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Progressive Taxation, Wage Setting, and Unemployment: Theory and Swedish Evidence

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Summary

■ The paper offers an investigation of how a progressive tax system affects wage formation. When there is bargaining over wages, a rise in tax progressivity is likely to lead to wage moderation because it makes real labor costs – and thereby employment – more sensitive to changes in the real wage. A progressive tax system may therefore also lead to a lower equilibrium unemployment rate in the economy. Our empirical analysis of wage determination exploits two different Swedish data sets. One data set contains time series on wages among workers in different skill categories; the other data set is a panel for 1989–92 with detailed information on individual workers. The results from the two data sets are broadly consistent with the theory, implying that tax progression contributes to wage moderation. This suggests that the decline in tax progressivity that has occurred over the past ten years may have increased the equilibrium unemployment rate in Sweden. ■

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Progressive Taxation, Wage Setting, and Unemployment: Theory and Swedish Evidence

Bertil Holmlund and Ann-Sofie Kolm*

Personal income taxes have been the main instrument for income redistribution in Sweden. From the early 1960s and through the early 1980s there was a gradual increase in marginal income tax rates, with top marginal rates exceeding 80 percent in some years. The marginal tax rate was roughly 40 percent for an average worker in the early 1960s and had risen to about 60 percent by the end of the 1970s. Average tax rates increased at a slower pace, from around 27 percent in the early 1960s to around 35 percent in the late 1970s. The trend increase in progressivity was broken in the early 1980s. There was in fact a marked trend decline in progressivity from the early 1980s and onwards, culminating in the major tax reform of 1991. The progressivity of the income tax system was lower in the early 1990s than it had been three decades earlier.

This paper is concerned with the implications for wage formation of this development of the Swedish tax system. In particular, we examine the hypothesis that a progressive income tax system may contribute to wage moderation. When there is bargaining over wages, a rise in progressivity is likely to reduce wage pressure because it makes real labor costs – and thereby employment – more sensitive to changes in workers' real take-home pay. The more sensitive employment is with respect to changes in the real wage, the more costly wage increases are to unions and employers. By reducing wage pressure, a progressive income tax system may lead to a lower equilibrium unemployment rate in the economy.

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The claim that tax progressivity is conducive to wage moderation may seem surprising at first. Indeed, exactly the opposite views are often voiced in the political discussion. Arguments like "lower marginal tax rates will facilitate wage negotiations and reduce wage inflation" are not unheard of in Swedish policy discussions over the postwar period. An early argument was developed by Erik Lundberg (1953) and later elaborated by Calmfors and Lundberg (1974). Lundberg's key concept was the "wage multiplier", which stated the amount of nominal wage increases required in order to achieve a given after-tax real wage target, taking the linkages between consumer prices and wage costs into account. The higher the marginal tax rate, the higher nominal wage increases required to achieve a given real wage target.

The wage multiplier analysis ignored the determination of the real wage target, however. An important insight offered by models of wage bargaining is that the real wage outcome is influenced by, *inter alia*, the parameters of the tax system. In these kinds of models it holds, under fairly general conditions, that the negotiated wage decreases if there is a rise in the marginal tax rate, holding the average tax rate constant. A higher marginal tax rate increases the "price" of wage increases, thereby inducing wage setters to substitute employment for real wages. Hersoug (1984) provided an early analysis of this case in a monopoly union framework.

The idea that tax progressivity may have favorable employment effects has appeared in many guises in the literature over the past ten years or so. One strand of theoretical work, associated in particular with Richard Jackman and Richard Layard, has examined the implications of so called tax-based incomes policies. These policies may involve a tax on wage increases, but are often represented by a progressive payroll tax scheme with a proportional tax on wages combined with an employment (per worker) subsidy. The implications of such a tax and subsidy scheme have been investigated in a variety of models of equilibrium unemployment, including models where wages are determined by monopoly unions, by bargaining between unions and firms, or bargaining between individual workers and employers. The implications have also been explored in the context of efficiency wages. A relatively robust result is that equilibrium unemployment is reduced by an increase in tax progressivity, i.e., an increase in the per-worker subsidy financed by a higher payroll tax. (See Jackman and Layard, 1990, and Layard *et al.*, 1991.)

A number of papers have discussed the effects of progressive income taxes in models with union wage setting or union-firm bargaining over wages. Lockwood and Manning (1993) offer a recent analysis, including empirical evidence for the United Kingdom. Lockwood and Manning focus exclusively on how the tax system affects wage setting, however, and do not pay much attention to general equilibrium effects. Another analysis is presented by Koskela and Vilmunen (1994), who offer a detailed microeconomic investigation of the effects of tax progressivity under alternative assumptions about the bargaining setup. Their basic conclusion is that progressive taxation is good for employment.

A first main purpose of our study is to provide a theoretical discussion of how tax progressivity influences wage setting, unemployment and welfare in an economy where wages are determined through decentralized union-firm bargaining. The theoretical exposition in Section 1 covers some familiar ground, but we also attempt to explore issues that have been neglected in earlier studies. There is a brief discussion of how the tax system shapes the structure of relative wages, and we consider the joint determination of wages and hours of work. Even if higher tax progressivity leads to wage moderation, it may well increase distortions in some dimensions of labor supply, such as the choice of education and decisions on hours of work. We consider one aspect of this tradeoff and discuss the *optimal* degree of progressivity.

