Tax-overshifting in wage bargaining models

by

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Abstract

It has frequently been noted in the wage bargaining literature that increasing average labour taxes may in fact be over-shifted in the pre-tax wage that is negotiated between unions and firms, raising workers post-tax wages. In this paper, we study the precise conditions for such tax over-shifting to occur under several different bargaining structures, and considering both competitive and imperfectly competitive output market conditions. In the case of competitive output markets and Nash bargaining over wages and employment, over-shifting is shown to hold for an entire class of commonly used concave production functions for which the divergence between marginal and average product is increasing in employment. Under right-to-manage bargaining, tax over-shifting is shown to depend on the curvature of the labour demand curve and on the wage elasticity of the firm's profits relative to the wage elasticity of labour demand. We further show that, under plausible assumptions, tax over-shifting is more likely to occur under monopolistically competitive output markets than under perfect competition; this holds for all bargaining models considered.

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1. Introduction

It has several times been noted in the literature that, when wages are determined as the outcome of union-firm bargaining, changes in marginal and average labour taxes may have quite different effects on the negotiated wage, and hence on employment (see, e.g., Malcolmson and Sator (1987), Lockwood and Manning (1993), and Pissarides (1998)). Whereas bargaining models consistently find that increasing the marginal tax rate reduces the post-tax wage, it has been pointed out that higher average tax rates may be over-shifted, in the sense that the negotiated pre-tax wage more than compensates for the tax increase. For example, Lockwood and Manning (1993) assumed a right-to-manage bargaining setting and a monopolistically-competitive output market. Assuming iso-elastic preferences and technologies, they showed that tax over-shifting always occurs: increases in the average labour tax always raise the post-tax wage. Although the result was only shown under isoelastic conditions, it was argued that it may be considered a plausible first approximation for the more general case. More recently, the possibility of tax over-shifting of average labour taxes has also been noted, for specific production and utility functions, in papers on tax reform in a right-to-manage bargaining framework (see, e.g., Bayundir-Uppman and Raith (2003) and Schöb (2003)).

In view of the economic and political interest in the impact of higher labour taxes on negotiated post-tax wages and employment levels (as stressed by, e.g., Creedy and McDonald (1991, p.346)), it is somewhat surprising that the precise conditions for tax over-shifting of average labour tax rates have not been studied in more detail in the literature¹. The purpose of this paper is to try to pin down more precisely the conditions for such tax over-shifting to occur. We do so under quite general assumptions on production technology, for several different bargaining structures, and considering both competitive and imperfectly competitive output market conditions. Several new results emerge. First, for the case of competitive output markets and Nash bargaining over wages and employment, over-shifting is shown to hold for an entire class of concave production functions for which the divergence between marginal and average product is increasing in employment. For the monopoly union model, over-shifting occurs whenever the labour demand curve is sufficiently convex. Moreover, the condition for tax over-shifting under right to manage bargaining turns out to be a combination of those obtained for Nash bargaining and the monopoly union model. Introducing a simple model of monopolistically competitive output markets implies that the results have to be

¹ The possibility of tax over-shifting on output prices has frequently been noted on imperfectly competitive markets (see, e.g., Stern (1987), Lockwood (1990) and Hamilton (1999)). More recently, Anderson, de Palma and Kreider (2001) derive the specific conditions for tax over-shifting to occur for both ad valorem and unit taxes within the framework of a differentiated oligopoly.

adjusted for differences in demand characteristics, but the main message remains. We show that, under plausible conditions, tax over-shifting is more likely to occur under this type of imperfect competition. Moreover, we confirm earlier results obtained in the literature as special cases.

Structure of the paper is as follows. In Section 2 we present the basic model we use to analyse tax over-shifting under competitive output market conditions, and analyse in detail the impact of tax changes on post-tax wages under different bargaining structures. In Section 3, we extend the results to a simple model of imperfect competition on the output market. A final section summarizes some conclusions.

2. Labour market bargaining and tax over-shifting: competitive output markets

2.1 Structure of the model

We consider a firm operating in a competitive output market. Profit is given by:

$$\pi(w,L) = f(L) - wL, \qquad (1)$$

in which the gross, pre-tax wage and employment levels are given by w and L respectively, and total revenue, denoted by f(L), is assumed to be concave ($f''(L) \le 0$).

It is assumed that the union takes into account both the well-being of the employed and the unemployed. Utility of the employed $U(\tilde{W})$ depends on the post-tax wage

$$\widetilde{W} = w - T(w, z) \tag{2}$$

Total tax payments T depend in general on the pre-tax wage rate w and a tax parameter z^2 . Union utility is specified as:

$$L\left[U(\tilde{W})\right] + (1-L)D$$

where D is the utility level of the unemployed, assumed to be constant³. Therefore, the union is interested in maximising:

² Several papers (e.g., Lockwood and Manning (1993) and Koskela and Schöb (1999)) explicitly distinguish between wage and payroll taxes in a right-to-manage bargaining model. These are found to have slightly different implications, both theoretically and empirically. To keep the results on overshifting as transparent as possible, note that we only consider wage taxes upon the employee.

