Wage setting and the tax system
Theory and evidence for the United Kingdom

Ben Lockwood

Department of Economics, University of Exeter, Exeter EX4 4RJ, UK

Alan Manning*

Department of Economics, London School of Economics, London WC2A 2AE, UK

Received July 1991, final version received July 1992

This paper analyses the effects of a non-linear tax system on wage bargaining. The main conclusions are: an increase in the marginal income or payroll tax rate reduces the pre-tax wage; in the isoelastic case, an increase in the average tax rate increases the pre-tax wage by *more than* the tax increase, and a measure of the progressivity of the tax system (residual income progression) is a sufficient measure of the effect of the tax system on wage pressure. Empirical evidence is presented to support these propositions, and the predictions of the model regarding the effect of recent changes to the U.K. tax system on the distribution of earnings discussed.

1. Introduction

Most recent empirical time-series work on wage determination has stressed the importance of the tax system. For example, Layard and Nickell (1986) claim that the rise in the tax wedge has played an important part in raising wage pressure. In the short run, other things being equal, this will tend to increase the natural rate of unemployment, although most models tend to assume that the long-run natural rate is unaffected. However, the theoretical models used to generate empirical wage equations have, without exception,

Correspondence to: B. Lockwood, Department of Economics, University of Exeter, Amory Building, Rennes Drive, Exeter EX4 4RJ, UK.

*We wish to thank a referee, Lars Calmfors and seminar participants at the Institute for Fiscal Studies, Swansea, Kent, Queen Mary and Westfield College and the EMRU Conference at Loughborough for their comments on earlier versions of this paper. Financial support from the Leverhulme Trust and the Economic and Social Research Council of the United Kingdom is gratefully acknowledged.

assumed both income and payroll taxes to be proportional, and, correspondingly, have used only measures of average tax rates in empirical work. This seems restrictive in two respects. First, a recent theoretical literature has suggested that if the wage is set as the outcome of union–firm bargaining, changes in marginal and average tax rates may have qualitatively different effects on the negotiated wage [Layard (1982), Hersoug (1984), Malcomson and Sator (1987), Hoel (1989)]. In particular, a very robust result is that increases in the marginal rate of income tax lower the pre-tax real wage, and hence unemployment, whereas an increase in the average tax usually has the opposite effect. In the long run, it may well be the case that the non-proportional aspects of the tax system have a larger effect on the natural rate of unemployment than the average level of taxation.

Secondly, the effects of a non-proportional tax system might be important in understanding the development of wage pressure as the U.K. tax system is (and has been) very non-proportional. For example, until earnings-related National Insurance contributions were introduced in 1961 the marginal payroll tax was zero for both employers and employees at any level of the wage, and it was not until 1970 that this marginal rate became positive for the average male manual worker, when the upper earnings limit exceeded average male manual earnings. By contrast, the average payroll tax on the employer of a typical male manual worker rose from around 2% in 1952 to over 7% in 1970. Even bigger discrepancies occur in income tax; over the 1950s, the marginal rate of income tax faced by a 'typical' male manual worker (on average earnings, married with two children) was about 20%, whereas his average tax rate never exceeded 6%, due to the existence of low-rate tax bands and relatively generous child tax allowances. This ratio has narrowed somewhat in recent years, but even in 1987 the marginal and average rates for the average male manual worker, married with two children, were 36% and 18%.

One of the aims of this paper is to extend the set of empirically testable hypotheses concerning the effects of the tax system on wages. To do this, we construct a fairly general model of firm–union wage setting, and show that a number of strong predictions can be made when profit and union utility functions are isoelastic. Among these are (i) an increase in the marginal tax rate, the average rate being constant, will lead to a decrease in the pre-tax real wage; (ii) an increase in the average tax rate, the marginal rate being held constant, will lead to an *increase* in the pre-tax real wage (i.e. more than 100% shifting), a result which is related to recent results on tax incidence in imperfectly competitive product markets [Seade (1985), Stern (1987)]; and (iii) it is the *ratio* of the average to marginal tax rates that determines the wage. Of these predictions, only (i) necessarily holds without isoelasticity, although substantial variation in elasticities may be needed to overturn the others. The first result is fairly well known [see, for example, Malcomson and

Sator (1987) and Hoel (1989)], but the last two are, to our knowledge, novel.[1]

The sort of model presented here may help to understand wage determination in the following ways. First, we can learn more about the effects of the tax system on wage pressure and hence on the natural rate of unemployment. For example, the analysis here suggests that if one wants to design a tax system to reduce wage pressure it should be strongly progressive with the marginal tax rate considerably above the average tax rate. A similar conclusion, based on the analysis of a linear tax system, was reached by Layard (1982).

Secondly, we may be able to have a better understanding of the effect of the tax system on the distribution of post-tax consumer wages. For example, the model predicts that while the current U.K. personal tax system acts to redistribute income towards those with income below the tax threshold from those above it, it also acts to redistribute *towards* the higher earners among those who pay the basic rate of tax. Because of the wide basic rate tax bracket this effect may be substantial. If one wants to have a tax system that redistributes towards the less well-off while maintaining the progressivity of the tax system to reduce wage pressure, one requires to have many small tax brackets with rising marginal tax rates. The linear tax system suggested in Layard (1982) would, like the present system, worsen the distribution of income.

Thirdly, the model here complements existing work on the effect of the tax system on labour supply. For male workers (which we consider here) whose labour supply seems to be fairly inelastic, a competitive model does not have a very interesting model of the link between taxes, wages and employment. But, if their wages are determined by collective bargaining (which is very important in Britain), the present model provides a theory of the link between the tax system and labour earnings. For example, the model can explain the increase in the earnings of high earners which has followed the large cut in their marginal tax rates, but it should be emphasized that this effect has nothing to do with increased incentives to work.

Clearly, the extent to which one should take these predictions seriously depends on whether the theory is a good model of collective bargaining. So, we also try to find empirical evidence for the effects discussed here. We estimate a version of the model on U.K. aggregate data from 1954 to 1987 to see whether there is any evidence for the predicted theoretical effects. We do find some role for the wedge between average and marginal tax rates as a

[1]It should be noted that we are talking only about the effect of the tax system on wage setting, holding unemployment constant. To understand the full effect of tax changes on the economy (which will generally involve changes in unemployment as well as wages) one needs to interact the wage equation derived here with an aggregate labour demand curve.

determinant of wage pressure, both in the estimation of strucutral, non-linear wage equations and log-linear ones.

The paper is organized as follows. In section 2, we present our basic theoretical framework, and derive our results on the effect of the tax system. In section 3 we describe how we move from the theory to our econometric equations. Section 4 presents our empirical results, and section 5 analyses the effect that the U.K. tax system has on the distribution of post-tax earnings.

2. Theoretical framework

In this section we present the theoretical model of wage bargaining between a firm and union, and derive our main results on the effects of the tax system on the wage. We start by parameterizing taxes in a general way which allows for any non-linearities in the tax system. We suppose that there is one worker per household, and that hours worked per year by the worker are fixed at $\bar{h}$. The nominal hourly wage paid by the firm is W. For convenience, we choose units so that $\bar{h}=1$ and we also suppose that the household has no non-wage income.

2.1. Taxes

First, we define the taxes paid by the household in a more general way than usual by subtracting benefits;[2] that is, as W is annual pretax income, we define total taxes paid net of all benefits received to be $T^{\mathrm{h}}(W,Z)$, where Z is a vector of parameters of the tax and benefit system, e.g. marginal tax rates, tax bands, etc. Note that T^{h} includes payroll taxes formally incident upon the employee. Note also that average and marginal tax rates are T^{h}/W and T^{h}_{W}, respectively, so that an increase in the average rate of tax, holding the marginal rate constant, is equivalent to a change in Z such that $T^{\mathrm{h}}_{Z}>0$ and $T^{\mathrm{h}}_{WZ}=0$, and similarly an increase in the marginal rate, holding the average rate constant is equivalent to $T^{\mathrm{h}}_{WZ}>0$ and $T^{\mathrm{h}}_{Z}=0$ [see Malcomson and Sator (1987)]. Next, we model the employer's payroll tax in exactly the same way. We define $T^{\mathrm{e}}(W,Z')$ to be the payroll tax function for the employer; changes in the average and marginal payroll taxes can be parameterized in a similar way to the income taxes.[3]

[2]By our definition of household, these are obviously benefits which the household receives when the 'head', or potential worker, is in fact in work. In the United Kingdom, the main such benefits are child benefit, family income supplement, and housing benefit. See the appendix for details on these benefits and how they were treated in empirical work.

[3]It is well known that theoretically the formal incidence of income and payroll taxes is irrelevant; nevertheless, we distinguish between income taxes (incident on the household) and payroll taxes (incident on the firm) because they seem to have different effects on wages in practice, and we wish to allow for these empirical effects in our empirical work.

