decrease the degree of substitution between capital and labour through policies that prohibit or limit the use of capital. Besides, the union may also restrict the number of labourers who can operate certain risky and high technology machines[2]. These are strong policies that reduce for the union members any risk of job loss due to accidents at work. However, from the perspective of the employer, the policy will provide them with very little options in production inputs.

This paper studies the effects of labour unions on the elasticity of substitution between production inputs in the US postal service industries from 1994 to 2010[3]. The study uses data from the National Income Product Accounts (NIPA) and the Current Population Survey (CPS). Learning about degree of substitution between production inputs is an important aspect of a firm's maximisation of profit. It measures the extent to which firms can substitute between two production inputs as the relative productivity or the relative cost of the two factors changes. The presumption is that unionisation should reduce the elasticity of substitution because union contracts are expected to impede flexibility in input substitutions. The higher the elasticity of substitution the more flexibility the firm has to substitute between inputs[4].

This study contributes to the previous literature in several ways. This is the first study that estimates elasticity substitution between production inputs, specifically in the postal service industry. The other contribution of this paper relates to the estimation technique. Firstly, the paper takes into account endogeneity of unionism which could otherwise bias the estimation. Further, while the previous literature compared the elasticity of substitution between production inputs in unionised and nonunionised industries, the present study incorporates a union parameter in the estimation of the unionised industry studied.

2. Literature Review

A considerable amount of literature has developed over the years concerning the impacts of unions on industry. Researchers have addressed these effects according to many dimensions including wages, unemployment, productivity, and welfare. For example, Siebert (1997) suggested that there is a need for a significant institutional change in the labour union in order to develop a better role in dealing with rising unemployment. Meanwhile, Brown and Medoff (1978) studied the effects of trade unions on worker productivity. They found that unionisation had a significant positive effect on output per worker. However, Kaufman and Kaufman (1987) in their study, of the automotive parts industry, found that the influence of unions on productivity was negligible.

On the other hand, Card (1996) studied the effects of unionism on the wage structure using a longitudinal analysis. He found that unions increased wages preferentially for workers with lower levels of observed skills. Lewis's book reviews (1964) concluded that the presence of unions altered relative wages in the late 1950s by around 10-15 percent. Using a general equilibrium approach, Pettengill (1979) showed that unions tend to raise relative wage differentials between distinct qualities of labour.

Since most of the research on unions has traditionally been focused on productivity and the wage distribution, less attention has been given to the effects of unions on the elasticity of substitution between labour and capital. In fact, the ease of substitution between capital and labour is a critical determinant of the elasticity of demand for labour and thus of the economic effects of unionism. Holding other factors constant and given the notion that unions increase the wages of all their workers, the higher the elasticity of substitution, the higher the elasticity of derived demand and the larger the displacement of labour.

Slichter (1941), Slichter, James and Livernash (1960) and Bok and Dunlop (1970) provided some discussions of substitution between capital and nonproduction workers. In addition, many have made an attempt to estimate elasticity of substitution between production inputs (see Kemfert (1998), Balistreri, McDaniel and Wong (2003), Upender (2009), Raurich, Sala and Sorolla (2012) and, Bishmanath, Basanta, and Akhilesh (2013). Meanwhile, other papers have emphasised the importance of studying capital labour substitution. For example Alvarez-Cuadrado, Van Long, & Poschke, (2014) stated that learning about the elasticity of substitution between inputs is essential in order to understand the form of structural change in addition to change in sectoral and aggregate factor income shares. Besides that, Miyagiwa and Papageorgiou (2003) pointed out that the greater the elasticity of substitution between inputs, the smaller the per capita output growth.

Several previous works have explained the importance of the relationship between the elasticity of substitution among production inputs and unionism. For example, Freeman and Medoff (1981) explained that in a sector where the elasticity is small, unions might be able to extract a substantial wage premium at little cost in terms of employment. But unions are weak in a sector where the elasticity is larger. Further, Johnson and Mieskowski (1970) emphasized that the elasticity substitution between capital and labour is the main factor behind the impact of the "union wage effect" on the earnings of non-union workers and on the efficiency of the economy. In addition, Rees (1963) reported that substitution of other factors of production for union labour may result in a decrease in relative employment in the union sector.