As an introduction to the empirical analysis, we offer in Section 2 a descriptive account of changes in the structure of Swedish taxes on labor income, focusing in particular on tax progressivity. The empirical analysis in Section 3 is concerned with real wage determination and exploits two different data sets. One data set contains time series on wages among workers in different skill categories, whereas the other data set is a panel for 1989–92 with detailed information on individual workers. The results from the two data sets are broadly consistent with the theory, implying that tax progression contributes to wage moderation. This suggests that the decline in tax progressivity that has occurred over the past ten years may have increased the equilibrium unemployment rate in Sweden.

1. Theoretical issues

We have developed the theoretical arguments by presenting a sequence of models where wages are determined through union-firm bargaining.[1] Although the choice of a wage bargaining framework should be uncontroversial, other assumptions may seem more questionable. We consider only negotiations that are decentralized in the sense that the parties involved in bargaining take economy-wide factors as exogenous to their wage choices. The wage agreed on in a particular sector is thus taken to have a negligible effect on, for example, the aggregate unemployment rate and the average wage in the economy. The particular setup of the models provides a link between "outside" labor market conditions and the wage outcome, a linkage with strong empirical support. We ignore the interrelationships between contractual wage increases and so-called wage drift, i.e., the difference between total wage increases and contractual increases.

High tax rates on earned income provide incentives for firms and workers to find forms of compensation that are excluded from taxation, i.e., to substitute untaxed fringe benefits for taxable earned income. Anecdotal evidence on these matters abound, but there is – to our knowledge – very little hard evidence (which is not to say that the phenomenon is likely to be unimportant). Our work does not deal with issues of substitution between different forms of compensation and the role of the tax system in this respect.

1.1. The basic model[2]

We consider first an economy where hours of work are fixed and normalized to unity. Employment is exclusively set by firms after wages have been agreed on in negotiations. To simplify the exposition, and without loss of generality for the issues of interest, we treat output prices as fixed (normalized to unity) and determined on world markets. Indirect taxes are not explicitly introduced; the effects of indirect taxes will in fact be equivalent to the effects of proportional income taxes, so there is no need to introduce them explicitly. There is a fixed number of identical firms using labor as the only variable input.

[1] The theoretical exposition and the empirical analysis are presented in greater detail in an extended version of the paper. The extended version is available as a Working Paper from the Department of Economics, Uppsala University.

[2] The formal model is presented in the Appendix.

The nominal wage (W_i) is determined by bargaining between a union and a firm (or a number of identical firms in a particular sector represented by an employer organization). Since output prices are fixed, bargaining over nominal wages is equivalent to bargaining over real (pre-tax) wages. The objective function of the union in sector i is increasing in the level of employment, N_i, as well as in the real after-tax consumption wage, $W_i^c = W_i - T(W_i)$, where $T(.)$ is the amount of taxes paid by the worker.

The bargaining model is taken to be of the Nash variety, where the wage is chosen so as to split the gains from a wage agreement according to the relative bargaining power of the two parties involved. Profit-maximizing firms determine employment given the negotiated wage. Using this bargaining setup it is straightforward to show that the wage will be reduced by an increase in the marginal income tax rate or the marginal payroll tax rate, holding the average income or payroll tax rate constant.[3] A rise in the marginal income tax rate with the average rate unchanged reduces the marginal gain to the union of a wage increase; a rise in the marginal payroll tax rate with the average rate constant increases the marginal cost to the firm of a wage increase. The rise in progressivity induces wage setters to substitute employment for real wages. The wage-reducing effect of higher progressivity holds even if the union is exclusively concerned with real wages and assigns no weight on employment.

When the worker's preferences are iso-elastic we can write the wage equation at the level of the firm (or sector) as:

$$(W_i^c)^{\sigma} = [\tfrac{1}{\sigma} - v\kappa]^{-1} \cdot \Gamma_0 \tag{1}$$

The parameter σ, with $\sigma \leq 1$, is a measure of the elasticity of marginal utility of income for the employed worker. Γ_0 is the utility available to a worker who fails to become employed in the sector. The terms in brackets can be seen as a mark-up factor, where v is a measure of the progressivity of the tax system and κ captures the union's bargaining strength, in a broad sense. We take κ as constant; it depends on the share of labor in value added, which is assumed constant. The power of the union decreases in the labor share, since a higher labor share implies a more wage-elastic labor demand schedule.

[3] Taxes that are formally incident on the worker are referred to as income taxes, whereas taxes that are formally incident on the firm are referred to as payroll taxes.

The progressivity of the tax system is captured by v (which may be a constant or a function that depends on W). There are two components of v, $v \equiv \tilde{v} \cdot \hat{v}$, where the first part captures progressive income taxes and the second progressive payroll taxes. In particular, we have $\tilde{v} \equiv [1-T'(.)]/[1-T/W_i]$. It is straightforward to verify that $\tilde{v}$ is the elasticity of the after-tax wage with respect to an increase in the pre-tax wage, i.e., $\tilde{v} = \partial \ln W_i^c / \partial \ln W_i$. This elasticity is known in the literature as the coefficient of residual income progression, and it has some attractive properties as a device for characterizing how alternative tax systems affect the after-tax distribution of income.[4] It is also readily confirmed that $\hat{v}$ is the inverse of the elasticity of labor costs, $LC \equiv W_i + S(W_i)$, with respect to an increase in the wage, i.e., $\hat{v} = 1/(\partial \ln LC / \partial \ln W_i) = [1+S/W_i]/[1+S'(.)]$, where $S(.)$ is the amount of payroll taxes per worker.