³ Given the specific focus of this paper on tax over-shifting, this assumption is convenient to obtain tractable results. It implies that we do not endogenise social security payments such as unemployment benefits. Relaxing this assumption requires an optimal taxation approach that clearly specifies why taxes are being raised and that explicitly incorporates distributional issues.

$$V(w, L, z) = L[U(\tilde{W}) - D] = L\{U[w - T(w, z)] - D\}$$
(3)

2.2. Tax over-shifting with Nash-Bargaining over wages and employment

The firm and the union are assumed to bargain over both the pre-tax wage and the level of employment. The tax system is taken as given. The relevant maximisation problem can be formulated as:

$$\underset{w,L}{Max} \quad \mu \ln V(w,L,z) + (1-\mu) \ln \pi(w,L)$$
(4)

where μ is an indicator of union negotiation power. Standard manipulations (see, for example McDonald and Solow (1981)) reveal that the negotiated wage and employment levels, for any given tax parameter, solve the following two conditions:

$$h_1(w, L, z) = U(\tilde{W}) - D - \lambda [1 - T_w](w - f'(L)) = 0$$
(5a)

$$h_2(w,L,z) = w - \mu \frac{f(L)}{L} - (1-\mu)f'(L) = 0.$$
 (5b)

where λ is the marginal utility of wage income. The first condition is the 'contract curve', the second is the 'Nash curve'. The contract curve is easily shown to be upward sloping. For later reference, note that applying the implicit function theorem to (5b) immediately yields the slope of the Nash curve:

$$\frac{\partial L^{Nash}}{\partial w} = \frac{1}{f'' - \frac{\mu}{L} \left(Lf'' + \frac{f}{L} - f' \right)} < 0$$
(6)

Interpretation of expressions (5a)-(5b) is standard. When the union has no power, (5b) implies that the resulting wage and employment levels are on the firm's labour demand curve: the wage equals the marginal product of labour. Moreover, it then follows from (5a) that the wage equals the reservation wage necessary to induce people to work, since then $U(\tilde{W}) = D$. At nonzero union power, the negotiated wage is no longer on the firm's labour demand curve: it is a weighted average of marginal and average products of labour.

We focus in this paper on the effects of an increase in the average tax on labour, holding the marginal rate constant⁴. This boils down to considering an increase in the tax parameter z such that $T_z > 0$, but assuming $T_{wz} = 0$ (see Malcolmson and Sator (1987)). Our main interest is in the effect of such a tax change on the post-tax wage. To derive this effect,

⁴ Several authors have also considered increases in marginal tax rates at constant average rates. It is generally found that there is no over-shifting in this case, i.e. it reduces the post-tax wage (see, e.g., Malcolmson and Sator (1987)). This result is also easily reproduced for the model considered in this paper. Since this is not a novel finding, it is not included.

first observe that the impact of the tax change on the negotiated pre-tax wage is positive. This can be seen by differentiating system (5a)-(5b) and solving by Cramer's rule to find:

$$\frac{dw}{dz} = -\frac{h_{1z}h_{2L}}{\Delta} = \frac{T_z}{\Delta} \left[\left\{ (w - f')\lambda'[1 - T_w] - \lambda \right\} \left\{ \frac{\mu}{L} \left[f' - \frac{f}{L} \right] + (1 - \mu)f'' \right\} \right]$$
(7)

where λ' is the impact of the post-tax wage on the marginal utility of income, and

$$\Delta = h_{1w}h_{2L} - h_{2w}h_{1L} = (1 - T_w)\left\{ (w - f')(1 - T_w)\lambda' \left[\frac{\mu}{L} \left(f' - \frac{f}{L} \right) + (1 - \mu)f'' \right] - \lambda f'' \right\}$$
(8)

is the determinant of the system. Assuming declining marginal utility of income $(\lambda' < 0)$ it immediately follows that $\Delta > 0$. Expression (7) then immediately implies that $\frac{dw}{dz} \ge 0$: an increase in the average tax rate raises the negotiated pre-tax wage.

To determine the conditions for tax over-shifting to occur, we consider the impact of the average tax increase on the net of tax wage $\tilde{W} = w - T(w, z)$. Differentiating this expression, substituting (7) and using (8), we find after simple manipulations:

$$\frac{d\tilde{W}}{dz} = \frac{dw}{dz}(1 - T_w) - T_z = \left\{\frac{T_z}{\Delta}\lambda[1 - T_w]\frac{\mu}{L}\right\}\left\{f''L + \frac{f}{L} - f'\right\}$$
(9)

where we have assumed for simplicity that the tax schedule is affine in w (i.e. $T_{ww} = 0$)⁵. Note that expression (9) immediately implies that, when the union has no bargaining power at all ($\mu = 0$), the tax increase leaves the net-of-tax wage unaffected. The intuition is that in that case the negotiated wage equals the reservation wage (see (5a)-(5b)); an increase in the tax on labour is fully translated into an equal increase in the negotiated wage.