2.2. Wage determination

We consider a fairly standard model with a unionized labour market and an imperfectly competitive product market along the lines of Layard and Nickell (1986) or Blanchard and Kiyotaki (1987). There are a number of firms $i=1,\ldots,F$ producing a differentiated product.[4] The demand schedule facing each firm is

$$Y_i^d = D(Q_i/Q), \tag{1}$$

where $Q_i = P_i(1+t_c)$, $Q=P(1+t_c)$, and P_i is the price charged by firm i, P is the economy-wide price level, and t_c is the rate of commodity taxation, e.g. VAT. The production function for firm i is

$$Y_i^s = f(N_i), \tag{2}$$

where N_i is the level of employment in the ith firm. The real profit of the ith firm is

$$\Pi_i/P = (P_i/P)D(P_i/P) - \Omega_i^p \psi(D(P_i/P)), \tag{3}$$

where $\Omega_i^p = (W_i + T^e(W_i, Z))/P$ is the real producer wage paid by the ith firm, and ψ is the inverse of the production function (2). The firm chooses P_i to maximize (3), which yields an optimal relative price P_i/P as a function of Ω_i^p, the real producer wage. This in turn implies that employment and profit can be written as functions of Ω_i^p only. Also, in the special case where demand in (1) is isoelastic with an absolute elasticity of $\eta > 1$, and the production function is Cobb–Douglas, i.e. $X_i = AN_i^\alpha$, then real profit and employment are also isoelastic functions of Ω_i^p:

$$N_i = C((W_i + T^e(W_i, Z))/P)^{-1/(1-\alpha)}, \tag{4}$$

$$\Pi_i/P = K((W_i + T^e(W_i, Z))/P)^{-\alpha'/(1-\alpha')}, \tag{5}$$

where $\alpha' = \alpha(\eta-1)/\eta < 1$ and C and K are constants [see, for example, Manning (1990) for a derivation].

Turning to wage setting, we assume that firm i negotiates W_i with a firm-specific trade union, and then employment is determined by the firm's demand for labour, e.g. (4). We suppose that trade union preferences over wages and employment are given by a general utility function $U(N_i, \Omega_i^c)$,

[4]We assume a large number of firms, as then each firm rationally takes the aggregate price level as fixed when choosing the nominal wage.

where $\Omega_i^c = (W_i - T^h(W_i, Z))/Q$ is the real consumer wage. We also consider the special isoelastic case

$$U = N_i^\gamma[(\Omega_i^c)^\delta/\delta - U_l], \tag{6}$$

where $(x)^\delta/\delta$ is the utility of real income x for a given union member, and U_l is the utility available to a union member who is laid off, or leaves the firm, and it is defined below in eq. (13). This formulation of union preferences is very general; it encompasses for example the utilitarian union of Oswald (1982), i.e. $\gamma = 1$, and the seniority model of Oswald (1985), i.e. $\gamma = 0$. It also allows for risk-neutrality ($\delta = 1$) or risk-aversion ($\delta < 1$) in preferences over income.

The nominal wage W_i is chosen to maximize the asymmetric Nash bargain

$$(\Pi_i - \underline{\Pi})^\lambda (U_i - \underline{U})^{1-\lambda}, \quad 0 \leqq \lambda \leqq 1. \tag{7}$$

Here λ denotes the relative power of the employer in wage bargaining and $\underline{\Pi}$ and $\underline{U}$ are the fall-back payoffs of the employer and union in the event of no agreement.[5] Taking logarithms of (7), we can write the maximand:

$$\Psi(W_i, Z, Z') = \lambda \ln(\Pi_i - \underline{\Pi}_i) + (1-\lambda) \ln[U(N_i, \Omega_i^c) - \underline{U}]. \tag{8}$$

The negotiated W_i maximizes (8) subject to the constraints that N_i and Π_i depend on W_i through Ω_i^p as described above [e.g. (4) and (5) in the iso-elastic case]. This first-order condition can be written as

$$\Psi_W = \lambda \frac{\Pi}{\Pi - \underline{\Pi}} \varepsilon_\pi \frac{(1 + T_w^e)}{(1 + T^e/W)}$$

$$+ (1-\lambda) \frac{U}{U - \underline{U}} \left[\theta_N \varepsilon_N \frac{(1 + T_W^e)}{(1 + T^e/W)} + \theta_\Omega \frac{(1 - T_W^h)}{(1 - T^h/W)} \right] = 0, \tag{9}$$

where ε_π and ε_N are the elasticities of the labour demand and profit functions respectively, with respect to the real product wage, θ_N and θ_Ω are the elasticities of the union utility function with respect to employment and the real consumer wage, respectively, and $\Psi_W = \partial\Psi/\partial W_i$, etc. Note that we have dropped the firm-specific 'i' subscripts; this is without loss of generality, as all firms are identical, so (9) can be interpreted as holding in symmetric equilibrium.

[5]For the first result derived below, i.e. the effect of marginal tax rates on W_i, we do not have to solve for W_i in closed form, and so can treat $\underline{\Pi}$ and $\underline{U}$ as arbitrary constants. For the remaining results, we set $\underline{\Pi}$ and $\underline{U}$ equal to zero, although this restriction could be relaxed somewhat.

2.3. *Effects of the tax system on wages: Some general results and the isoelastic case*

We are interested in the effects of changes in marginal and average income and payroll taxes on the wage. In the general (i.e. non-isoelastic) case, the only unambiguous result obtainable relates to changes in the marginal rates. More specifically, an increase in the marginal rate of tax on the household or employer unambiguously reduces the consumer wage. The intuition for this is as follows. An increase in the marginal tax rate with the average rate unchanged ($T_{WZ}>0, T_Z=0$) raises the 'price' in terms of forgone employment to the union of a unit increase in the post-tax wage, but leaves union income unchanged to first order as $T_Z=0$. So, it is a pure substitution effect, and unambiguously decreases the wage.

To see this formally, note that from (8), assuming the second-order condition $\partial\Psi^2/\partial^2 W<0$ holds,

$$\operatorname{sgn}\frac{\partial W}{\partial Z}=\operatorname{sgn}\Psi_{WZ}, \qquad \operatorname{sgn}\frac{\partial W}{\partial Z'}=\operatorname{sgn}\Psi_{WZ'}. \tag{10}$$

Now consider variations in Z and Z' such that $T^{\mathrm{h}}_{WZ'}T^{\mathrm{e}}_{WZ'}>0$ and $T^{\mathrm{h}}_{Z}=T^{\mathrm{e}}_{Z'}=0$. Then, from (9), using the fact that such variations leave both the producer and consumer wages unchanged, we get

$$\begin{aligned}\Psi_{WZ}&=-(1-\lambda)\frac{U}{U-\underline{U}}\theta_{\Omega}T^{\mathrm{h}}_{WZ}<0,\\ \Psi_{WZ'}&=\left[(1-\lambda)\frac{U}{U-\underline{U}}\theta_N\varepsilon_N+\lambda\frac{\Pi}{\Pi-\underline{\Pi}}\varepsilon_\pi\right]T^{\mathrm{h}}_{WZ'}<0,\end{aligned} \tag{11}$$

using the facts that ε_N, $\varepsilon_\pi<0$, θ_N, $\theta_\Omega>0$. Then from (10) and (11), the result follows. This is a slight generalization of the existing literature: in Malcomson and Sator (1987) the same result is demonstrated for an income tax only in the special case of the monopoly union, i.e. $\lambda=0$, and in Hoel (1989), the same result is derived in a more general model allowing for efficiency wage effects, but for a more restrictive form of the tax function.[6] There are no general results to be obtained for the effects of the average tax; as Malcomson and Sator point out, an increase in the average rate 'is a pure income effect whose sign cannot be determined without more information about utility, tax and profit functions'.

[6]Both Hoel (1989) and Hersoug (1984) assume a tax function of the form $T(W)=\alpha W^{\beta}$, where β is in fact the ratio of the marginal to the average rates of tax, and so measures the progressivity of the tax system. Changes in either α or β normally change *both* average and marginal rates simultaneously, and so this parameterization cannot be used to look at a 'pure' marginal change, where the average rate is held constant, or vice versa.

However, in the isoelastic case, an explicit solution to (9) can easily be derived, and more specific comparative statics results obtained. Assume first that in the event of a disagreement over wages, no union members are employed; then from (6), $\underline{U}=U(0,\Omega_i^c)=0$. Assume also that these union members cannot profitably be replaced by outsiders: then $\underline{\Pi}=0$ also. Note that from (4) and (5), ε_π and ε_N are constant at $-\alpha'/(1-\alpha')$ and $-1(1-\alpha')$, respectively, and from (6) θ_N is constant at γ and $\theta_\Omega=(\Omega^c)^\delta/((\Omega^c)^\delta/\delta-U_l)$. Substituting these in (9) we get

$$\frac{(\Omega^c)^\delta}{(\Omega^c)^\delta/\delta-U_l}=\frac{-[\lambda\varepsilon_\pi+(1-\lambda)\gamma\varepsilon_N]}{(1-\lambda)v_h v_e}, \tag{12}$$

where $v_h\equiv(1-T_W^h)/(1-T^h/W)$ and $v_e\equiv(1+T^e/W)/(1+T_W^e)$. In symmetric equilibrium U_l is given by a weighted combination of the real consumer wage and real post-tax benefits, B, accruing to households where the 'head' is out of work, where the weights depend on the probability of being reemployed and on the discount rate of the worker,

$$U_l=[\phi(u)B^\delta+(1-\phi(u))(\Omega^c)^\delta]/\delta, \tag{13}$$

where $\phi'>0$; (13) can be derived formally from a dynamic programming argument [see Manning (1988)]. Combining (12) and (13), we get an equation for the real consumer wage as a mark-up over real post-tax benefits:

$$(\Omega^c)^\delta=B^\delta[1-\mu v_h v_e/\phi(u)]^{-1} \tag{14}$$

and $\mu=-\delta(1-\lambda)[\lambda\varepsilon_\pi+(1-\lambda)\theta_N\varepsilon_N]^{-1}$ is a constant.