To analyze the general equilibrium implications of changes in tax progressivity we need to specify workers' outside labor market opportunities. We take Γ_0 to be a weighted average of real wages outside the firm (W^c) and real unemployment benefits (B), with the weights determined by the aggregate unemployment rate (u) in the economy. By imposing symmetry, $W_i^c = W^c$, we obtain an aggregate wage-setting schedule which can be written in logs as

$$\ln W^c = const + (\sigma'/\sigma) \ln B - (1/\sigma) \ln [1 - \sigma \kappa v / \phi u] \tag{2}$$

where ϕ is a constant and σ' is a measure of the elasticity of marginal utility of income for the unemployed worker. It is clear that the effect of an increase in v on the consumption wage is increasing in the mark-up factor and decreasing in unemployment.

The model is closed by adding a labor demand schedule. Employment at the level of the firm is, in general, determined by the real producer wage and hence given as $N_i = N(\theta W_i^c)$, where θ is the wedge between the producer wage and the consumer wage, i.e., $\theta \equiv (W+S)/(W-T) =$

[4] Compare two post-tax income distributions associated with two alternative tax systems and the same pre-tax distribution. Suppose that v is lower at all levels of income for the first tax system. It then holds that the first post-tax income distribution is less unequal than the second in the sense that the Lorenz curve corresponding to the first distribution is everywhere above the Lorenz curve of the second distribution. (See Jakobsson 1976.) The result that the tax system affects the after-tax real consumption wage through v was first established by Lockwood and Manning (1993).

$(1+s)/(1-t)$, where s and t are average payroll and income tax rates. At the aggregate level this relationship can be written as

$$(1-u)L = N(\theta W^c) \tag{3}$$

where L is the size of the labor force relative to the number of firms. Eqs. (2) and (3) determine unemployment and real consumer wages for any given benefit level and for given values of average tax rates (s and t) and given progressivity (v). In general, the tax rates as well as the measure of progressivity may depend on the pre-tax wage, i.e., $v=v(W)$ and $\theta=\theta(W)$; in this case W and u are determined from (2) and (3), noting that $W^c=W(1-t(W))$.

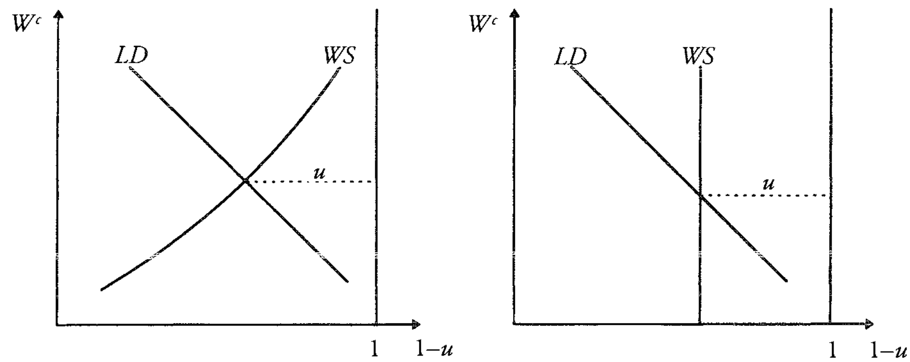
The model has some less attractive features for the long run, however. Favorable shifts in labor demand, induced by capital formation or technical progress, will reduce unemployment when the benefit level is fixed. This is not plausible; capital formation and technical progress are unlikely to have any permanent effects on unemployment. This requires some flexibility in real benefits, or more generally in the value that workers attach to non-employment. If there is a fixed replacement ratio, $B=\rho W^c$, we can translate the wage-setting equation into an unemployment equation of the simple form

$$u = \frac{v\kappa\sigma}{\phi(1-\rho^{\sigma})} \tag{4}$$

where $\sigma'=\sigma$ is assumed. This can be thought of as a vertical wage-setting schedule as long as v is constant. Eq. (4) then determines unemployment, whereas the real wage is obtained from the labor-demand schedule (3).

Two cases are illustrated in Figure 1, with W^c and $1-u$ (the employment rate) on the axes. In the first example there is a fixed benefit level yielding a positively sloped wage-setting schedule and the second with a fixed replacement ratio, which gives a vertical wage-setting schedule. Suppose that tax progressivity is increased, holding the average tax rate constant. This produces a shift to the right of the wage-setting schedule and a fall in unemployment. Suppose instead that the average tax rate is increased while holding progressivity constant. In the first case there would be an increase in unemployment, whereas no effect on unemployment would appear in the second case. The incidence of taxes on labor earnings is crucially dependent on whether or not unemployment benefits are responsive to changes in the going wage.

Figure 1. Wage and employment determination



Fixed real benefits   Fixed replacement ratio

Of course, a number of changes in the tax system are conceivable, perhaps realistically involving simultaneous changes in marginal as well as average tax rates. One could, for example, compare the implications of alternative tax systems under the condition that they all yield the same amount of government revenues. We proceed in this direction below.

1.2. Progressive taxation and relative wages

Wage inequality in Sweden declined sharply during the 1960s and 1970s. There was, for example, a marked reduction in overall wage dispersion and in the relative earnings advantage of highly educated workers as well as a substantial narrowing of wage differentials among workers within broad occupational and educational groups. This trend decline in wage inequality was broken in the 1980s. Wage differentials along several dimensions have widened from the mid-1980s to the early 1990s. There has been some increase in overall wage inequality as well as slightly increasing educational wage differentials. (See Edin and Holmlund, 1995.)