However, a modern econometric analysis on the effect of unions on the elasticity of substitution between labour and capital was conducted by Freeman and Medoff (1982). They showed that the elasticity of substitution between labour and non-production labour is smaller under collective bargaining, while the elasticity of substitution for capital and labour is almost the same in the unionised and non-unionised industries. Since the estimates of this study only focused on the manufacturing industry, it does not explain the power of unions in different industries. A new recent study of unionism was conducted by Young and Zuleta (2015). Their paper concluded that a labour union has a positive linear relationship with labour share. In contrast, the present paper differs by incorporating the union variable inside its production function. As a result, the inverse labour demand is estimated in the form of non-linear.

3. Data Description

3.1 Data on unions

Data on unions is obtained from the Union Membership and Coverage database extracted from the Current Population Survey (CPS). Quarterly data was used to analyse the effects of unions on the elasticity of substitution between labour and capital. The period covered by the data is from 1983-2010. The data provides information on the total employment, the number of employed workers who were union members and the number of employed workers who were covered by a collective bargaining agreement.

3.2 Data on labour and factor price

Data for labour and capital inputs was obtained primarily from the National Income and Product Account (NIPA) tables of the Bureau of Economic

Analysis (BEA). The NIPA Table 6.4 was used to obtain data on L_t. The table outlines the total number of full-time and part-time employees by industry for each year. In addition, NIPA Table 6.9 includes data on the total hours of work for all workers per year (H_t) by industry. Further, NIPA Table 6.3 depicts the data on w_t. The table displays the total wage and accrual per year by industry. Thus, the average hourly wage is the ratio of w_t over H_t.

Data for operation labour and nonoperation labour was obtained from the Current Population Survey (CPS). The data provided information on the numbers and wages of operation labour and non-operation labour for each industry. Operation and non-operation labour are identified according to major occupation categories. Management, service, sales and office occupations are categorised as non-operation jobs while occupations such as yardmaster, bus driver and flight maintenance are categorised as operation jobs.

3.3 Data on capital and factor price

In Following Lup Tick and Oaxaca (2010), a recursive equation was used to obtain the series on non-labour input K_t given initial conditions on K_t and a calculated capital depreciation of δ_t. On the other hand, a series on r_t was obtained from the user cost of capital equation. The following total revenue equation was used:

$$PtQt = wtLt + rtKt \qquad (1)$$

where P_tQ_t is the total revenue from output in quarter t. Data for P_tQ_t is derived from the NIPA Table 6.1, National Income without Capital Consumption Adjustment by Industry. Further, BEA, table SQ7, State Quarterly Income Estimates, was used to obtain the data for w_tL_t where w_tL_t is the total cost for labour in quarter t. The only data that is not available is the data on r_tK_t where r_tK_t is the cost for capital in quarter t. Data on $\delta_t\, r_{t-1}K_{t-1}$ was obtained from NIPA Tables 6.13 and 6.22, Non-corporate and Corporate Capital Consumption by Industry, where δ_t is a depreciation rate and $r_{t-1}K_{t-1}$ is the cost of capital in a previous period. Moreover, the data for $r_{t-1}K_{t-1}$ was available from NIPA Table 3.3ES, Historical Cost Net Stock of Private Fixed Assets by Industry. Thus, given data on $\delta_t\, r_{t-1}K_{t-1}$ and $r_{t-1}K_{t-1}$, δ_t was calculated.