Eq. (14) allows us to ask what the effects of changes in the tax system are on real consumer wages, *conditional* on real post-tax benefits, B, being fixed. This is only a sensible question to ask if, in practice: (i) benefits accruing to a household with an unemployed worker are untaxed and unrelated to earnings; and (ii) there is no systematic relationship between the rate of payroll tax and benefit at the aggregate level through the government budget constraint. If either of these two conditions does *not* hold, then changes in the tax system will affect Ω^c in ways other[7] than through v_h and v_e. Given our definition of B in our empirical work, both these assumptions are

[7]If benefits are taxed, then (14) becomes $(\Omega^c)^\delta=B^\delta(1-T_h(B,Z)/B)^\delta[1-\mu v_h v_e/\phi(u)]^{-1}$, where B is now real *pre-tax* benefits, so that changes in the parameters Z of the tax system also affect Ω^c through $T_h(B,Z)$. If benefits are (say) proportional to pre-tax earnings, i.e. $B=bW/Q$, where b is fixed, then (14) reduces to $1=b^\delta(1-T_h(W,Z)/W)^{-\delta}[1-\mu v_h v_e/\phi(u)]^{-1}$. If the tax system is proportional, then this equation fixes the rate of unemployment, and real wages are determined residually by labour demand. For non-proportional tax systems, this equation defines a *nominal* wage conditional on b and u.

certainly satisfied over the sample period.[8] So, we feel that a fixed B is appropriate.

Given this, (14) has the following interesting implications. First, it predicts that the income and payroll tax variables affect the real consumer wage *only* through $v = v_h v_e$: the higher v, the higher the real consumer wage. This result is especially interesting because v_h is a well-known measure of progressivity of the tax system, known as the *coefficient of residual income progression*, RIP[9] [Musgrave and Musgrave (1976)]. It is easy to calculate that v_h, or the RIP coefficient, is the elasticity of the household's post-tax income with respect to its pre-tax income; according to the RIP criterion, a tax system is said to be progressive (at income level W) if $v_h < 1$ at W.

The second implication of (14) is that an increase in the marginal rate of income or payroll tax, holding the average rate constant, decreases v_h or v_e, and so has a negative effect on the real consumer wage, confirming the general result above. The third is that an increase in the average rate of income or payroll tax, holding the marginal rate constant, increases v_h or v_e, and so has a positive effect on the consumer wage (more than 100% shifting). Note that an indirect tax variable does not appear in (14); this is because we

[8]The details are as follows. First, in the United Kingdom, (ii) is satisfied for any plausible definition of B. In principle, revenues from payroll taxes finance social insurance benefits, such as unemployment benefit, via the National Insurance Fund. In practice, there is no simple relationship between payroll tax revenue and unemployment benefit, for two reasons. First, the government makes a substantial contribution to the National Insurance Fund from general tax revenue. Second, the Fund finances many other insurance-related benefits such as pensions.

Second, the extent to which (i) is satisfied does depend on how B is defined. In the empirical work, our definition of B is supplementary benefit plus housing benefit (both are non-insurance-related welfare payments). Over the sample period 1954–1987, supplementary benefit was not taxed (income support, which was introduced in 1988, was taxed from April 1990). Furthermore, supplementary benefit was not earnings related, and thus would not vary with W.

However it could be argued that B should include unemployment benefit, not income support. Unemployment benefit has been taxable for longer (since July 1982). However, if we assume that our representative household (as defined in section 4 below) has no other income than unemployment benefit, it would be below the tax threshold for the whole of the sample period, and hence not liable for tax. A more serious problem is that between October 1966 and January 1982, unemployment benefit was earnings related, so that total benefit comprised a flat-rate sum plus a sum proportional to earnings, up to a maximum earnings limit.

[9]Although there are, of course, several different measures of progression in the public finance literature (Musgrave and Musgrave, for example, give three, including RIP), the coefficient of RIP has some attractive properties. For example, if a tax system 1 has a coefficient of RIP of less than tax system 2 at *all* levels of income, tax system 1 generates a post-tax distribution of income that is less unequal than that of tax system 2 in the strong sense that the Lorenz curve for the post-tax distribution of tax system 1 lies everywhere above that of the post-tax distribution of tax system 2 [Jackobsson (1976)]. This result holds *whatever* the pretax distribution of income. Also, Kay and Morris (1984) have shown that the inverse of the coefficient of RIP measures the percentage increase in gross income needed to keep post-tax real income constant, following a 1% increase in the wage, and call this inverse the gross earnings deflator (GED). They have calculated values of the GED for the United Kingdom from 1973–74 to 1982–83, averaged across all income groups, which is around 1.2, implying an average for v_h of about 0.84. The variation of $v_h v_e$ across income groups is discussed in section 5 below.

have assumed that indirect taxes are proportional, and so have a v equal to 1. In other words, the burden of indirect taxes is fully shifted to the firms.[10]

The most striking (and perhaps surprising) result is probably the over-shifting of changes in the average rates of income and payroll taxes. The intuition for it is as follows. First, v_h and v_e measure the elasticity of the real consumer wage, Ω^c, with respect to the real producer wage, Ω^p, i.e. by definition

$$(\partial \ln \Omega^c / \partial \ln \Omega^p) = v_h v_e.$$

This means that, in turn, v_h and v_e affect the elasticity of profits and employment with respect to the consumer wage. For example, for employment, we have

$$\frac{\partial \ln N}{\partial \ln \Omega^c} = \frac{\partial \ln N}{\partial \ln \Omega^p} \frac{\partial \ln \Omega^p}{\partial \ln \Omega^c} = \frac{\partial \ln N}{\partial \ln \Omega^p} \frac{1}{(v_h v_e)}. \tag{15}$$

By looking at (15), we can now understand why an increase in the pure average rate of tax, the marginal rate being held constant, increases the real consumer wage (over-shifting). First, it increases v_h, and so from (15) decreases $\partial \ln N / \partial \ln \Omega^c$. We know that, in general, the more inelastic is labour demand, the higher wages will be set, and so as an increase v_h makes demand relate to Ω^c more inelastic, Ω^c rises. The same intuition is offered for the beneficial effect of a linear tax system in Layard (1982).

This over-shifting result can also be related to the recent literature on tax incidence in oligopolistic product markets [Seade (1985), Stern (1987), Lockwood (1990)]. One of the main results in this literature is that when demand is isoelastic, specific taxes are over-shifted (i.e. shifting greater than 100%), but ad valorem taxes are 100% shifted. Specific and ad valorem income taxes in this context are tax functions $T^h(W, Z) = T$ and $T^h(W, Z) = tW$, respectively. In the first case, the marginal rate of tax is zero, and the average rate is T/W; therefore, an increase in T corresponds precisely to an increase in the average rate only, holding the marginal rate constant, which as we have just argued, is over-shifted. In the second, marginal and average rates are constant at t, so $v_h = 1$, and so the real consumer wage is unaffected by t; precisely 100% shifting. In other words, our results can be reconciled precisely with the existing literature on product markets.

Of course all of these results, apart from the effect of the marginal tax rate, can be over-turned by having non-constant elasticities. But, as we have no real idea about the way in which elasticities might vary, and some sorts of

[10]All statements about shifting should be understood to be conditional on a given level of unemployment; of course, the equilibrium level of unemployment in the labour market will, in general, change in response to changes in the tax system.

variation would strengthen our results, we might think of the results reported above as being 'best guesses' about the effect of the tax system. But, we would be happier if we could find some empirical support for the predictions of the theory, and this is the purpose of the next section where we estimate an aggregate wage equation.

3. From theory to testing

In using the theory to derive a testable aggregate wage equation, several problems arise. The first problem that we face is that the tax variables that affect the consumer wage (namely ($T^{\mathrm{h}}_W, T^{\mathrm{h}}/W$ and $T^{\mathrm{e}}_W, T^{\mathrm{e}}/W$) are endogenous and in fact depend on household earnings and other characteristics, such as number of children, earnings of secondary workers within the household, etc. This in itself raises several problems. The first is theoretical: if union members have heterogeneous preferences (because, for example, they face different marginal and average tax rates), it is not clear what the objective of the union (if any) is, and hence how the wage is chosen. There have been several solutions suggested in the literature: one is a public choice approach, where the trade-union objective is derived from majority voting among the membership [Booth (1985), Oswald (1985)]; another is the utilitarian approach [Oswald (1982)], which suggests that the union maximand is a weighted average of individual utilities over wages and employment. The majority voting approach suggests that the negotiated wage should depend on the tax variables of the median voter; the utilitarian approach suggests that it should depend on the tax variables of all household types.