The period of narrowing wage differentials coincides with a period of rising tax progressivity, whereas the widening of wage differentials from the mid-1980s coincides with a period where the tax system became less progressive. The key movements of wage inequality in Sweden over the past three decades are thus rather strongly correlated with changes in tax progressivity. Is there any reason to take this correlation seriously as reflecting a *causal* relationship? Does a more progressive tax system produce smaller wage differentials? We attempt to shed some light on this issue by means of simple models of wage bargaining.[5]

We consider the distribution of wages among workers with different skills, where each firm employs both "unskilled" and "skilled" workers. (In the Swedish context, we might think of the two categories as blue-collar and white-collar workers.) There are a number of unions negotiating on behalf of unskilled workers and another group of unions concerned with the welfare of skilled workers. Wage bargaining takes place at the level of the firm (or sector), with no coordination between the negotiating unions. Under these assumptions (and assuming Cobb-Douglas technologies) we can derive wage-setting schedules that are completely analogous to eq. (2) above. In other words, for each category i ($i=1,2$) we have wage equations of the form

$$\ln W_i^c = const_i + (\sigma'/\sigma)_i \ln B - (1/\sigma_i) \ln[1 - \sigma_i \kappa_i v_i / \phi_i u_i] \tag{5}$$

where κ_i is the measure of the union's bargaining power that is relevant for the i:th worker category. The labor shares are taken as constants with $i=1$ referring to unskilled workers and $i=2$ to skilled workers.[6]

In order to ascertain how changes in tax progressivity affect relative wages we need to incorporate labor demand. From the firms' first-order conditions we have labor demand equations analogous to eq. (3) of the form

$$(1-u_i)\, L_i = N_i(\theta_1 W_1, \theta_2 W_2) \qquad (i=1,2) \tag{6}$$

It is difficult to obtain clear-cut results without further assumptions about the parameters of the problem. There is no obvious presumption, however, that higher progressivity causes wage compression. We can write the relative pre-tax wage as:[7]

$$\ln(W_2/W_1) = \frac{1}{\bar{v}}\,[\ln W_2^c(\bar{v}) - \ln W_1^c(\bar{v})] \tag{7}$$

[5] Hibbs (1987) as well as Locking (1994) have argued that increased tax progression would bring about pay compression, a hypothesis that is not refuted in their time-series analyses of wage dispersion among Swedish blue-collar workers.

[6] The fall-back position of firms in the wage bargain is taken to be zero; when the production function is Cobb Douglas, both worker categories are neccessary in production, so a conflict involving one group would imply zero output.

[7] Note that the after-tax wage is given as $W^c = \alpha W^{\bar{v}}$.

Consider the effects of changes in progressivity, conditional on the unemployment rates for the two worker categories. An increase in $\tilde{v}$, i.e., a decline in progressivity, has two effects. One effect influences the pre-tax wage differential at a given after-tax wage differential. It is clear from (7) that this effect is unambiguously negative. This simply mirrors the fact that a decline in progressivity widens after-tax wages at given pre-tax wages. The other effect works through changes in the negotiated real wages. Inspection of (5) reveals that a rise in $\tilde{v}$ in general has ambiguous effects on $\ln(W_2^c/W_1^c)$. A rise in v is reinforced by a high mark-up factor (κ), so there is a presumption that the after-tax wage differential widens in response to a decline in progressivity. The net effect on pre-tax wage differentials is therefore ambiguous.

This discussion ignores the general equilibrium implications, and in particular the effects that work through the induced changes in unemployment. We present a few numerical examples in order to show how tax progressivity affects relative wages as well as unemployment rates. The production function is $Q = AN_1^{\gamma_1} N_2^{\gamma_2}$, with $\gamma_1 = 0.25$ and $\gamma_2 = 0.40$, which implies that the skilled wage would be 60 percent higher than the unskilled wage if the labor market had been perfectly competitive with the same number of skilled and unskilled workers. The benefit level is taken to be the same for the two skill groups. In the simulations, presented in Table 1, we treat relative labor supply (L_2/L_1) as fixed at unity. We focus exclusively on progressive taxes paid by households.

The reference case involves proportional income taxation at the rate 0.3. Progressive income taxes are introduced in two alternative ways. In the first case we consider a linear tax schedule of the form $T = -a + mW$, where m is the constant marginal tax rate and a is a lump-sum grant.The marginal rate is set at 0.6 and the lump-sum grant is adjusted so that the new equilibrium yields the same amount of tax revenue as the case with proportional taxes. In the third column we show the implications of a tax system where $\tilde{v}$ does not vary with income.

Consider the results in Table 1. In the reference case the unemployment rates are 10.5 and 3.3 percent for unskilled and skilled workers, respectively. The wage premium for the skilled worker is close to 50 percent ($W_2/W_1 = 1.48$). When the proportional tax is replaced by a progressive linear tax with 60 percent marginal tax rate there is a substantial reduction in the unemployment rate among unskilled workers (from 10.5 to 4.4 percent), and a slight reduction in unemployment among skilled workers as well. Relative wages before tax are *widened* rather than com-

Table 1. Tax progressivity, unemployment and relative wages with fixed relative supply

	Wage bargaining, Cobb-Douglas $Q = AN_1^{\gamma_1} N_2^{\gamma_2}$		
	Proportional taxes	Progressive taxes	
	$[m = t = 0.3;\ \tilde{v} = 1]$	Linear taxes $[m = 0.6]$	Non-linear taxes $[\tilde{v} = 0.5]$
	(1)	(2)	(3)
u_1	0.105	0.044	0.042
u_2	0.033	0.023	0.019
W_1	1.94	1.86	1.86
W_2	2.87	2.90	2.90
W_2/W_1	1.48	1.57	1.56
W_1^c	1.36	1.47	1.49
W_2^c	2.01	1.89	1.87
W_2^c/W_1^c	1.48	1.29	1.25
m_1	0.3	0.6	0.60
m_2	0.3	0.6	0.68
t_1	0.3	0.21	0.19
t_2	0.3	0.35	0.36
$\tilde{v}_1$	*1.0*	0.50	0.5
$\tilde{v}_2$	*1.0*	0.61	0.5