In the more general case with nonzero union power, it follows from (9) that tax over-

shifting will occur (i.e. $\frac{dW}{dz} > 0$) if and only if:

$$\left(f''L + \frac{f(L)}{L} - f'\right) > 0 \tag{10}$$

This condition is independent of union power; it has several simple and equivalent economic interpretations:

(i) First, it implies that tax over-shifting occurs if and only if the difference between the marginal and average products of labour is rising in employment. Indeed, simple algebra shows:

⁵ This assumption makes the results that follow more transparent; qualitatively, it does not affect the message from this paper.

$$\frac{d\left(f'-\frac{f}{L}\right)}{dL} = \frac{1}{L}\left\{f''L + \frac{f}{L} - f'\right\}$$
(11)

(ii) Second, (10) implies that tax over-shifting occurs whenever, at given employment L, the Nash curve implies a lower wage sensitivity of employment than the labour demand curve. To see this, note that the labour demand curve is implicitly defined by the first-order condition of the firm's profit maximization problem with respect to employment, w = f'(L). Denoting the solution as $L^{d}(w)$, it follows that the slope of the labour demand curve is given by

$$\frac{\partial L^d}{\partial w} = \frac{1}{f''} \tag{12}$$

Comparing this slope and the slope of the Nash curve derived before (see (6)), we immediately have the stated result. Graphically, tax over-shifting occurs whenever, at given employment levels, the Nash curve is steeper than the labour demand curve.

(iii) A third interpretation is derived by considering the impact of higher union power on the wage sensitivity of employment, as captured by the slope of the Nash curve (again, see (6)). It is easily shown that:

$$\operatorname{sgn}\frac{\partial^2 L^{Nash}}{\partial w \partial \mu} = -\operatorname{sgn}(Lf'' + \frac{f}{L} - f')$$
(13)

Condition (10) then shows that tax over-shifting will occur when a more powerful union reduces the sensitivity of negotiated employment outcomes with respect to wage increases. If this is the case, higher union power makes wage increases that result from tax changes less costly in terms of lost employment.

We summarize our findings in the following result.

Result 1: For an affine tax system, an increase in the average tax rate on wages increases the post-tax wage under Nash-bargaining iff one of three equivalent conditions hold: (i) the difference between marginal and average product is increasing in employment; (ii) the Nash curve is steeper than the labour demand curve at given employment levels; (iii) higher union power reduces the sensitivity of employment with respect to wage increases.

For the iso-elastic case often used in the literature, the above Result 1 is easily shown to hold. Indeed, let

$$f(L) = kL^{\alpha}, \quad \alpha < 1$$

Then simple algebra shows

$$f''L + \frac{f}{L} - f' = (\alpha - 1)^2 k L^{\alpha - 1} > 0$$

so that there is always over-shifting under Nash bargaining. Note, however, that Result 1 does not hold for the standard textbook case with inverse U-shaped marginal and average product curves (over the relevant range where average product is declining). To illustrate, let

$$f(L) = \alpha L + \beta L^2 + \gamma L^3,$$

where, to guarantee declining marginal product and positive average product throughout, the following restrictions on the parameters are assumed to hold:

$$\alpha > 0, \beta > 0, \gamma < 0, \beta < -3\gamma L$$

We then find:

$$f''L + \frac{f}{L} - f' = 4\gamma + \frac{\beta}{L} < 0$$

Hence, there is no over-shifting with Nash bargaining.

2.3. Tax over-shifting under Right-to-Manage bargaining

Under Right-to-Manage bargaining, the firm and the union bargain over wages only. For any given wage rate, the firm employs labour according to its labour demand curve $L^{d}(w)$ implicitly defined by the first-order condition for profit maximization w = f'(L). The negotiation outcome can therefore be modelled as the solution of the following maximization problem:

$$\underset{w}{Max} \quad \mu \ln V(w, z) + (1 - \mu) \ln \pi(w) \,. \tag{14}$$

where

$$V(w,z) = \left[L^{d}(w) \right] \left\{ U \left[w - T(w,z) \right] - D \right\}$$
$$\pi(w) = f \left[L^{d}(w) \right] - wL^{d}(w)$$

Standard manipulations reveal the first-order condition for wage bargaining:

$$h_3(w,z) = \mu \left[\frac{\lambda(1-T_w)}{U(.)-D} + \frac{1}{Lf''} \right] - (1-\mu)\frac{L}{\pi} = 0$$
(15)

As is well known, the monopoly union model is obtained as a special case for $\mu = 1$.

Not surprisingly, one again easily shows that an increase in the average tax rate, holding the marginal rate constant, raises the negotiated pre-tax wage. It follows from (15) that (to simplify matters, we have again assumed an affine tax structure in w ($T_{ww} = 0$)):

$$\frac{dw}{dz} = -\frac{h_{3z}}{h_{3w}} \tag{16}$$

where:

$$h_{3z} = \frac{-\mu T_z (1 - T_w)}{(U - D)} \left\{ \lambda' - \frac{\lambda^2}{(U - D)} \right\} \ge 0.$$
 (17)

$$h_{3w} = \mu \left\{ \left[\frac{\left(1 - T_w\right)^2}{U - D} \right] \left[\lambda' - \frac{\lambda^2}{U - D} \right] - \frac{1 + \frac{Lf'''}{f''}}{(Lf'')^2} \right\} - (1 - \mu) \left[\frac{1}{\pi f''} + \frac{L^2}{\pi^2} \right]$$
(18)

Concavity of the objective function of the bargaining model implies $h_{3w} < 0$, so that (16) implies the tax increase raises the pre-tax wage.