A second problem is that the tax variables depend on the earnings of the household. Endogeneity itself is not a problem as the tax variables can be instrumented; the problem is that the tax functions $T^{\mathrm{h}}(\cdot, Z)$ and $T^{\mathrm{e}}(\cdot, Z')$ are non-linear. This means that when aggregating across different industries, where earnings will in general be different, the *average* marginal and the *average* average tax rates will in general, not be equal to the marginal and average tax rates evaluated at the average earnings, i.e. $(1/n)\sum_{i=1}^{n} T^{\mathrm{h}}_W(W^i, Z) \neq T^{\mathrm{h}}_W((1/n)\sum_{i=1}^{n} W^i, Z)$, etc. As we only have data on average earnings, we are constrained to constructing the tax variables at the average wage, but there will inevitably be a bias in the measurement of the tax variables.[11] However, we should note that because the basic rate tax bracket was so broad for most of the period, and most workers pay the same marginal national insurance contributions, that aggregation bias is not likely to be severe for our measures of the marginal tax rates. Existing studies of

[11] One might think of using a measure of the dispersion of earnings as a way of capturing some of the aggregation bias but, as will become apparent later, v is neither an everywhere concave nor everywhere convex function of W, making the expected sign on the dispersion ambiguous and potentially varying over time.

aggregate wage determination which use average tax rates also suffer from aggregation problems; so, it is not clear that the aggregation problem is any more severe in our study.

Our approach is the following. We assume that in each bargaining group the distribution of household characteristics is the same and we assume that the median household type is decisive. Given that we are trying to explain male manual earnings, we regard the median worker as being married with two children and assume that non-labour income is zero, that the only benefits received are child benefit and family allowances, and that other members of the household earn no income. The last assumption is not very attractive given the increase in female labour force participation over the sample period, but as we have no data on the earnings of partners of typical male manual workers we could think of no alternative. We also ran our regressions for other family types (single householder, married with zero, one or three children) and the results were very similar.

As our earnings variable, we used average earnings for male manual workers. Given our emphasis on the median voter in the above discussion, one might wonder whether it would be better to use median earnings. However, average earnings are likely to be a better measure if, as seems likely, wages no not vary within bargaining units and median household characteristics do not vary much across bargaining units.

To derive our measures of tax rates we used information on the tax system in force in each year and computed the average and marginal tax rates that a male manual worker on average earnings would have faced. More precise details of the assumptions and calculations are in the appendix. Our computations for the household average and marginal tax rates are presented in fig. 1, where they are denoted by ATH_t and MTH_t, respectively. For comparison, we compare our measure of the average tax rate with that used by Layard and Nickell (1986) which is based on actual tax payments (this series is denoted by *LN* in fig. 1). As can be seen the association is very close, except for the early years, suggesting that it does not matter very much which method of calculation is used. As we can be reasonably confident about the marginal tax rates faced by the vast majority of male manual workers (except for a few years at the beginning of the sample), our personal tax variables are probably fairly reliable.

The average and marginal payroll taxes, ATE_t and MTE_t, present more problems, mainly caused by the presence of Selective Employment Tax (SET) in the years 1966–73. As its name suggests, this was a selective (lump-sum) tax on employment in some service industries together with, for the years 1966–68, a subsidy to workers in manufacturing. The picture is complicated still further by the fact that the method of tax collection was for all employers to pay the tax, and then eligible employers claimed a refund and/ or the subsidy. This process inevitably took time and take-up of the rebate

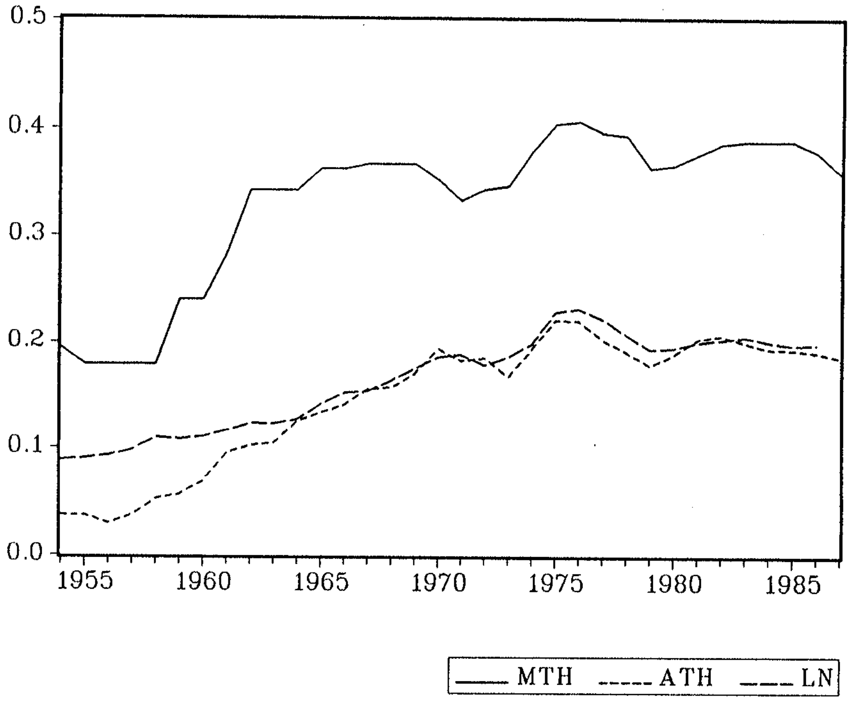


Fig. 1. Household marginal and average tax rates.

might not have been 100%. What this means is that we are very uncertain what the average payroll tax on a male manual worker was in this period. Given this, we consider two measures. The first, ATE_t^1, assumes that no manual worker paid SET, while the second, ATE_t^2, assumes that the proportion of workers paying SET is our estimate of the proportion paying it in the whole economy. Both measures are present in fig. 2. By comparison with the Layard–Nickell average payroll tax rate, which is based on the ratio of total labour costs to wages and salaries, we can see that ATE_t^1 seems to be a more comparable measure, although it still peaks more in the SET years.[12] However, we present results using both measures below.

Fig. 3 presents our measure of the replacement ratio (post-tax consumer wages over benefits) over our sample period. From (14), we can see that the tax variables that should explain this ratio are the v_h and v_e defined above. v is very closely related to the difference between average and marginal tax rates and is equal to one for a proportional tax. Fig. 4 presents our measures of v_h and v_e that we have computed. For the payroll taxes, we present two measures, v_e^1 and v_e^2, depending on how we treat SET (see the discussion above). Several points about fig. 4 deserve comment. First, v_e is always above v_h, indicating that the payroll taxes are less progressive than personal income

[12]Note that as the Layard–Nickell series is defined as the ratio of two indices, it is only measured up to a constant and we should not be concerned with differences in the levels of our series and theirs.

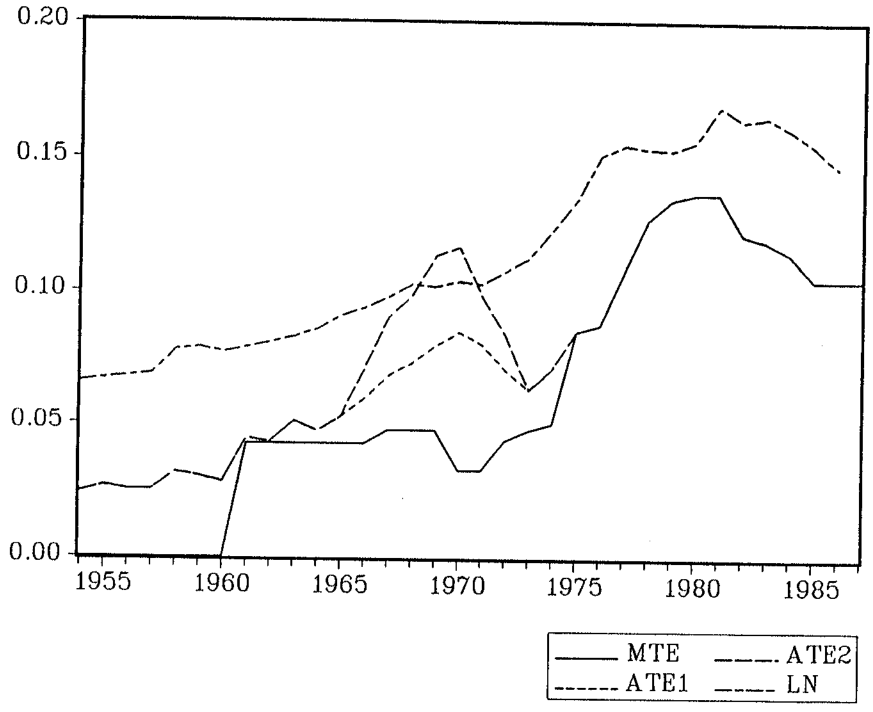


Fig. 2. Employer marginal and average tax rates.