Notes: The lump-sum subsidy associated with the linear tax schedule is endogenously determined so as to satisfy the fixed revenue requirement. With a non-linear tax schedule of the form $W_i^c = \alpha W_i^{\tilde{v}(\cdot)}$, α is analogously determined. The parameters are as follows: $A = 50$, $\gamma_1 = 0.25$, $\gamma_2 = 0.40$, $L_1 = L_2 = 250$, $\lambda_1 = \lambda_2 = 0.4$, $B = 1$, $\sigma = -2$, $\sigma' = -0.25$ and $\phi_1 = \phi_2 = 0.5$.

pressed by the progressive tax system. Relative wages after tax are substantially reduced, involving a decline in the skilled worker's wage premium from 50 to 30 percent. The third column, where $\tilde{v}$ is parametric, conveys the same message as the second column.[8]

The assumption of an elasticity of substitution of unity between skilled and unskilled workers is not very attractive, except for its simplicity. There is evidence that the elasticity of substitution between skilled and unskilled (or white-collar and blue-collar) workers is quite high, and

[8] We have also examined the implications of a progressive tax system with the property that progressivity increases with income in the sense that $\tilde{v}'(W) < 0$. This is a realistic feature of progressive taxation in Sweden over the past two decades or so (as will become clear in Section 2). The effects of this tax system on relative wages and unemployment rates are similar to those of the linear tax system.

that the own-wage demand elasticity is lower for more skilled workers (see Hamermesh 1993). We have also explored the implications of more general production functions of the CES-variety (not shown in the table). These examples tell the same basic story as the one that followed from the simulations shown in the table; there is no indication that tax progressivity reduces wage inequality.

In the examples so far there has been a fixed number of workers in the two categories. There is substantial evidence, however, that individuals' educational decisions and occupational choices are responsive to relative earnings differentials.[9] A progressive tax system that leads to substantial compression in earnings after tax will thus reduce the relative supply of skilled workers, which would tend to increase the skilled worker's relative wage.

In the experiments in Table 1, we obtained a slight increase in relative wages as well as reduced differences in unemployment rates. Changes in progressivity that reduce the relative supply of skill would clearly tend to reinforce the increase in relative wage differentials. To account for this mechanism we have also undertaken numerical simulations with a simple log-linear relative supply function, where relative supply responds to differences in relative average earnings in the two categories. The fact that progressive taxation compresses post-tax earnings differentials reduces the relative supply of skill, which in turn induces a marked upward pressure on the pre-tax wages of the skilled relative to the unskilled. In the numerical examples, progressive taxation produces an increase in relative pre-tax wages of between 25 and 45 percent; the more redistributive the tax system, the sharper the increase in pre-tax wage differentials.[10]

In conclusion, the hypothesis that pay compression is driven by progressive tax policies is not given much support from these models. Of course, there may well be other models that are able to do a better job in explaining a decline in wage inequality by increased tax progressivity. There is, however, a rather strong presumption that the adjustment in relative supplies has contributed to a widening of pre-tax wage differentials as a response to after-tax wage compression.

[9] See Freeman (1986) for a survey of the empirical evidence on the demand for education. Edin and Holmlund (1995) and Fredriksson (1994) provide evidence for Sweden that suggests substantial responsiveness of enrollment in higher education to changes in the returns to education.

[10] These examples are shown in the extended version of the paper.

1.3. Bargaining over wages and hours of work

When some dimension of labor supply is responsive to tax policies, it becomes meaningful to discuss the effects on total output as distinct from the effects on total employment. Absent labor supply responses, it follows trivially that a policy that increases employment will also increase output. The possibility of a tradeoff between employment (and equality) on the one hand and output on the other is obvious when relative supplies are variable and there are productivity differentials among workers. The optimal tax system may not be the system that minimizes unemployment.

There is a huge literature on taxes and labor supply, a literature that has typically considered a setting where hours of work are determined by utility-maximizing individuals. By extending the basic model of this paper to incorporate decisions on hours of work, we can obtain a framework where welfare issues can be examined from a new perspective. It may well be that high progressivity is good for employment but at the same time bad for welfare. This possibility arises when the supply of hours is reduced by progressive income taxes.

To simplify we assume that the employed worker's utility function takes the form

$$U(Wh,h) = \ln(Wh - T(Wh)) - \frac{h^{1+\delta}}{1+\delta} \tag{8}$$

The worker's utility is increasing in income after tax (consumption) and decreasing in hours of work. Consider the case where the individual worker determines hours of work. Maximization of (8), with the wage treated as parametric by the worker, yields an individual labor supply function of the form

$$h = \tilde{v}^{\,1/(1+\delta)} \tag{9}$$

The chosen utility function has the property that hours of work are affected by changes in tax parameters and wages only through the measure of progressivity, $\tilde{v}$. The lower progressivity is – the higher $\tilde{v}$ is – the more hours are supplied. The labor-supply schedule is wage inelastic in the sense that the wage has no *direct* effect on hours of work. There may, however, be an indirect effect to the extent that $\tilde{v}$ varies with income, i.e., $\tilde{v} = \tilde{v}(W)$. Note also that the parameter δ determines the responsiveness of hours with respect to changes in progressivity; the larger δ is, the less responsive hours are to changes in $\tilde{v}$. An increase in progressivity reduces unemployment.[11]

When there is *bargaining* over hours of work, rather than determination of hours by the individual worker, the results are very similar. By the assumption of perfect substitutability between workers and hours, it follows that the firm is indifferent to the number of hours per worker; the decision on hours can therefore be delegated to the union, which is *not* indifferent. The number of hours has a direct effect on the employed workers' welfare and an indirect effect on the firm' s demand for labor. It is straighforward to establish that the union prefers a shorter working time than the individual employed worker, the reason being that the union recognizes that a shorter working time increases the firm's demand for labor.