To determine the effect of z on the post-tax wage, we use (16), (17), and (18) to find:

$$\frac{d\tilde{W}}{dz} = \frac{dw}{dz}(1 - T_w) - T_z = \frac{T_z}{h_{3w}f''} \left\{ \frac{\mu}{(Lf'')^2} (f'' + Lf''') + \frac{(1 - \mu)}{\pi^2} (\pi + f''L^2) \right\}$$
(19)

Expression (19) shows that the condition for tax over-shifting to occur under right to manage bargaining depends on the union's bargaining power, unlike in the Nash bargaining case. It is a weighted average of two terms, where the relevant weight is the union power parameter.

To facilitate the interpretation, we first consider the special case of a monopoly union $(\mu = 1)$. Then (19) implies that the net-of-tax wage rises in the average tax rate if and only if

$$f'' + Lf''' > 0. (20)$$

In other words, the third derivative must be positive and sufficiently large for over-shifting to occur. This is equivalent to assuming that the labour demand curve must be sufficiently convex⁶. Conditional on a given slope (i.e., for a given f'') a more convex labour demand curve (larger f''') implies a smaller loss of employment when the monopoly union goes for higher wages. We summarize in result 2.

⁶ The concavity of the right-to-manage bargaining objective function imposes a restriction on the convexity of the labour demand curve. However, one easily shows that there is a range of values for f''' such that concavity of the objective function holds and tax over-shifting does occur.

Result 2: For an affine tax system, a sufficient condition for tax over-shifting in the case of a monopoly union is that the labour demand curve is sufficiently convex.

Finally, we turn to the more general right-to-manage case in which the firm has at least some negotiation power. In that case, the above condition (20) is neither necessary nor sufficient due to the appearance of the final term $(\pi + f''L^2)$ in (19). To interpret this term, define the elasticities of labour demand and firm profits with respect to wages as, respectively:

$$\varepsilon_{w}^{L} = \frac{\partial L^{d}(w)}{\partial w} \frac{w}{L} = \frac{1}{f''} \frac{w}{L} < 0$$
$$\varepsilon_{w}^{\pi} = \frac{\partial \pi}{\partial w} \frac{w}{\pi} = -L \frac{w}{\pi} < 0$$

where, in the derivation of the last expression, we have used w = f'. Simple algebra then shows that:

$$\pi + f''L^2 = f''L^2 \left[1 - \frac{\varepsilon_w^L}{\varepsilon_w^\pi}\right]$$

This shows that tax over-shifting is more likely to the extent that, in absolute value, the elasticity of profit with respect to wages is smaller than the wage elasticity of labour demand. This conditions seems plausible. Wage increases reduce both firm profits and employment; when the firm has negotiation power and the impact on profits is small relative to the employment effects, one expects it to be less opposed to accepting higher wages. The more power the firm has, the more this effect matters.

Our findings can be summarized in the following result⁷:

Result 3: For an affine tax system, a sufficient set of conditions for tax over-shifting under right to manage bargaining is that (i) the labour demand curve is sufficiently convex and (ii) the elasticity of profit with respect to wages is smaller than the wage elasticity of labour demand by the firm. Alternatively, tax over-shifting is more likely the more convex the labour demand curve and the larger the labour demand wage elasticity relative to the wage elasticity of profit.

⁷ Some algebra shows that the impact of higher union power on the likelihood of tax over-shifting is, unfortunately, ambiguous.

Interestingly, let us point out that condition (19) for tax over-shifting under right to manage bargaining can be considered as a combination of the conditions required for a monopoly union and under Nash bargaining. To see this, note that, using the definition of profit and the condition w = f', we can also write:

$$\pi + f''L^2 = L(Lf'' + \frac{f}{L} - f')$$

A set of sufficient conditions therefore consists of conditions f''+Lf''' > 0 and $f''L + \frac{f(L)}{L} - f' > 0$. These were the conditions (10) and (20) derived for Nash

bargaining and a monopoly union, respectively.

To illustrate the previous Results 2 and 3, consider again the two examples given before. First, let $f(L) = kL^{\alpha}$, $\alpha < 1$. We have

$$Lf'''+f''=\alpha(\alpha-1)^2kL^{\alpha-2}>0$$

It follows that there is always over-shifting under monopoly unions and, combining with our earlier findings, for the general right to manage model. Second, let $f(L) = \alpha L + \beta L^2 + \gamma L^3$, with the appropriate restrictions on the parameters imposed. Then

$$Lf'''+f''=2(\beta+6\gamma L)<0$$

hence there is no over-shifting, neither under the monopoly union model nor for right to manage bargaining.