In order to obtain r_t, a normal rate of return was assumed. Thus, the user cost of capital can be calculated as following:

$$r_t = (I_t + \delta_t + \tau_t)pd_t \qquad (2)$$

where pd_t represents the price deflator, I_t is the quarterly 3-month T-bill rate and τ_t is a corporate income tax obtained from a Historical Corporate Top Tax Rate (1909-2010). The data on the price deflator (pd_t) was obtained from NIPA table 7.6, Chain-Type Quantity and Price Indexes for Private Fixed Investment by Type, while the data for the 3-month T-bill rate (I_t) came from the Federal Reserve Statistical Release of Historical Data[5]. Thus, the series on K_t was obtained residually from (1):

$$Kt = \frac{PtQt - wtLt}{rt} \tag{3}$$

By this construction of K_t, the equation ensures internal consistency of data.

To be specific, W_t is measured in hourly wage. L_t represents the total number of labours in the industries while K_t represents the total value of capital in the industries for the particular period of time. Further, r_tK_t measures the total cost of capital in the industries.

4. Conceptual Framework and Econometrics Specification

The effect of unions on the elasticity substitution between capital and labour will be analysed during the time interval spanning from the first quarter of 1983 to the fourth quarter of 2010. Two types of production functions are used to determine how unions respond to different models of production. The first model is Constant Elasticity Substitution (CES), while the second model in the analysis is Translog Cost Function.

4.1 CES production function

The advantage of the CES production function is that it assigns a constant value to the substitutability between inputs. That is, the elasticity parameter can vary from zero to infinity (Tyler, 1974). Thus, the CES function is very intuitive because it allows the inputs to range from perfect substitution to no substitution. In comparison with the Cobb Douglas function, which has unity elasticity of substitution, the value of the elasticity of substitution in the CES model provides more variability and flexibility (Hsing, 1993). Furthermore, the CES model is being proposed because the assumption of the unit elasticity of substitution of the Cobb Douglas production function is not checked in the empirical studies (Arrow, Chenery, Minhas, & Solow, 1961). More importantly, the CES function is considered as the general case of the Cobb Douglas and the Leontief production function (Salem, 1994). Below, the CES production function is described:

$$Q_t = A_t \left[\sum_{i=1}^{2} \alpha_i L_{it}^{\left(\frac{\sigma_t - 1}{\sigma_t}\right)} + \left(1 - \sum_{i=1}^{2} \alpha_i\right) K_t^{\left(\frac{\sigma_t - 1}{\sigma_t}\right)} \right] \phi\left(\frac{\sigma_t}{\sigma_t - 1}\right) \qquad (4)$$

where Q_t is a measure of output in quarter t, A_t is a scale factor that captures neutral technological change, and script *i* represents type of labour. In the present study two types of labour inputs have been used; operation labour and non-operation labour. L_{it} is employment level in quarter t for type *i* labour, and K_t represents capital input in quarter t. A share parameter for input *i* in a range of $0 < \alpha < 1$ is defined as α_i, while ϕ refers to the return-to-scale parameter. Note that the elasticity of substitution between capital and labour is measured by the σ parameter. The effects of unions on elasticity substitution are captured in the elasticity equation as defined below:

$$\sigma_t = e^{(\rho_0 + \rho_1 U_t)} \qquad (5)$$

where σt is the elasticity of substitution between labour and capital in quarter t and Ut is the density of unions in industry in quarter *t*. Here, $\rho 0$ represents an intercept while ρ1 measures how much effect unions have on elasticity substitution. By defining elasticity substitution (σt) in the exponential function, it is guaranteed that the elasticity of substitution will be positive (Allen, 1938). To show the effects of unions on elasticity substitution between capital and labour, the following derivative of the natural log of equation (5) was used:

$$\frac{dln(\sigma)}{dU} = \rho 1 \qquad (6)$$

The coefficient of ρ_1 is expected to be negative. Thus, an increase of union density in the industry will result in a smaller elasticity substitution between labour and capital. Note that in the case of no unionism in the industry, the elasticity substitution of σ_t is just a function of ρ_0. Further, marginal products of type *i* labour (MPL_{it}) and marginal products of capital (MPK_t), respectively, can be expressed as:

MPL_{it} =

$$(\alpha_i)\left(\frac{\sigma_t}{\sigma_t-1}\right)\left(\frac{\sigma_t-1}{\sigma_t}\right)(\phi)L_{it}^{\frac{\sigma_t-1}{\sigma_t}-1}A_t\left[\sum_{i=1}^{2}\alpha_i L_{it}^{\left(\frac{\sigma_t-1}{\sigma_t}\right)}+\left(1-\sum_{i=1}^{2}\alpha_i\right)K_t^{\left(\frac{\sigma_t-1}{\sigma_t}\right)}\right]\phi\left(\frac{\sigma_t}{\sigma_t-1}\right) \quad (7)$$

MPK_t =

$$\left(1-\sum_{i=1}^{2}\alpha_i\right)\left(\frac{\sigma_t}{\sigma_t-1}\right)\left(\frac{\sigma_t-1}{\sigma_t}\right)(\phi)K_t^{\frac{\sigma_t-1}{\sigma_t}-1}A_t\left[\sum_{i=1}^{2}\alpha_i L_{it}^{\left(\frac{\sigma_t-1}{\sigma_t}\right)}+\left(1-\sum_{i=1}^{2}\alpha_i\right)K_t^{\left(\frac{\sigma_t-1}{\sigma_t}\right)}\right]\phi\left(\frac{\sigma_t}{\sigma_t-1}\right) \quad (8)$$

Next, by assuming the firm practices cost minimization, the marginal product of capital labour is equated with the factor input price w_{it} and r_t as following:

$$\frac{MPL_{it}}{MPK_t}=\frac{w_{it}}{r_t} \quad (9)$$

By substituting (7) and (8) into (9), the following is obtained:

$$\frac{K_t^{\frac{1}{\sigma t}}\alpha_i}{L_t^{\frac{1}{\sigma t}}\left(1-\sum_{i=1}^{2}\alpha_i\right)}=\frac{W_{it}}{r_t} \quad (10)$$

Taking the log of the equation (10) yields a set of inverse relative input demand functions as follows:

$$\left(\frac{1}{\sigma_t}\right)ln\left(\frac{K_t}{L_{it}}\right)+ln\left(\frac{\alpha_i}{1-\sum_{i=1}^{2}\alpha_i}\right)=ln\left(\frac{w_{it}}{r_t}\right) \quad (11)$$

Equation (11) can also be expressed as:

$$ln\left(\frac{K_t}{L_{it}}\right)=\sigma_t\left[ln\left(\frac{1-\sum_{i=1}^{2}\alpha_i}{\alpha_i}\right)+\ ln\left(\frac{w_{it}}{r_t}\right)\right] \quad (12)$$

By substituting for σt from union function (5), the following equation is obtained:

$$ln\left(\frac{K_t}{L_{it}}\right) = e^{(\rho_0 + \rho_1 U_t)} \left[\ln\left(\frac{1-\sum_{i=1}^{2}\alpha_i}{\alpha_i}\right) + \ln\left(\frac{w_{it}}{r_t}\right)\right] \quad (13)$$

Since (13) is not linear, a seemingly unrelated non-linear least square regression is used to estimate the following equation.

$$ln\left(\frac{K_t}{L_{it}}\right) = e^{(\rho_0 + \rho_1 U_t)} \left[\ln\left(\frac{1-\sum_{i=1}^{2}\alpha_i}{\alpha_i}\right) + \ln\left(\frac{w_{it}}{r_t}\right)\right] + \varepsilon_t \quad (14)$$

$$ln\left(\frac{K_t}{L_{jt}}\right) = e^{(\rho_0 + \rho_1 U_t)} \left[\ln\left(\frac{1-\sum_{i=1}^{2}\alpha_i}{\alpha_j}\right) + \ln\left(\frac{w_{jt}}{r_t}\right)\right] + \varepsilon_t \quad (15)$$

$$ln\left(\frac{L_{jt}}{L_{it}}\right) = e^{(\rho_0 + \rho_1 U_t)} \left[\ln\left(\frac{\alpha_j}{\alpha_i}\right) + \ln\left(\frac{w_{it}}{w_{jt}}\right)\right] + \varepsilon_t \quad (16)$$

where the parameters of interest are ρ_0, ρ_1 and α.