We illustrate how the optimal degree of progressivity depends on the sensitivity of hours of work to changes in progressivity. As a measure of social welfare we take the worker's expected utility

$$\Lambda = (1-u)\left(\ln[Wh - T(Wh)] - \frac{h^{1+\delta}}{1+\delta}\right) + u\ln[\rho\left(Wh - T(Wh)\right)] \quad (10)$$

where the individual worker determines hours of work. To capture long-run considerations we assume that there is free entry of firms; each firm must incur a fixed cost (C) to enter the market, however. The real product wage (W) and the level of labor input per firm (Nh) are then determined by the zero-profit condition

$$Q(Nh) - WNh - C = 0 \quad (11)$$

along with the usual requirement $Q'(Nh) = W$. Changes in taxes will thus only affect the real consumption wage, not the real product wage.[12] The welfare effects work through the effects on unemployment, the real consumption wage and hours of work.

We consider only tax systems with the property that $\tilde{v}$ is independent of income. There is a given revenue requirement, in our examples rough-

[11] The equation for equilibrium unemployment when $\tilde{v}$ is independent of income is: $u = (\kappa/\phi)\,[(1/\tilde{v})\ln(1/\rho) - 1/(1+\delta)]^{-1}$.

[12] The number of firms (M) is determined from the equation $(1-u)L = M \cdot N$, where N is employment per firm. The unemployment rate is determined from a vertical wage-setting equation (see footnote 11), and h i determined by (9).

Table 2. Optimal tax progressivity with variable hours of work

	$\delta=1$	$\delta=5$	$\delta=10$
$\bar{v}$	0.53	0.45	0.36
u	0.070	0.037	0.028
m	0.65	0.69	0.75
t	0.38	0.32	0.30

Notes: The production function is $Q=50(Nh)^{0.65}$. Other parameters are $L=500$, $\lambda=0.1$, $C=75$, $\phi=1$ and $\rho=0.2$.

ly corresponding to an average income tax rate of 30 percent. The parameter α in the tax function $T=Wh-\alpha(Wh)^{\bar{v}}$ is adjusted so as to satisfy the revenue requirement. Marginal (m) and average tax rates (t) are thus endogenously determined. The benefit replacement ratio (ρ) is taken as fixed. The parameter δ in the worker's utility function determines the elasticity of hours with respect to changes in progressivity.

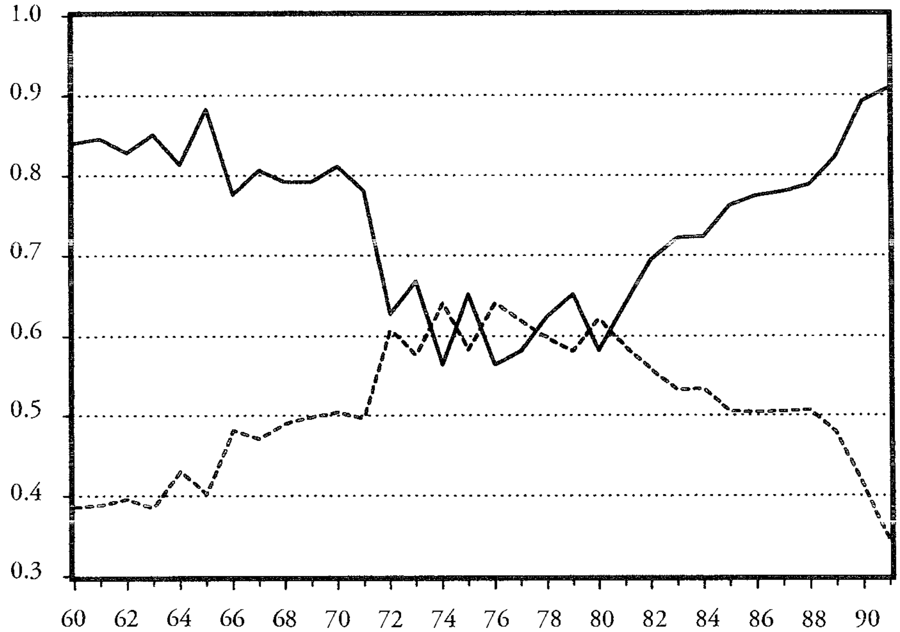
There is no closed-form solution for the optimal degree of progressivity, so we present some numerical examples in Table 2. The optimal tax system is progressive in all three examples, but the optimal degree of progressivity is increasing in the value of δ. A very high progressivity can reduce unemployment to an arbitrarily small number, but this is not optimal because of the adverse effects on hours of work.

The examples suggest that a rather high degree of progressivity would be optimal. It would be very ill-advised, however, to take these numbers seriously as guidelines for the design of an actual tax system. There are other important margins of supply adjustment, such as the choice of education, that should be considered in a complete analysis. We expect, however, that there will in general be a case for *some* degree of progressivity, once the effects on wage bargaining are taken into account.