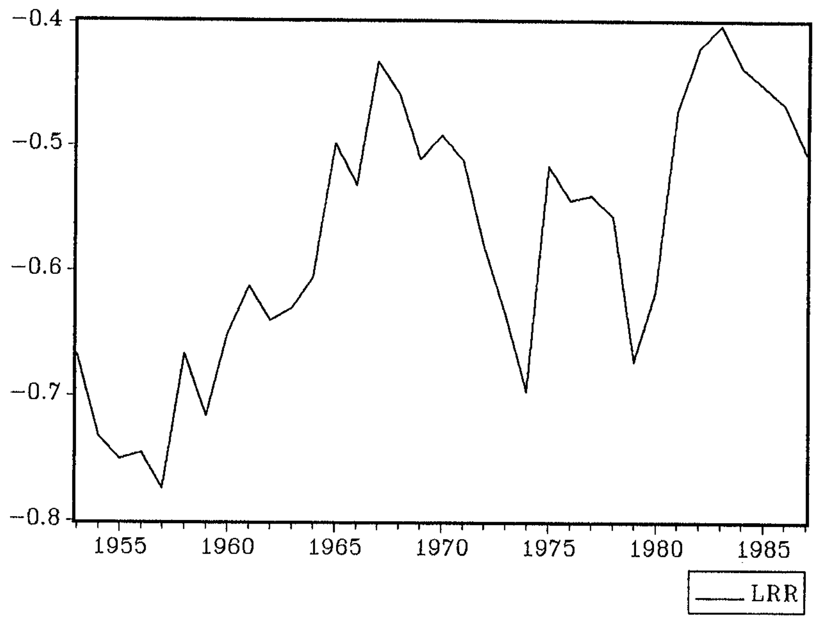


Fig. 3. The logarithm of the replacement ratio.

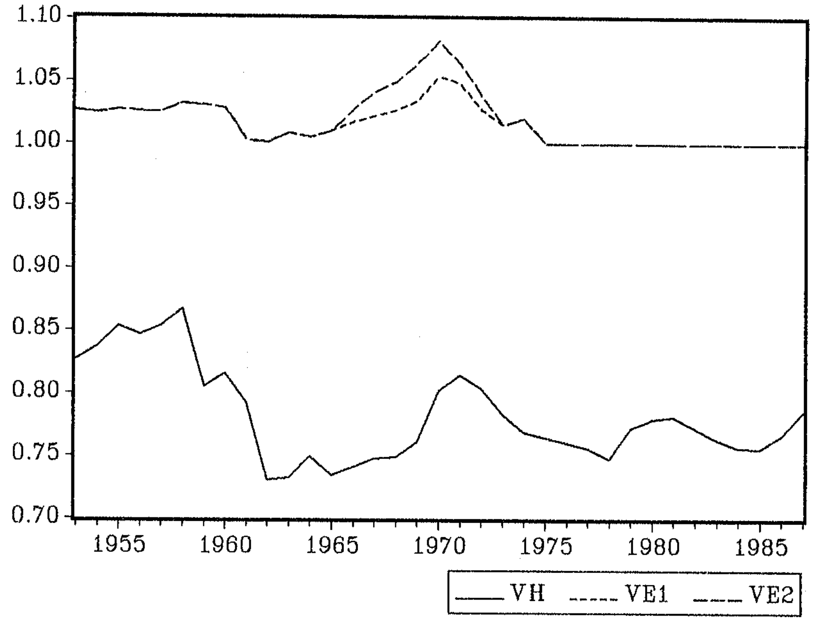


Fig. 4. v_h and v_e.

taxes in the United Kingdom. Secondly, until 1975, v_e is above unity indicating that, because of the flat-rate part of national insurance contributions in this period, payroll taxes were regressive. However, since 1975, v_e has been equal to unity for a worker on average earnings as national insurance contributions are now proportional. Note also that there is very little variation in v_e except in the period of SET when our measures of v_e may be at their most inaccurate; we will return to this problem below. Turning to the household taxes, we can see that v_h is always below unity because the income tax system is progressive and that there is considerably more variation than in v_e.

From (14) we also need a measure of utility when unemployed for which we use the level of real benefits appropriate to the family type, a measure of unemployment for which we used the male unemployment rate, and a measure of the wage mark-up for which we used the log of trade union density as a crude measure of trade union influence. We also tried including a measure of hours worked (as this should affect utility when in work), various incomes policy dummies, and the change in unemployment. All these other variables proved insignificant.

Finally, there is the issue of identification. First, both the marginal and average taxes, and average and marginal payroll taxes, are functions of the wage and the tax parameters; viewing the model therefore as a five-equation model we can easily identify the wage equation as we exclude the tax parameters (and there are many of them) from the wage equation as separate explanatory variables on theoretical grounds. From this discussion it is apparent that we need variation in tax parameters to identify our wage equation. It is for this reason that we use time-series data in which the tax system varies over time, rather than cross-section data in which the tax system is constant. Ideally, panel data over a lengthy period (to have enough variation in the tax system) should be used and we hope to do this in later work.

4. Empirical results

4.1. Non-linear structural models

In this section we present results based on the structural model of wage bargaining presented in (14). We model $\phi(u)$ as a linear function, ϕu, which can be justified on dynamic programming grounds [see Manning (1988)]. Then, taking logs, (14) can be written as

$$\ln(\Omega^c/B)=\frac{1}{\delta}[\ln(u)-\ln(u-(\mu v/\phi))], \tag{16}$$

where $v=v_h v_e$. Eq. (16) is used as the basis of our estimation. Note that the dependent variable is essentially the inverse of the replacement ratio. We modelled the mark-up, μ, as being linear in the log of trade union density, and we also included a constant because of possible mismeasurement of scale effects in (Ω^c/B). We also found that (16), as estimated, tended to have a lot of residual autocorrelation, so that we included a lagged dependent variable. Also, we included both current and lagged v in our equations, the latter tending to work better. Finally, to allow us to consider whether any estimated effects of v are significant we modelled the v term as a weighted average of v and a constant. So, our estimated equation is

$$\ln(\Omega^c/B)_t=\beta_0+\beta_1\ln(\Omega^c/B)_{t-1} + \beta_2\{\ln(u_t)-\ln[u_t-(\beta_5 v+1-\beta_5)(\beta_3+\beta_4\ln(den)_t)]\}. \tag{17}$$

Comparing (16) and (17), we can see that (16) implies that $\beta_5=1$, while $\beta_5=0$ would imply that v has no effect on post-tax wages. So, we can use the estimate of β_5 as a test of the significance of our tax variables. Finally, it should be noted that (17) is very non-linear; the problem that arose in estimation was to stop the last term in the equation becoming the log of a negative number.[13] For this reason we are unable to present unrestricted estimates of (17). We consider a grid of size 0.001 for the value of β_3 and then estimated the rest of the parameters.

The results for the estimation of (17) when the employer's tax variable does not include SET is presented in table 1. The first two columns estimate

[13]Given this problem, we also experimented with non-linear estimation of (14) itself, rather than the logged version (16). However, the same problem arose in this case also.

Table 1

Non-linear wage equations excluding SET.[a]

Dependent variable: $\ln(\Omega_t^c/B_t)$.
Method of estimation: instrumental variables.
Sample period: 1954–87.

	(1)	(2)	(3)	(4)	(5)
β_0	0.24	0.22	0.22	0.21	0.21
	(3.45)	(3.13)	(3.26)	(3.14)	(3.03)
β_1	0.45	0.49	0.47	0.49	0.50
	(3.17)	(3.41)	(3.25)	(3.45)	(3.43)
β_2	0.30	0.24	0.18	0.18	0.14
	(1.41)	(1.09)	(1.48)	(1.33)	(1.32)
β_3	0.064	0.056	0.069	0.063	0.060
β_4	0.067	0.058	0.072	0.066	0.062
	(14.59)	(11.99)	(20.06)	(16.06)	(19.70)
β_5	2.32	1.58	1.00	1.00	0.00
	(2.06)	(0.91)			
IV criterion $\times 10^{-2}$	0.9937	1.5270	1.2993	1.5545	1.6960
Tax variable	lagged	current	lagged	current	
AR(2)	0.27	0.18	0.30	0.22	0.23
	(2,25)	(2,25)	(2,26)	(2,26)	(2,26)
BAS	0.38	0.57	0.40	0.49	0.51
	(7,22)	(7,22)	(8,22)	(8,22)	(8,22)
LIN	1.05	0.90	1.52	1.20	1.27
	(2,27)	(2,27)	(2,28)	(2,28)	(2,28)
HET	1.03	1.29	1.22	1.28	1.23
	(3,26)	(3,26)	(3,27)	(3,27)	(3,27)
NORM	0.30	0.17	0.37	0.35	0.46

[a]Notes to all tables are at the end of table 4.