4.2 Translog cost function

The second model in the analysis is the translog cost function[6]. The advantage of the translog cost function is the flexibility of specification that can be applied to multifactor production. In addition, the translog cost function does not require imposition of prior restriction in order to get the Allen elasticities of substitution (Mohabbat, 1984; Yanikkaya, 2004). For the translog cost function, the period covered in the analysis is only from first quarter 1994 to the fourth quarter 2008 because the wage data for production labour and nonproduction labour is not available before 1994.

Assuming the firm practices cost minimization in production, the translog cost function can be represented as following:

$$\ln C = \alpha_0 + \sum_{i=1}^{3}\alpha_i \ln wi + 1/2\sum_{i=1}^{3}\sum_{j=1}^{3}\delta_{ij}(\ln wi)(\ln wj) + \alpha_Q \ln Q + (1/2)\delta_{QQ}(\ln Q)^2$$
$$+ \sum_{i=1}^{3}\delta_{iQ}(\ln wi)(\ln Q) + \sum_{i=1}^{3}\theta_i U \ln wi \quad (17)$$

By assuming that the cost function is well behaved, (17) is positive and homogeneous of degree one in factor prices. Thus, the following assumptions are applied in the translog cost function:

$$\sum_{i=1}^{3} \alpha_i = 1$$

$$\delta_{ij} = \delta_{ji}$$

$$\sum_{j=1}^{3} \delta_{ij} = 0$$

Further, the production function is restricted in this study to Constant Return to Scale (CRTS). Thus, additional assumptions are imposed in the translog cost function as follows: (Homothetic)

$\delta_{QQ} = 0$ (Homogeneity of a constant degree)

$\alpha_Q = 1$ (Constant Return to Scale)

With all the above assumptions imposed, the translog cost function becomes:

$$\ln C = \alpha_0 + \sum_{i=1}^{3} \alpha_i \ln wi + 1/2 \sum_{i=1}^{3} \sum_{j=1}^{3} \delta_{ij} (\ln wi)(\ln wj) + \ln Q + \sum_{i=1}^{3} \theta_i U \ln wi \qquad (18)$$

It is known from the present author's work on cost functions that the Shepard Lemma implies that $\frac{dC}{dWi}$ = X_i. In logarithm form $\frac{dlnC}{dWi} = \frac{dC}{dWi}\frac{Wi}{C}$. Substituting the result from the envelope theorem, the following is obtained $\frac{dlnC}{dWi} = X_i \frac{Wi}{C}$ = S_i, where S_i is the cost share of the ith input.

From the translog cost function, the following formulae are produced:

$$\frac{dlnC}{dlnw1} = S_1 = \alpha_1 + \delta_{11} \ln w_1 + \delta_{12} \ln w_2 + \delta_{13} \ln w_3 + \theta_1 U \qquad (19)$$

$$\frac{dlnC}{dlnw2} = S_2 = \alpha_2 + \delta_{22} \ln w_2 + \delta_{21} \ln w_1 + \delta_{23} \ln w_3 + \theta_2 U \qquad (20)$$

$$\frac{dlnC}{dlnw3} = S_3 = \alpha_3 + \delta_{33} \ln w_3 + \delta_{31} \ln w_1 + \delta_{32} \ln w_2 + \theta_3 U \qquad (21)$$

To simplify, the derivative was put in the function of only two inputs of w1 and w2. Therefore, (19), (20) and (21) become:

$$\frac{dlnC}{dlnw1} = S_1 = \alpha_1 + \delta_{11}\ln(W_{NPL}/W_r) + \delta_{12}\ln(W_{PL}/W_r) + \delta_{13}\ln(W_r/W_r) + \theta_1 U \qquad (19')$$

$$\frac{dlnC}{dlnw2} = S_2 = \alpha_2 + \delta_{21}\ln(W_{NPL}/W_r) + \delta_{22}\ln(W_{PL}/W_r) + \delta_{23}\ln(W_r/W_r) + \theta_2 U \qquad (20')$$

$$\frac{dlnC}{dlnw3} = S_3 = \alpha_3 + \delta_{31}\ln(W_{NPL}/W_r) + \delta_{32}\ln(W_{PL}/W_r) + \delta_{33}\ln(W_r/W_r) + \theta_3 U \qquad (21')$$