2. Progressive taxation in Sweden

Our measure of income tax progressivity, the elasticity of net income with respect to changes in gross income ($\bar{v}$), was sharply reduced during the first half of the 1970s. While this elasticity stood at around 0.8 in the 1960s, it had declined to 0.6 in the mid-1970s (see Figure 2). The trend increase in progressivity was broken in the early 1980s. There was a

Figure 2. Marginal tax rate (dashed) and income tax progressivity (solid) for a blue-collar worker 1960–91



Source: Locking (1994).

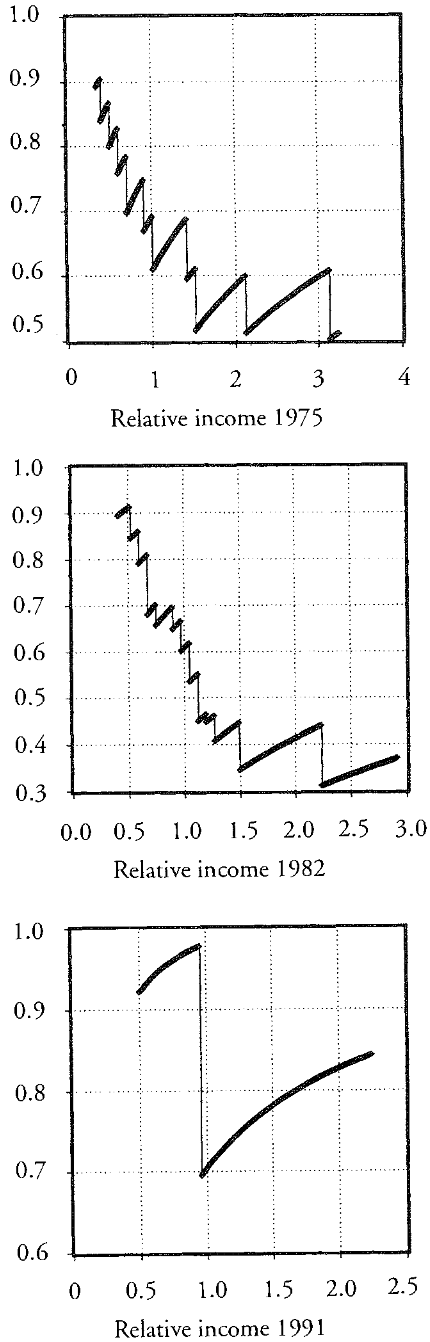
marked trend decline in progressivity from the early 1980s and onwards. In this respect, the major tax reform of 1991 implied a continuation of a process that had been going on for a decade.

The progressive income tax system was implemented through a large number of tax brackets with rather small bands. It was thereby possible to have a tax system where progressivity was increasing with income, i.e., a system where $\tilde{v}$ was falling with income. Figure 3 shows how $\tilde{v}$ varied with relative income in 1975, 1982 and 1991. (Mean income is represented by mean annual earnings among those who worked full time and during the whole year.)[13] For high-income earners in 1975, $\tilde{v}$ was in the range 0.5 to 0.6; by 1982 $\tilde{v}$ had been reduced to the range 0.3 to 0.4. Note that $\tilde{v}$ is increasing in income within a given tax band with constant marginal and rising average tax rate.

During the 1980s the tax system was gradually changed towards lower

[13] These data on earnings are obtained from the Swedish income distribution survey (HINK); see the extended version of the paper for details on the data.

Figure 3. The progressivity of personal income taxes ($\tilde{v}$) in Sweden 1975, 1982 and 1991



progressivity and wider tax bands. The 1991 tax reform resulted in two tax brackets, one large bracket with a 31 percent marginal tax rate on average and another bracket with a 51 percent marginal rate on average. There are only municipal income taxes in the first bracket; these are linear, vary by municipality, and stood at 31 percent on average in 1991. In the second bracket there is an additional state tax of 20 percent. The wide tax bands implied by the two-bracket system imply that $\tilde{v}$ is increasing with income for most income earners, i.e., those who pay only the linear municipal taxes.

Social security contributions and the wage taxes paid by employers, referred to here as payroll taxes, have been proportional since 1982. Before 1982, however, payroll taxes had a somewhat complicated structure because of various rules pertaining to tax bases. In fact, the average payroll tax rate was higher than the marginal rate for workers with high earnings. The payroll tax system was thus regressive rather than progressive. In our subsequent empirical analysis we disregard this nonproportionality of payroll taxes.

3. Empirical evidence

3.1. Previous research

There has been a large amount of empirical work on aggregate real-wage determination over the past ten years or so. These studies have often relied on bargaining theory, typically as a guide for specification although sometimes also as a tight theoretical structure imposed in the estimations (see Bean, 1994, for a thoughtful discussion of this work). Taxes have been important in these models, but the overwhelming majority of the studies have treated the tax system as proportional. The consequences of allowing for progressive taxes, i.e., differences between average and marginal tax rates, have rarely been explored. There are a few exceptions, however, most of them exploiting data for countries other than Sweden.

Evidence for the United Kingdom have been presented by Manning (1993) as well as Lockwood and Manning (1993). These two studies use conventional bargaining models and apply somewhat different specifications. The empirical analyses are based on aggregate time series and the results suggest that wage pressure is reduced by a rise in the marginal relative to the average income tax rate. These results are also captured in the reduced-form unemployment equation estimated by Manning (1993); an increase in progressivity is found to reduce unemployment in the UK.