β_5 freely for both current and lagged v variables. For our purposes the results on β_5 are the most interesting. For both current and lagged v the estimates of β_5 are above one and, for lagged v, significantly different from zero. This is some weak evidence that the model that we have analysed here may be appropriate. It should be noted that the model with lagged v does seem to fit better and, consequently, may be preferred on those grounds. Columns (3) to (5) estimate the model with restricted β_5 both to zero and one. The model with $\beta_5=1$ always fits better than that for $\beta_5=0$. We also present some diagnostic tests which provide no evidence of serious misspecification. Table 2 presents the same results but now using a measure of the employer's tax variables that does include SET payments. The results are basically the same, although somewhat weaker.

These non-linear structural equations do provide some evidence that is consistent with the model of the effects of the tax system that we have presented above. However, it is difficult, in the context of the non-linear equations, to test the assumptions that it is the difference between marginal and average tax rates that is important. We might want to allow average and

Table 2

Non-linear wage equations excluding SET.[a]

Dependent variable: $\ln(\Omega_t^c/B_t)$.
Method of estimation: instrumental variables.
Sample period: 1954–87.

	(1)	(2)	(3)	(4)
β_0	0.23	0.21	0.22	0.22
	(3.31)	(3.05)	(3.22)	(3.10)
β_1	0.47	0.50	0.48	0.50
	(3.5)	(3.47)	(3.34)	(3.52)
β_2	0.22	0.18	0.17	0.18
	(1.32)	(1.09)	(1.45)	(1.27)
β_3	0.069	0.062	0.068	0.059
β_4	0.072	0.064	0.071	0.061
	(14.09)	(14.24)	(19.13)	(13.95)
β_5	2.11	1.12	1.00	1.00
	(1.62)	(0.53)		
IV criterion $\times 10^{-2}$	1.1154	1.6097	1.3487	1.6126
Tax variable	lagged	current	lagged	current
AR(2)	0.22	0.18	0.27	0.19
	(2,25)	(2,25)	(2,26)	(2,26)
BAS	0.43	0.58	0.42	0.51
	(7,22)	(7,22)	(8,22)	(8,22)
LIN	1.08	1.05	1.44	1.01
	(2,27)	(2,27)	(2,28)	(2,28)
HET	1.08	1.25	1.20	1.24
	(3,26)	(3,26)	(3,27)	(3,27)
NORM	0.19	0.33	0.34	0.31

[a]Notes to all tables are at the end of table 4.

marginal tax rates to have potentially different effects. However, this is easy to do in a log-linear equation and this is what we turn to next.

4.2. Log-linear estimation

Turning to our log-linear regression, our basic equation is

$$\log(\Omega^c/B)_t = \beta_0 - \beta_1 \log(u)_t + \beta_2 \log(den)_t + \beta_3 \log(v)_t. \tag{18}$$

The advantage of the log-linear formulation is that it makes it easier to test the predictions in the theory about the effects of average and marginal tax rates. For example, consider the following more general formulation of (18):

$$\log(\Omega^c/B)_t = \beta_0 - \beta_1 \log(u)_t + \beta_2 \log(den)_t + \beta_{31} \log(1-MTH)_t + \beta_{32} \log(1-ATH)_t + \beta_{33} \log(1+MTE)_t + \beta_{34} \log(1+ATE)_t + \beta_{35} vat_t, \tag{19}$$

Table 3

Log-linear wage equations excluding SET.[a]

Dependent variable: $\ln(\Omega_t^c/B_t)$.
Method of estimation: instrumental variables.
Sample period: 1954–87.

	(1)	(2)	(3)	(4
Const	0.68	0.78	1.20	1.14
	(5.21)	(6.83)	(3.35)	(2.85)
$\ln(u_t)$	−0.10	−0.12	−0.08	−0.09
	(4.12)	(5.68)	(1.80)	(1.70)
$\ln(den)_t$	0.37	0.27	0.62	0.60
	(1.88)	(1.58)	(1.78)	(1.67)
$\ln(1-mth_t)$	0.65	1.40	0.94	0.95
	(2.58)	(4.96)	(1.55)	(1.54)
$\ln(1-ath_t)$	−0.65	−1.40	−0.64	−0.66
			(0.55)	(0.56)
$\ln(1+mte_t)$	−0.65	3.88	2.86	2.87
		(3.47)	(1.65)	(1.45)
$\ln(1+ate_t)$	0.65	−3.88	−4.29	−4.10
			(2.31)	(1.71)
vat				0.71
				(0.13)
R^2	0.62	0.73	0.78	0.79
S.E.	0.069	0.059	0.055	0.055
AR(2)	5.39	1.33	1.61	1.49
	(2,26)	(2,25)	(2,23)	(2,22)
BAS	2.57	0.45	0.50	0.53
	(9,21)	(8,21)	(6,21)	(6,20)
LIN	0.58	0.56	0.25	0.24
	(2,28)	(2,27)	(2,25)	(2,24)
HET	1.10	0.79	1.27	1.07
	(3,27)	(3,26)	(3,24)	(3,23)
CHOW(83)	1.30	0.63	4.00	3.72
	(4,26)	(4,25)	(4,23)	(4,22)
CHOW(79)				
	1.09	0.40	2.13	1.75
	(8,22)	(8,21)	(8,19)	(8,18)
NORM	1.00	1.51	1.39	1.16

[a]Notes to all tables are at the end of table 4.

where *vat* is a measure of the indirect tax rate (see the appendix for variable definitions). Several interesting models are special cases of (19). For example, (18) is the case where $\beta_{31}=-\beta_{32}=-\beta_{33}=\beta_{34}$, $\beta_{35}=0$, and other hypotheses about the separate effects of personal, payroll and indirect taxes can also be easily tested within this framework.

Table 3 presents estimates of (19), where we use the measure of the average payroll taxes excluding the effect of SET. The first column presents estimates of the basic model (18). As can be seen, v has the expected theoretical sign and is significant. Unemployment is also very significant with a coefficient of the usual size found in similar wage equations. The coefficient on union density is of the exptected sign and marginally significant. This equation is supportive of the basic theory, although there is some evidence of misspecification. However, we might be interested in whether we can accept the restrictions on the general model (19) implied by (18). Column (2) presents estimates allowing v_h and v_e to have separate effects, but continuing to impose the restriction that indirect taxes have no effect. This form of the equation assumes that only the non-proportionality (as measured by v) of the tax system matters, but allows different taxes to have different effects. Formally, we impose the restrictions $\beta_{35}=0$, $\beta_{31}=-\beta_{32}$ and $\beta_{33}=-\beta_{34}$ on (19). The coefficient on $\log(v_h)$ is now larger and more significant but a problem is that the coefficient on $\log(v_e)$ is now of the wrong sign and very significant. This suggests that we can reject the hypothesis that personal and payroll taxes have the same long-run incidence. This is confirmed by an F-test of the validity of the restrictions in column (1), which yields a value $F(2,29)=5.76$, which is easily rejected at the 5% level. This presents something of a problem, as any theory based on maximizing behaviour, not just the special ones estimated here, would suggest that the formal incidence of a tax should be irrelevant in the long run. One possibility is that the restrictions imposed by column (2) on (19) are unacceptable.

The next step is to relax the assumption that only the non-proportionality of the tax system matters. We do this by estimating (19) in its unrestricted form. Column (4) of table 3 reports estimates of (19), including indirect taxes. It is clear that indirect taxes have no effect (as the theory predicts). Column (3) reports estimates omitting the indirect tax variable. The standard errors on the estimated coefficients in column (3) are rather high because of the considerable collinearity among the regressors, but the coefficients on the marginal and average personal tax rates are opposite in sign, roughly equal in magnitude, and have the signs predicted by the theory. However, an F-test for the validity of the restrictions in column (2) against column (3) takes on the value $F(2,27)=3.46$, which is just rejected at the 5% level, but accepted at the 1% level.

This regression provides evidence that high marginal income tax rates depress wages, whereas high average income tax rates lead to high consumer wages. However, the coefficients on the payroll tax variable are more of a problem. They are of opposite sign and roughly equal in magnitude (allowing for the large standard errors) but both coefficients are the opposite of what is predicted from the theory and have the opposite effect from the personal tax variables. This result simply confirms the finding of column (2) that personal and payroll taxes seem to have opposite effects. So, while we do find some evidence that personal taxes affect wage determination in the way predicted by our rather special theory, we also find evidence that payroll taxes have an effect opposite to that of personal taxes, a finding that any model based on maximizing behaviour would find hard to explain. One possible explanation is that there is very little variation in v_h (see fig 4) so that it is hard to identify its effects, and so it behaves like a dummy variable for the late 1960s. Finally, in table 4 we present estimates of similar equations using a measure of the average payroll tax including SET. The results are very similar, although it is now possible to accept the hypothesis that only the non-proportionality of the tax system matters ($F(2,27)=1.75$, which is easily accepted at the 5% level).

It should be noted that the estimated coefficients in columns (3) and (4) of both tables tend to have low t-statistics, which implies that it would be relatively easy to accept any hypothesis about the effects of the tax system on wages. So, the best we can say is that the evidence on the effect of personal taxes on wages is consistent with the theory.

5. The tax system and the distribution of earnings

So far, our analysis has been a representative agent model in which we have paid nothing more than lip service to heterogeneity in the work-force. But, once we do recognize that workers differ in their earnings and that v will also differ with the level of earnings, we realize that not only will the tax system affect the average level of earnings but also its distribution. This issue is the subject of this section.