Where:

$S_1 + S_2 + S_3 = 1$ and $0 < S_i < 1$

$\alpha_1 + \alpha_2 + \alpha_3 = 1$

$\delta_{11} + \delta_{12} + \delta_{13} = 0$

$\delta_{21} + \delta_{22} + \delta_{23} = 0$

$\Theta_1 + \Theta_2 + \Theta_3 = 0$

w_{NPL}= non-operation labour wage, w_{PL}= operation labour wage, w_r= return to capital. Note that $\ln(W_r / W_r) = 0$.

In order to allow for error in cost minimization, a classical additive term is added to (19'), (20'), and (21'). The error term is sum to zero in each observation because cost share is sum to unity. Thus, covariance structure is singular. Therefore, one equation was dropped for joint estimation. Here, equation (21') was dropped and estimated jointly (19') and (20'). Thus, (19') and (20') are estimated by using Seemingly Unrelated Regression (SUR). In order to obtain the values of estimates for the three inputs' symmetric translog cost function, Zellner Efficient (ZEF) estimation was used. The ZEF was iterated until the estimates converge to the maximum likelihood (ML) estimates so that the estimates are invariant to which equation (21') is dropped.

In order to measure elasticity substitution of factor input, the Allen partial elasticity of substitution (AES) was employed as following:

$$£_{ij} = \frac{\delta ij + SiSj}{SiSj} \quad \text{and} \quad £_{ii} = \frac{\delta ii + Si(Si-1)}{SiSi} \qquad (22)$$

where the union effects are captured inside the cost share variables *(S_i)*. To show the effects of unions on elasticity substitution between input productions, the derivative of Allen elasticity with respect to union density was taken as follows:

$$\frac{d£ij}{dU} = \frac{-(\delta ij)\left(\alpha i\theta j + \alpha j\theta i + ln\left(\frac{wi}{wj}\right)(\theta i\delta ji + \theta j\delta ii) + ln\left(\frac{wk}{wj}\right)(\theta i\delta jk + \theta j\delta ik) + 2\theta i\theta jU\right)}{\left(\left(\alpha i + \delta iiln\left(\frac{wi}{wj}\right) + \delta ikln\left(\frac{wk}{wj}\right) + \theta iUt\right)\left(\alpha j + \delta jiln\left(\frac{wi}{wj}\right) + \delta jkln\left(\frac{wk}{wj}\right) + \theta jU\right)\right)\text{^}2} \quad (23)$$

4.3 Endogeneity of union density

The source of the endogeneity in the union density is due to structural reverse causality between union density and dependant variables in both the CES production function and the translog cost function. Failure to consider this endogeneity problem will result in bias in estimating equation (14), (15), and (16) for the CES production function and equation (19) and (20), (21) for the translog cost function.

In the CES production function, the more workers who sign up for union membership, the lower the demand for capital by limiting capital input in the production through labour union's bargaining. Thus, it results in the lower ratio of capital and labour demand in the left-hand side of nonlinear least square regression[7]. However, the causal effect could also be in the opposite direction. The high demand for new capital which results in the higher ratio of capital and labour motivates more workers to sign up for the union membership to avoid losing their job. Thus, by this assumption, the coefficient of union density on the inverse labour demand is negative while the coefficient of the inverse labour demand on the union density is positive. Thus, failure to consider this structural reverse causality between inverse labour demand and union density will result in a downward bias in estimating nonlinear least square regression of the impacts of union density on the inverse labour demand.