3. Labour tax over-shifting in a simple model of imperfectly competitive output markets

In the previous section, it was shown that under competitive conditions on the output market over-shifting is uniquely determined by the characteristics of the production function. In this section, we briefly extend the model to capture imperfect competition on the output market to see whether imperfect competition raises or reduces the likelihood of over-shifting occurring. We use the simplest possible version of imperfectly competitive output markets for illustrative purposes, making two strong simplifying assumptions to facilitate the exposition. First, we assume that the sector considered is very small relative to the economy, so that the effect of bargaining-induced price increases in the sector on consumer welfare can be ignored. Second, we assume constant elasticity demand functions x(p) throughout. Reflecting market

power, the price elasticity of demand is assumed to be strictly larger than one in absolute value.

To fix ideas, note that the model can be interpreted as describing one monopolistic sector which is small relative to the economy as a whole; alternatively, it can be interpreted as describing one sector among a large number of monopolistically competitive sectors in the spirit of Dixit-Stiglitz (1977). For applications of this type of model in a bargaining setting see, e.g., Layard and Nickell (1986), Lockwood and Manning (1993), and Wu and Zhang (2000)). These models typically assume that there are a large number of sectors, where in each sector one firm produces a different variety of a single differentiated product. Union utility depends on real net wages, and firms care about real profit. However, assuming that both unions and firms take the aggregate price level as fixed when negotiating about nominal wages, the impact of bargaining-induced price changes in one sector on the aggregate price level, and therefore on consumer welfare, can be ignored⁸.

3.1. Tax over-shifting under Nash bargaining

Suppose firms and unions bargain over wages and employment. It is clear that the negotiated outcomes immediately determine the firm's profit: negotiated employment determines output which, through the inverse demand function, determines the price the firm charges on the market. Denoting the inverse demand function by p(x) and noting that output is related to employment through the production function x = f(L), the bargaining problem in the sector under consideration can be written in terms of wages and employment as follows:

$$\max_{w,L} \ \mu \ln V(w,L,z) + (1-\mu) \ln \pi(w,L)$$

where

⁸ Demand for sector i's product is typically written as:

$$x_i = \left(\frac{p_i}{P}\right)^{\beta} \frac{E}{nP}$$

where p_i is the price in sector i, E is total consumer expenditures, n is the number of sectors and P is an aggregate price index. In this setup, the price elasticity β is equal to minus the elasticity of substitution between different varieties in the consumer's utility function. The firm is assumed to be interested in real profit, π_i / P . Similarly, union utility in an arbitrary sector is defined on real net wages: $\tilde{W}_i = [w_i - T(w_i, z)] / P$. The model presented in this section is consistent with this setting, assuming that all sectors are identical in all other respects and that the aggregate price level is exogenous in nominal wage negotiations (so that one can normalize P = 1).

$$V(w,L,z) = L\left\{U\left[w-T(w,z)\right] - D\right\}$$
$$\pi(w,L) = \left\{p\left(f(L)\right)\right\}f(L) - wL$$

Working out the first order conditions, we easily obtain the contract and Nash curves (the equivalent of system (5a)-(5b)) under imperfect competition:

$$g_1(w, L, z) = U(\tilde{W}) - D - \lambda(1 - T_w) \left\{ w - pf'\left(1 + \frac{1}{\beta}\right) \right\} = 0$$
 (21a)

$$g_2(w,L,z) = w - \mu \left(\frac{pf}{L}\right) - (1-\mu) \left[pf'\left(1+\frac{1}{\beta}\right)\right] = 0$$
(21b)

System (21a-21b) implies that wages are a weighted average of marginal and average revenue products. It also follows that, if the union has no power, the wage equals the reservation wage; the firm then determines employment as to maximise profit, wages equal the marginal revenue product of labour, and the firm charges the monopolistic price:

$$p = \frac{w}{f'} \frac{1}{\left(1 + \frac{1}{\beta}\right)} = \frac{MC}{\left(1 + \frac{1}{\beta}\right)}.$$
(22)

In all cases where the union has at least some power, the price falls short of the monopoly price. Finally, if the union has full power, system (21a-21b) implies that firm profit is zero.

Using similar procedures as for the perfect competition case, we show in Appendix 1 that the condition for tax over-shifting to occur is given by:

$$\left(f''L + \frac{f}{L} - f'\right) + K > 0 \tag{23}$$

where K>0 under a very mild condition (viz., unless profit is strongly negative, see Appendix 1). Note that condition (23) is the same as the corresponding condition under perfect competition on the output market (see (10)), with exception of the term K. The latter captures the effects of imperfect competition. Importantly, since K > 0, condition (23) implies that imperfect competition increases the likelihood of tax over-shifting to occur. The possibility to partially shift higher wages into higher prices induces the firm to reduce its opposition to negotiated wage increases⁹. We have result 4.

⁹ Note that imperfect competition effects enter in a simple linear way in (23). Of course, this is only true given our assumption of constant elasticities of demand. However, since the key mechanism underlying Result 4 is that higher wages, and hence lower output, can be offset by higher prices, Result 4 is likely to hold for nonconstant elasticities, as long as demand is downward sloping.