A common approach to thinking about the effect of the tax system on the distribution of post-tax earnings is to treat the distribution of pre-tax earnings as exogenously given and then to apply the tax system in a mechanical way. Applying this approach to the U.K. personal tax system one would conclude that it acts to narrow the distribution of earnings as the average tax rate rises with income. Such a conclusion would probably also be reached using a labour supply model in which pre-tax earnings are endogenous through variation in hours, taking hourly earnings as exogenous.

However, the model presented here suggests that it may not be a legitimate assumption to regard the distribution of pre-tax earnings as exogenous. Our model suggests that post-tax earnings are positively related to v. So, if one level of earnings has a higher v than some other level, one would think that the tax system tends to redistribute towards the first group. One needs to be a bit careful about drawing this conclusion because the sensitivity of post-tax earnings to v may vary with the individual's position in the income distribution. For example, if individuals are low earners because they have a low mark-up in wage bargaining or because they are in a group with high unemployment, this will tend to reduce the sensitivity of post-tax earnings to changes in v [to see this just differentiate (14)]. However, we would expect a tax system that redistributes from rich to poor to have the feature that high earners have low values of v while low earners have high values of v.

Table 4

Log-linear wage equations excluding SET.[a]

Dependent variable: $\ln(\Omega_t^c/B_t)$.
Method of estimation: instrumental variables.
Sample period: 1954–87.

	(1)	(2)	(3)	(4)
Const	0.62	0.72	0.97	0.95
	(4.53)	(6.89)	(2.66)	(2.44)
$\ln(u_t)$	−0.11	−0.11	−0.99	−0.09
	(4.21)	(5.91)	(2.01)	(1.76)
$\ln(den)_t$	0.39	0.27	0.48	0.46
	(1.86)	(1.67)	(1.34)	(1.25)
$ln(1-mth_t)$	0.46	1.12	0.83	0.84
	(1.78)	(4.83)	(1.50)	(1.47)
$\ln(1-ath_t)$	−0.46	−1.12	−0.67	−0.67
			(0.61)	(0.58)
$\ln(1+mte_t)$	−0.46	2.20	1.43	1.62
		(4.04)	(1.16)	(1.33)
$ln(1+ate_t)$	0.46	−2.20	−2.30	−2.40
			(2.61)	(1.99)
vat				−0.78
				(0.14)
R^2	0.58	0.77	0.79	0.79
S.E.	0.073	0.055	0.053	0.055
AR(2)	7.34	1.33	1.42	1.23
	(2,26)	(2,25)	(2,23)	(2,22)
BAS	3.16	0.29	0.33	0.37
	(9,21)	(8,21)	(6,21)	(6,20)
LIN	1.09	0.36	0.18	0.19
	(2,28)	(2,27)	(2,25)	(2,24)
HET	1.10	1.49	1.43	1.42
	(3,27)	(3,26)	(3,24)	(3,23)
CHOW(83)	1.39	0.61	3.46	3.61
	(4,26)	(4,25)	(4,23)	(4,22)
CHOW(79)	0.51	0.54	1.92	1.70
	(8,22)	(8,21)	(8,19)	(8,18)
NORM	1.63	0.64	0.91	0.73

Notes to all tables

1. *t*-statistics in parentheses.

2. The non-linear equations were estimated by non-linear 2SLS, and the linear equations by instrumental variables. The instruments used in both cases were a lagged dependent variable, lagged unemployment, lagged log of union density, lagged v, lagged real rate of national insurance fixed rate, national insurance marginal rate, SET rate, personal tax allowances and basic rate of tax, time trend and squared time trend.

3. The misspecification tests used are the following, details of which can be found in the page references to Spanos (1986) given below. With the exception of NORM, all these test statistics have an approximate F-distribution under the null of no misspecification. Degrees of freedom are given in the parentheses under each test statistic.

AR(2) is an LM test for second-order residual autocorrelation based on an auxiliary regression of the residuals on two lagged residuals and fitted values (see Spanos p. 521).

BAS is a test of the over-identifying restrictions based on a regression of the residuals on the instruments (see Spanos, p. 652).

LIN is a RESET test for linearity based on a regression of the residuals on the fitted values, their squares and cubes (see Spanos, p. 461).

HET is a RESET test for heteroscedasticity based on a regression of the squared residuals on the fitted values, their squares and cubes (see Spanos, p. 469).

CHOW is Chow's second test for parameter stability (see Spanos, p. 486).

NORM is the Jarque–Bera test for normality of the residuals which has a $\chi^2(2)$ distribution under the null (see Spanos, p. 454).

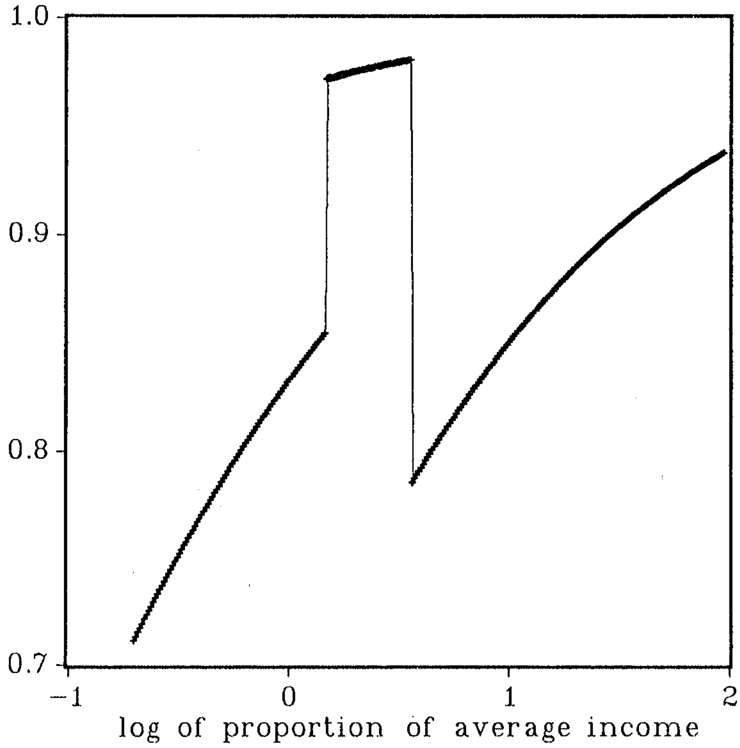
Fig. 5(a) presents estimates of v for a married man with two children for the U.K. personal tax system (income tax, national insurance and child benefit) in the tax year 1988–89 for income levels varying from 50% to 700% of average earnings.[14] The most striking feature is that, although the relationship between v and pre-tax earnings is non-monotonic, it is the high earners who generally have the higher levels of v and who, our theory would predict, receive most help from the tax system. Far from redistributing from the poor to the rich, the tax system is likely to be doing the reverse.[15]

The explanation for this is very simple. The first portion of the curve applies to workers who are paying the standard rate of income tax (25%) and are still making national insurance contributions at the marginal rate of 9%. All these workers face the same marginal tax rate but, as the average tax rate rises with income, v also rises. The big jump in v occurs when workers reach the upper earnings limit for national insurance contributions and their marginal tax rate is 25%. The big drop that occurs in v at still higher income levels is at the introduction of the higher tax rate (40%). For higher incomes v rises again as the marginal tax rate is constant but the average tax rate rises. One should remember that less than 5% of tax-payers pay the higher rate of tax so that virtually all workers are in the left-hand half of the figure. For this group v rises monotonically with income. Particularly favoured are those workers earning above the upper earnings limit for national insurance contributions for whom marginal and average tax rates are very close and v is close to one.

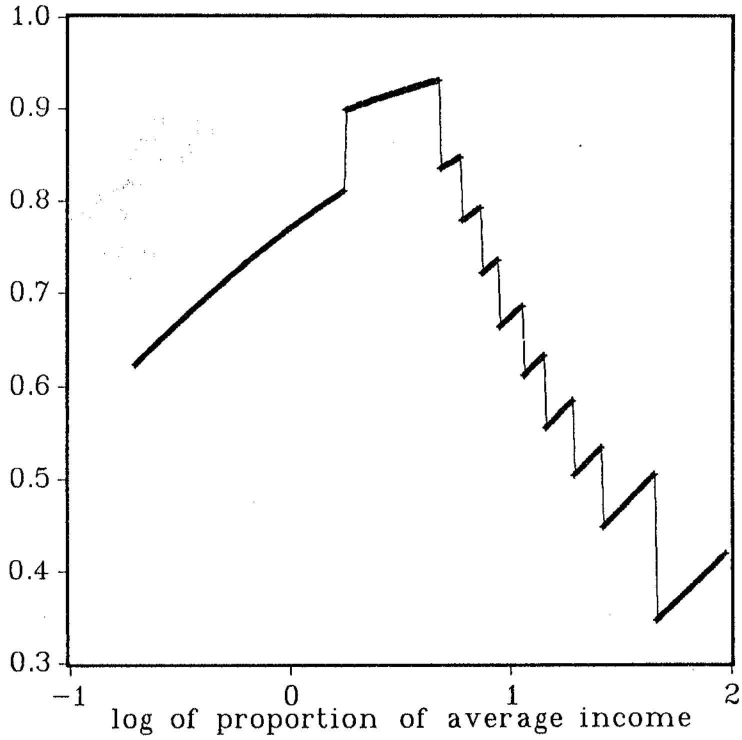
One may wonder whether this kind of picture is inevitable. In any tax band where the marginal tax rate is constant and the average tax rate rising, v will be higher for higher earnings. However, one can mitigate this problem by having thinner tax bands and more variation in marginal tax rates. For very high earners this is what used to be a feature of the tax system. Fig. 5(b) also compute v for the 1978–79 tax system. For the left-hand half of the diagram the picture is very similar to 1988–89, although there has been a general rise in v as Mrs. Thatcher has made the tax system less progressive. However, for very high earners v generally used to fall with income as there were many relatively small tax bands with higher and higher marginal tax rates (83% being the highest rate on earned income in 1978–79). So, if one wants a tax system which tends to have a negative relationship between v and income, one should abolish the large standard rate tax bracket and

[14]To our knowledge, there have been no estimates of the distribution of v across income levels for the United Kingdom. Most studies of the progressivity of the tax system have focused on the *average* v across different income groups, or some transformation of this average [Kay and Morris (1984), Morris and Preston (1986)].