In the translog cost function, the more workers who sign up for union membership, the higher the cost share of labour in the production due to an increase in wage for union members. However, an increase in wages for workers which increases the cost share of labour, results in a lower union density because the workers see that wages and salary can be raised without them being a union member. Thus, by this assumption, the coefficient of union density on the cost share of labour is positive while the coefficient of the cost share of labour on the union density is negative. Thus, failure to consider this structural reverse causality between cost share of labour and union density will result in an upward bias in estimating seemingly unrelated regression (SUR) of the impacts of union density on the cost labour share.

In order to solve this problem, *union density in the federal sector (excluding postal)* is used as an instrumental variable for union density in the postal service industry. The specification for the *first stage regression* is as follows:

$$Union_t = \alpha + \beta(Federal\ Sector\ Union) + X + \varepsilon \tag{23}$$

This instrumental variable is valid because union density in the federal sector has a very strong relationship with the union density in the industry and does not directly affect current labour demand. A motivation to join a trade union could depend on union density in the federal sector. A high (low) union density in the other industry signals a positive (negative) return to being a union member. In addition, the success (failure) of the labour union in the federal sector motivates workers to join (leave) the labour union. This is because postal workers are federal sector employees. Therefore, the best instrument is to use union density in the federal sector that excludes postal workers. Further, the union density in the federal sector is a valid instrument because it does not have a direct effect on a labour demand in the industry. The strength of the labour union in the federal sector does not influence the firm's decision on production. Thus, to estimate the current model, a Seeming Unrelated Regression (SUR) was run with an instrument variable for the translog cost function and CES production function.

5. Result and Discussion

Table 1 shows a CES result of Seemingly Nonlinear Two Stage Least Square (N2SLS) regression of the inverse production labour demand, the inverse non production labour demand, and a ratio of production labour demand and non-production labour demand on the union density, a ratio of production labour wage and rate of return to capital, a ratio of non-production labour wage and rate of return to capital, and a ratio of non-production labour wage and production labour wage in the postal service industry. The interested coefficient of union ρ_2 shows a positive and significant coefficient in both the inverse production labour demand and non-production labour demand. Thus, the presence of a labour union in the postal service is not able to reduce an elasticity of substitution between production labour and capital and between non-production labour and capital.

Table 1: Seemingly Nonlinear Two Stage Least Square (N2SLS) regression

	Coefficient
alpha_one	2.00e-07***
	(1.49e-08)
alpha_two	9.61e-06***
	(9.08e-07)
rho_one NPL_C	-.8708147***
	(.017344)
rho_two NPL_C	.491533***
	(.024006)
rho_one PL_C	-.7720673***
	(.057298)
rho_two PL_C	.5554967***
	(.013854)
rho_one PL_NPL	-1.369717***
	(.213710)
rho_two PL_NPL	-.8703636***
	(.015272)

Table 2 shows the mean elasticity substitution between capital and production labour and between capital and non-production labour for the postal service industry. Both pairs of input production elasticity show a mean elasticity below 1.00. Therefore, the postal service industry is inelastic to substitution between capital and production labour and between capital and non-production labour.

Table 2: Mean elasticity of substitution between non-production labour and capital, and between production labour and capital

	Mean
Elasticity Production Labour-Capital	0.6049
Elasticity Non-Production Labour-Capital	0.7005

To summarise, although a mean elasticity substitution shows the inelastic of production labour and non-production labour to substitute with capital in the postal service industry, the positive coefficient of ρ_2 implies that the presence of labour unions is not associated with lower elasticity of substitution between inputs production. Thus, the inelastic substitution between production labour and capital and between non production labour and capital but the positive coefficient of union density in the postal service industry are not consistent with a hypothesis that the union decreases the degree of substitutability between labour and capital in the postal service industry.

Table 3 shows the translog cost function results for Seemingly Unrelated Regression (SUR) estimation of cost shares with instrumental variables for the postal service industry. Both cost share of production labour and cost share of non-production labour in the postal service industry have positive coefficients on union density. The positive coefficient of union membership implies that the higher the percentage of union membership in the industry has been transformed to an ability of the labour union to maintain higher cost (higher wage and or higher percentage) of production labour or non-production labour to capital in the industry. Thus, the presence of a union was able to limit and reduce the use of capital in the operation or production.