Result 4: With Nash bargaining, monopolistically competitive output markets raise the likelihood of tax over-shifting to occur.

3.2. Tax over-shifting under right to manage bargaining

Under right to manage bargaining the firm chooses employment so as to maximise profits:

$$\underset{L}{Max} p(x)f(L) - wL$$

where p(.) is the inverse demand function and x = f(L) is the production function. Optimal behaviour implies the first-order condition:

$$w - pf' \left[1 + \frac{1}{\beta} \right] = 0 \tag{24}$$

which implicitly defines the demand for labour by the firm, $L^{d}(w)$. Bargaining outcomes are the solution to the problem:

$$\max_{w} \ \mu \ln V(w,z) + (1-\mu) \ln \pi(w)$$

where

$$V(w,z) = L^{d}(w) \left\{ U[w - T(w,z)] - D \right\}$$
$$\pi(w) = \left\{ p[f(L^{d}(w))] \right\} f(L^{d}(w)) - wL^{d}(w)$$

In Appendix 2 we show that the increase in the average tax rate on net of tax wages is given by:

$$\frac{d\tilde{W}}{dz} = \frac{T_z}{g_{3w}} \left\{ -\frac{\mu}{L^2} \left(L \frac{\partial^2 L^d(w)}{\partial^2 w} - \left(\frac{\partial L^d(w)}{\partial w} \right)^2 \right) + \frac{1 - \mu}{\pi^2} \left[\pi \frac{\partial L^d(w)}{\partial w} + L^2 \right] \right\}$$
(25)

where $g_{3w} < 0$.

For purposes of interpretation, first again consider the monopoly union case ($\mu = 1$). A sufficient condition for tax over-shifting is again that the labour demand curve should be sufficiently convex:

$$L\frac{\partial^2 L^d(w)}{\partial^2 w} - (\frac{\partial L^d(w)}{\partial w})^2 > 0$$

More interestingly, however, to compare with the perfect competition case, note that one easily shows that this condition can be rewritten as follows (see Appendix 2):

$$Lf''' + f'' + R > 0 \tag{26}$$

where R captures imperfect competition effects. The sign of R is ambiguous in general; however, it will be positive unless the price elasticity is very large, i.e., unless the firm has very limited market power. Comparing (26) with (20), this implies that under plausible conditions the likelihood of tax over-shifting is larger with imperfect competition than under perfect competition.

If the firm has at least some negotiation power, the impact of the final term in (25) is nonzero. Simple algebra shows again that:

$$\pi \frac{\partial L^d(w)}{\partial w} + L^2 = 1 + \frac{\varepsilon_w^L}{\varepsilon_\pi^L}$$

where we have used the first-order condition (24) for profit maximization by the firm. This implies that interpretation is the same as in the perfect competition case. However, to investigate whether tax over-shifting is more or less likely under imperfect than under perfect competition, we show in Appendix 2 that the above term can alternatively be written as:

$$\pi \frac{\partial L^{d}(w)}{\partial w} + L^{2} = pL \frac{\partial L^{d}(w)}{\partial w} \left[\left(f''L + \frac{f}{L} - f' \right) + K \right]$$
(27)

where, as indicated before, K>0. Summarizing (26)-(27) yields the following result 5.

Result 5: Under right to manage bargaining, tax over-shifting is more likely for monopolistically competitive output markets, unless the firm has limited market power.

Note that this result confirms the earlier finding in the literature (Lockwood and Manning (1993)) that iso-elastic production and utility functions always imply over-shifting of average labour taxes.

4. Conclusions

This paper studied the conditions for increases in average tax rates to be over-shifted in higher wages in labour market bargaining models. In the case of competitive output markets and Nash bargaining, over-shifting was shown to hold for an entire class of concave production functions for which the divergence between marginal and average product is increasing in employment. For the monopoly union model, over-shifting occurs whenever the labour demand curve is sufficiently convex. Moreover, a sufficient set of conditions for tax over-shifting under right to manage bargaining was shown to consist of the conditions obtained for Nash bargaining and the monopoly union model. Finally, using a specific model of monopolistic competition, we showed that, under plausible conditions, tax over-shifting is more likely to occur under imperfect than under perfect competition. With Nash bargaining, imperfect competition unambiguously raises the likelihood of over-shifting as long as profits are positive; under right-to-manage bargaining, it does so unless the firm has very limited market power.

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Appendix 1

We here derive the condition for tax over-shifting in the case of Nash bargaining over wages and employment with imperfectly competitive output markets. First, differentiating the system of first-order conditions (21a)-(21b) and solving by Cramer's rule yields the effect of a tax increase on the pre-tax wage:

$$\frac{dw}{dz} = -\frac{g_{1z}g_{2L}}{H}$$

where $H = g_{1w}g_{2L} - g_{2w}g_{1L}$. The various terms are given by:

$$g_{1w} = -\lambda'(1 - T_w)^2 \left[w - pf'\left(1 + \frac{1}{\beta}\right) \right]$$

$$g_{1L} = \lambda(1 - T_w) \left[p\left(1 + \frac{1}{\beta}\right) f'' + pf'\left(1 + \frac{1}{\beta}\right) \frac{f'}{\beta f} \right]$$

$$g_{2w} = 1$$

$$g_{2L} = \frac{\mu}{L^2} \left[pf - pLf'\left(1 + \frac{1}{\beta}\right) \right] - (1 - \mu) \left[p\left(1 + \frac{1}{\beta}\right) f'' + pf'\left(1 + \frac{1}{\beta}\right) \frac{f'}{\beta f} \right]$$

$$g_{1z} = T_z \left\{ \lambda'(1 - T_w) \left[w - pf'\left(1 + \frac{1}{\beta}\right) \right] - \lambda \right\}$$