[15]One should note that our discussion refers to redistribution among households of a given demographic type; there is also redistribution between household types (single, married with children, etc.) which needs to be evaluated in any complete description of the tax system.



(a)



(b)

Fig. 5. (a) v_h at different levels of income: 1988–89; (b) v_h at different levels of income: 1978–79.

replace it with a series of smaller tax brackets with more gradation in marginal tax rates.

It is also worth noting that figs. 5(a) and 5(b) show that the very high earners have had very big increases in the value of their v in the 1980s. This is one possible explanation of why they have increased their earnings so dramatically. However, the explanation provided by our model for this huge increase in earnings has nothing to do with any desirable incentive effects. The increase in the earnings for high income groups that seems to have followed reductions in their marginal tax rates and reductions in the overall progressivity of the tax system in many countries is exactly what one would predict from a bargaining model of wage formation, and is not necessarily indicative of large incentive effects in effort or labour supply.[16] One may wonder whether a bargaining model which we have motivated in terms of a union, is an appropriate model for the analysis of high earners. However, although these workers are generally not unionized, they do have some bargaining power (e.g. because they have firm-specific skills) and one could reasonably apply the model to the determination of their wages [e.g. with $\gamma=0$ in (6)].

6. Conclusions

This paper has analyzed the consequences of non-proportional tax systems for wage bargaining in unionized economies. The main theoretical conclusions were that: (i) an increase in marginal tax rates reduces wage pressure (measured as the consumer wage for given unemployment); (ii) an increase in average tax rates increases wage pressure in the case where profit and union utility functions are isoelastic; and (iii) it is the progressivity of the tax system as measured by the coefficient of residual progression (approximated by the difference between marginal and average tax rates) that is important for understanding wage pressure. Some empirical evidence was presented to indicate that the actual process of wage determination is consistent with these predictions. It was argued that the analysis of the tax system presented here has several interesting implications. First, if one is concerned with reducing wage pressure (and, hence, the natural rate of unemployment), one should have a tax system which is strongly progressive. So, for example, the low unemployment rates in Scandinavia may be because of their progressive tax systems instead of in spite of them, as is commonly believed. Secondly, the model here predicts that the U.K. personal tax system does not necessarily act to redistribute towards the less well-off. Among those on the standard rate of tax, the tax system tends to increase the earnings of the

[16]An alternative explanation of the large rise of real earnings at the top of the income distribution (relative to the average) is that as their marginal tax rates have fallen, they have had less incentive to seek remuneration in the form of fringe benefits.

higher paid as they have the same marginal but lower average tax rates. If one wanted to design a tax system that was more redistributive in nature one should have more tax bands with a steeper gradation in marginal tax rates. Thirdly, the model presented here can explain the big increase in earnings of the very high earners that followed the large reduction in their marginal tax rates. But, this has nothing to do with any efficiency effect: it is simply the outcome of wage bargaining.

So, the model does have a number of interesting predictions which are at odds with commonly held views. Whether it is a better explanation can only be decided by more rigorous testing of the model presented here: this we hope to do in later work.

Appendix

A.1. Direct tax variables

The marginal and average tax variables for the household were constructed as follows. First, we defined, on an annual basis, taxable income:

$$\text{taxable income}_t = W_t + FA_t - PA_t - CA_t,$$

where W_t is annual wage income and is defined below, FA_t is family allowance (taxable), and PA_t and CA_t are the personal allowances and child allowances appropriate for the composition of the household which, in our results, we take to be a married man with two children. As child tax allowances differed by age band (below 11, 11–15, 16–18) until they were abolished in 1979, we took the simple average of these allowances and multiplied by the relevant number of children in the household. All data on tax allowances, tax rates and tax brackets are taken from the *Reports of the Commissioners of the Inland Revenue*, Table 24, various issues. Finally, given taxable income for each household type, and the marginal rate appropriate in each tax bracket, we can calculate both the marginal rate of income tax for each type, $MITH_t$, and the total income tax liability for each type, TAX_t.

Next, using national insurance tax rates and bands, we can compute the analogous marginal and average rates of employee payroll tax. We assume that our representative employee is a contracted-in employee liable for Class 1 contributions. About half of all Class 1 employees are contracted in [1984, 46% (*DHSS Social Security Statistics*, 1986)] and given the relatively low participation of manual workers in occupational pension schemes over the sample period, this is probably a reasonable assumption. (Also, as long as the contracted-in and contracted-out rates are highly correlated over time, it does not matter.) Then, the marginal rate of national insurance contribution for an average wage-earner is $NIMTH_t$, and the total payment is $NICON_t$. These variables are obviously independent of household composition. Note that until April 1961, there was no earnings-related National Insurance, and the upper earnings limit was initially sufficiently low that it was not until 1970 that the average wage fell below it. Consequently, $NIMTH_t$ is zero except in 1970 and 1972–87.

Finally, the overall marginal and average rates of tax are defined as follows:

$$MTH_t = MITH_t + NIMTH_t,$$

$$ATH_t = (TAX_t + NICON - CB_t - FA_t)/W_t,$$

where CB_t and FA_t are the child benefit or family allowance accruing to the household where appropriate. Note that family allowance was replaced by child benefit in April 1977.

We can now compare ATH_t with the conventional average direct tax rate constructed from national accounts data. The latter is used for example by Layard and Nickell (1986); it is defined as the ratio of direct taxes plus employee's contributions to social security divided by household's current receipts. For comparison, we use this variable constructed from OECD national accounts.

A.2. Employer's payroll tax variables

In the same way, we compute the total national insurance liability for an employer of a Class 1 contracted-in employee on average wages ($NICONE_t$) and the associated marginal payroll tax rate MTE_t. Then, the average payroll tax incident on the employer is $ATE_t = NICONE_t/W_t$. In constructing $NICONE_t$, we face the additional complication of Selective Employment Tax, a tax on service industries which was introduced in April 1966 and ended in April 1973. This tax was levied by raising the level of the employer's flat rate National Insurance contributions, and refunding the increase to employers in manufacturing and some other industries, the intention being to bring about an expansion in manufacturing. We considered two ways of dealing with SET. In the first measure, we assumed that no worker paid it and omitted it from our calculations of the average payroll tax. In the second measure we assumed that a fraction λ of workers paid it, where λ is the ratio of employment in SET-paying industries to total employment. The calculations for λ come from *British Labour Statistics Historical Abstract* and *Yearbooks* (although this series applies to all workers not just manual workers for whom we do not have an available series). The data on SET rates are from Reddaway (1973, appendix I).

In fig. 2 we compare ATE_t with a conventional measure of the average payroll tax taken from Layard and Nickell (1986). The latter is constructed from national accounts, and is defined as the ratio of total labour costs per unit of output to wages and salaries per unit of output; it is an index and so may be negative. The correspondence is reasonably close, except that ATE_t peaks more over the period when SET was in operation. The difference may be due either to a bias in the representative household, or to the fact that the Layard–Nickell variable includes employer's contributions to private pensions schemes.

A.3. Other variables

$W_t = 0.5E_t + 0.5E_{t+1}$, where E_t is 52 times weekly earnings for full-time male manual workers in all industries and services in the United Kingdom in April of year t. We compute the average to try to get a better measure of income in the tax year. The source for E_t is *Department of Employment Gazette, British Labour Statistics Yearbook* 1969–76, *BLS Historical Abstract* 1948–86.

B_t = log of real benefits (supplementary benefit plus rent addition) to unemployed household (married couple with two children). Source: *DHSS Annual Abstract*, 1988.

Q_t = Retail Price Index, *Economic Trends.*

u_t = Male unemployment rate, *Department of Employment Gazette.*

den_t = Union density, *Department of Employment Gazette.*

vat_t = log of ratio of GNP at market prices to GDP at factor cost, *Economic Trends.*

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