Table 3: Seemingly unrelated 2SLS regressions of cost share non-production labour, and cost share of production labour

	Coefficient
Regression of Cost Share Non-Production Labour-Capital	
Variables:	
Log wage non-production labour/ return capital	0.6277***
	(0.1955)
Log wage production labour/ return capital	0.4523*
	(0.2646)
Union density	2.6051
	(1.2139)
Constant	-9.8562
	(4.3150)
Regression of Cost Share Production Labour-Capital	
Variables:	
Log wage non-production labour/ return capital	0.8749**
	(0.3030)
Log wage production labour/ return capital	1.4948***
	(0.4103)
Union density	4.8071
	(1.8821)
Constant	-21.092**
	(6.6902)

Table 4 shows the mean Allen elasticities of substitution between production labour and capital and between non-production labour and capital for the postal service industry. The mean elasticity of substitution between production labour and capital and between non-production labour and capital are below 1.00. Therefore, in the postal service industry, there was inelastic substitution between production labour and capital and between non-production labour and capital.

Table 4: Mean Allen Elasticity of Substitution between non-production labour and capital, and between production labour and capital

	Mean
Elasticity Non Production Labour-Capital	0.4927
Elasticity Production Labour-Capital	0.5929

Table 5 shows mean derivatives of the Allen elasticities of substitution with respect to union density between production labour and capital and between non-production labour and capital in the postal service industry. Both production labour and non-production labour have positive mean derivatives of elasticity of substitution with respect to unions. Thus, although the union's presence was able to maintain a greater ratio cost of labour to capital, it was unable to influence elasticity substitution between inputs of production. On the other hand, the positive effect of union on elasticity substitution was not strong enough to change inelastic substitution between production inputs.

Table 5: Mean derivative of Allen Elasticity of Substitution between non-production labour and capital, and between production labour and capital

	Mean
Derivative Elasticity Non Production Labour-Capital	5.879725
Derivative Elasticity Production Labour-Capital	5.794972

6. Conclusion

Through the analysis we find the presence of labour unions unable to reduce the flexibility to substitute production labour and capital and non-production labour and capital. However, the union was able to control and maintain inelastic substitution between production inputs in the firm through a greater percentage of production labour and non-production labour in the firm by lowering the use of capital. This result contributes to earlier findings by Freeman and Medoff (1982) who showed that the elasticity of substitution between production labour and non-production labour is smaller under collective bargaining.

In the emergence of new technology, the presence of labour unions in the postal service industry is still relevant to the firms' decisions on choice of production inputs. This success of unionism could be because the postal service industry is a less competitive industry. If the postal service is a less competitive industry, an increase in production cost due to increases in wages and benefits (due to the union) could be transformed into a higher price of the final goods.

Notes

1. The average of union membership from 1983 to 2010 in this industry was about 76.8 percent while the percentage of labour union membership in this industry in 2010 was about 72 percent.
2. High risk or high technology machines require a trained worker to operate them.
3. The earlier version of this paper was presented at the 9th Asian Pacific Economics Association Conference in Osaka, Japan during Summer 2013.
4. Freeman and Medoff (1982) argued that unions decrease the degree of substitution between capital and labour through policies that prohibit or limit the use of capital. Besides, the union may also restrict the number of labourers who can operate certain risky and high technology machines.
5. T-bill rate refers to a short-term debt obligation backed by the U.S. government with a maturity of less than one year. Treasury bills are securities traded in the U.S. Treasury of first and secondary market.
6. Cost function approach provides a convenient way to obtain the supply and demand equation. Furthermore, the cost function provides a sound, theoretical approach for using price and cost data to estimate a consistent set of factor-demand equations.
7. The role of labour unions is to obtain a permanent position for the unionised worker. If more workers join the union and obtain permanent status, this translates to a small number of workers who can be easily terminated, which results in the low demand for the new labour.

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