Using $\lambda' < 0$, assuming positive profit, and noting that system (21) implies:

$$w > pf'(1 + \frac{1}{\beta})$$

the following signs can be shown to hold: $g_{1w} > 0, g_{1L} < 0, g_{2L} > 0, g_{1z} < 0, H > 0$. It then immediately follows that a tax increase raises negotiated wages: $\frac{dw}{dz} > 0$.

The effect of a tax increase on the net of tax wage is given by:

$$\frac{d\tilde{W}}{dz} = \frac{dw}{dz}(1 - T_w) - T_z$$

which leads after standard manipulations, using the above expressions, to:

$$\frac{d\tilde{W}}{dz} = p \left\{ \frac{T_z}{H} \lambda \left[1 - T_w \right] \frac{\mu}{L} \right\} \left\{ \frac{f}{L} - f' \left(1 + \frac{1}{\beta} \right) + \left(1 + \frac{1}{\beta} \right) \left[f'' L + \frac{(f')^2 L}{\beta f} \right] \right\}$$
(A1.1)

Next, note that simple algebra allows us to write:

$$\frac{f}{L} - f'\left(1 + \frac{1}{\beta}\right) + \left(1 + \frac{1}{\beta}\right) \left[f''L + \frac{(f')^2L}{\beta f}\right] = \left(f''L + \frac{f}{L} - f'\right) + K$$

where

$$K = \frac{1}{\beta} \left\{ f''L - f' + \frac{(f')^2 L}{f} \left(1 + \frac{1}{\beta} \right) \right\}$$
(A1.2)

Substitution of (A1.2) in (A1.1) then yields:

$$\frac{d\tilde{W}}{dz} = p\left\{\frac{T_z}{H}\lambda\left[1-T_w\right]\frac{\mu}{L}\right\}\left\{\left(f''L + \frac{f}{L} - f'\right) + K\right\}$$

so that $\left(f''L + \frac{f}{L} - f'\right) + K > 0$ is a sufficient condition for tax over-shifting. This is

expression (23) in the main body of the paper.

The term K captures the effects of imperfect competition. If we assumed perfect competition, K would be zero and we reproduce the results for perfect competition, see (10). Note that K can be shown to be positive as follows. First, use the Nash curve (21b) to obtain:

$$f'\left(1+\frac{1}{\beta}\right) = \frac{w}{(1-\mu)p} - \frac{\mu}{1-\mu}\frac{f}{L}$$

Substitute this into (A1.2), use the definition of profit $\pi = pf - wL$, and rearrange to find:

$$K = \frac{1}{\beta} \left[\frac{-f'\pi}{(1-\mu)pf} + f''L \right]$$

This is positive as long as profit is positive.

Finally, interpretation of (23) is the same as under perfect competition. One easily shows that:

$$\operatorname{sgn}\left\{\frac{\partial\left[\frac{pf}{L} - pf'\left(1 + \frac{1}{\beta}\right)\right]}{\partial L}\right\} = \operatorname{sgn}\left\{\left(f''L + \frac{f}{L} - f'\right) + K\right\}$$

so that tax over-shifting occurs when the difference between average and marginal revenue product curves is declining in employment. Alternatively, the condition can again also be interpreted in terms of the difference in the slope of the Nash curve and the firm's labour demand curve. Using (21b), the slope of the Nash curve is easily shown to be given by:

$$\frac{\partial L^{Nash}}{\partial w} = \frac{1}{p\left(1 + \frac{1}{\beta}\right)\left[f'' + \frac{(f')^2}{f\beta}\right] - \frac{\mu}{L}\left\{\left(f''L + \frac{f}{L} - f'\right) + K\right\}}$$
(A1.3)

Similarly, the slope of the labour demand curve is easily derived as:

$$\frac{\partial L^{d}}{\partial w} = \frac{1}{p\left(1 + \frac{1}{\beta}\right) \left[f'' + \frac{(f')^{2}}{f\beta}\right]}$$
(A1.4)

Comparison of the slopes immediately produces the desired result. Finally, the expression for the slope of the Nash curve also shows that tax over-shifting depends on the effect of higher union power on the wage sensitivity of labour demand.

Appendix 2

For the right to manage model, the first order condition of the bargaining problem can be written as:

$$g_3(w,z) = \mu \left[\frac{\lambda(1-T_w)}{U(.)-D} + \frac{1}{L} \frac{\partial L^d(w)}{\partial w} \right] - (1-\mu) \frac{L^d(w)}{\pi} = 0$$

It immediately follows that an increase in the average tax rate raises the negotiated wage:

$$\frac{dw}{dz} = -\frac{g_{3z}}{g_{3w}} = \frac{1}{g_{3w}} \left\{ \frac{\mu T_z (1 - T_w)}{U - D} \left[\lambda' - \frac{(\lambda)^2}{U - D} \right] \right\} > 0$$

since

$$g_{3w} = \mu \left[\frac{(1 - T_w)^2}{U - D} \left(\lambda' - \frac{\lambda^2}{U - D} \right) + \frac{1}{L} \left(\frac{\partial^2 L^d(w)}{\partial^2 w} - \frac{1}{L} \left(\frac{\partial L^d(w)}{\partial w} \right)^2 \right) \right] - (1 - \mu) \left[\frac{1}{\pi} \frac{\partial L^d(w)}{\partial w} + \frac{L^2}{\pi^2} \right]$$

is possible by the second order condition

is negative by the second order condition.

Furthermore, the impact on the net of tax wage is given by:

$$\frac{d\tilde{W}}{dz} = \frac{dw}{dz}(1 - T_w) - T_z$$

This can easily be shown to be:

$$\frac{d\tilde{W}}{dz} = \frac{T_z}{g_{3w}} \left\{ -\frac{\mu}{L^2} \left(L \frac{\partial^2 L^d(w)}{\partial^2 w} - \left(\frac{\partial L^d(w)}{\partial w}\right)^2 \right) + \frac{1-\mu}{\pi^2} \left[\pi \frac{\partial L^d(w)}{\partial w} + L^2 \right] \right\}$$
(A2.1)

An interesting issue is whether imperfect competition raises or reduces the likelihood of tax over-shifting under right to manage bargaining. By working out the various terms appearing in (A2.1), this question can be answered.

First, differentiating the slope of the labour demand curve derived before, see (A1.4), and rearranging we have:

$$\frac{\partial^2 L^d(w)}{\partial^2 w} = -\left(\frac{\partial L^d(w)}{\partial w}\right)^3 \left[p\left(1+\frac{1}{\beta}\right)\right] \left\{f'''+\frac{3f'f''}{f\beta}+\frac{(f')^3(1-\beta)}{(f\beta)^2}\right\}$$
(A2.2)

Combining (A1.4) and (A2.2) we further derive:

$$L\frac{\partial^2 L^d(w)}{\partial^2 w} - \left(\frac{\partial L^d(w)}{\partial w}\right)^2 = -\left(\frac{\partial L^d(w)}{\partial w}\right)^3 \left[p\left(1+\frac{1}{\beta}\right)\right] \left\{Lf'''+f''+R\right\}$$
(A2.3)

where

$$R = \frac{f'}{f\beta} \left\{ 3Lf'' + f' \left[1 + \frac{Lf'}{f\beta} (1 - \beta) \right] \right\}$$
(A2.4)

It follows from (A2.3) that a sufficient condition for tax over-shifting under the monopoly union model is given by Lf'''+f''+R > 0, see (26) in the main body of the paper.

To see the determinants of the sign of R, note that a sufficient condition for it to be positive is that

$$\left[1 + \frac{Lf'}{f\beta}(1 - \beta)\right] \tag{A2.5}$$

be negative. Now note from the condition for profit maximising behaviour

$$w = pf'\left(1 + \frac{1}{\beta}\right)$$

that

$$f' = \frac{w}{p} \frac{\beta}{\beta + 1}$$

Substituting in (A2.5) implies, using the definition of profit and some simple rearrangement:

$$\left[1 + \frac{Lf'}{f\beta}(1-\beta)\right] = \frac{1}{\beta+1} \left[\frac{(\beta-1)\pi}{pf} + 2\right]$$
(A2.6)

Since the price elasticity was assumed to strictly exceed unity in absolute value and profit relative to revenues is smaller than one, it follows from (A.2.4) and (A.2.6) that R will be positive unless the price elasticity is very large, i.e., unless the firm has very limited market power.

Second, when the firm has some negotiation power, the term $\pi \frac{\partial L^d(w)}{\partial w} + L^2$ also

matters. Rewrite this term as:

$$\pi \frac{\partial L^{d}(w)}{\partial w} + L^{2} = L \frac{\partial L^{d}(w)}{\partial w} \left[\frac{\pi}{L} + L \frac{1}{\frac{\partial L^{d}(w)}{\partial w}} \right]$$

Then substitute the profit maximising price into the definition of profit, use (A1.4), and rearrange to find:

$$\pi \frac{\partial L^{d}(w)}{\partial w} + L^{2} = pL \frac{\partial L^{d}(w)}{\partial w} \left[\left(f''L + \frac{f}{L} - f' \right) + K \right]$$
(A2.7)

where K is defined as in (A1.2):

$$K = \frac{1}{\beta} \left\{ f''L - f' + \frac{(f')^2 L}{f} \left(1 + \frac{1}{\beta}\right) \right\}$$

For the right to manage model, using the first order condition for profit maximising behaviour, K can again be shown to be positive.