Evidence for Italy has been offered by Malcomson and Sartor (1987) as well as Padoa Schioppa (1990). Both papers use a monopoly union framework. The results reported by Malcomson and Sartor imply that an increase in income tax progressivity would reduce the union's optimal wage. Padoa Schioppa's results are more difficult to summarize since the empirical model is rather involved.

Few Swedish studies have been concerned with the non-proportionality of the income tax system. An early example with some evidence on the role of tax progressivity in wage determination is the study by Normann (1983). Normann estimated Phillips-curve type specifications on Swedish time series and included a measure of progressivity in the equation for nominal wage changes. Taken at face value, Normann's estimates suggested that an increase in progressivity would reduce wage inflation. This result is not easily reconciled with standard bargaining models where the tax system has *real* effects, i.e., effects on the real wage rather than on wage inflation. Normann's result is nevertheless interesting and suggests that there may be something in the data which may also show up in theoretically more satisfactory specifications.

Another Swedish study that pays attention to tax progressivity is Forslund (1993). Forslund estimated a structural union model, involving joint estimation of a labor demand equation and the first-order condition for the union's optimal wage. The marginal tax rate entered the first-order condition in such a way that the union's desired wage would decrease as a response to a rise in the marginal tax rate, holding the average tax rate constant. The model was estimated with a tight theoretical structure imposed; there was no explicit *test* of how tax progressivity affects wage behavior. A recent paper by Aronsson *et al.* (1995) is similar in spirit, although it is based on microdata on firms.

3.2. Evidence from time series

In our empirical work we exploit time series as well as panel data on employed workers. Both data sets are based on the Swedish income distribution survey HINK, a data source that has rarely been used in studies of wage determination.[14] A major advantage is that we can exploit the fact

[14] Gustafsson and Johansson (1994) use these data, although their paper has a different focus than ours.

that tax progressivity varies across groups with different levels of earnings. The tax reforms of the past two decades have not had a completely uniform impact on tax progressivity across the earnings distribution. A disadvantage is that HINK provides information about annual earnings, not monthly or hourly earnings. To get as close as possible to measures of hourly wages, we restrict our analyses to individuals who have worked full time during the whole year.

The time series data consist of series on average earnings per decile for the period 1975–92.[15] These series are aggregated into average earnings for each quintile. We regard the data as time series on earnings for five different skill categories. The evolution of average annual earnings according to these HINK data closely traces the evolution of hourly wages for blue-collar workers in manufacturing. For each quintile and year we compute average (t) and marginal (m) tax rates, and hence our measure of progressivity $\tilde{v}=(1-m)/(1-t)$.

Our estimating equations are essentially of the form given by eq. (5), although we simplify by using an equation that is linear in the parameters:

$$\ln\,(W_t/P_t) = \beta_{0i} + \beta_{1i}\,\tilde{v}_{it} + \beta_{2i}\ln(1-t_{it}) + \beta_{3i}\ln B_t + \beta_{4i}\,u_{t-1} + \xi_{it}. \qquad (12)$$
$$i = 1,\ldots,5$$

The theory predicts that the relevant dependent variable is the real after-tax consumption wage, $\ln(W(1-t)/P)$. Rather than imposing the "tax restriction" we test its validity by choosing the real pre-tax wage as the dependent variable and including the income retention factor $\ln(1-t)$ as a right-hand side variable in the regressions. If the theory holds, the coefficient on $\ln(1-t)$ should not differ significantly from minus one. Other right-hand side variables are the measure of progressivity, real after-tax unemployment benefits, and the unemployment rate lagged one year. The benefit level is the maximum daily benefit level for insured workers, expressed as annual after-tax real income. This may be less relevant for workers with very low earnings. In the regressions for the first quintile we therefore use a measure of benefits that correspond to "cash assistance" (*KAS*), expressed as real after-tax annual income. The unemployment var-

[15] We are grateful to Björn Gustafsson and Mats Johansson for allowing us to use their data, which were in turn supplied by Statistics Sweden. Observations for 1976, 1977 and 1979 are imputed by using information on wage changes for groups that roughly correspond to the HINK-deciles.

Table 3. Real after-tax earnings and tax progressivity, by quintile

	Quintile				
	1	2	3	4	5
Real earnings (logs)					
1975	4.102	4.303	4.399	4.498	4.758
1983	4.119	4.261	4.341	4.426	4.626
1992	4.216	4.418	4.538	4.676	4.977
Relative change in real earnings (percent)					
1975–83	1.7	–4.1	–5.6	–6.9	–12.4
1983–92	10.2	17.0	21.8	28.4	42.0
1975–92	12.1	12.2	14.9	19.5	24.5
Average tax rates					
1975	0.301	0.350	0.373	0.405	0.493
1983	0.315	0.351	0.373	0.399	0.487
1992	0.267	0.282	0.289	0.300	0.371
Tax progressivity ($\tilde{v}$)					
1975	0.755	0.719	0.666	0.618	0.528
1983	0.743	0.722	0.699	0.630	0.485
1992	0.941	0.961	0.970	0.700	0.778

Source: Own computations based on HINKdata on pre-tax earnings and official tax tables.

iable is the aggregate unemployment rate according to the labor force surveys, measured as a percentage of the labor force.

The variable capturing progressivity is quintile specific and clearly endogenous. It should be noted, however, that there can be no presumption that OLS-estimation would necessarily introduce a *positive* bias in the estimate of β_1. It is apparent from Figure 3 that $\tilde{v}$ has been inversely correlated with earnings across the tax bands, and positively correlated within any given tax band. The inverse correlation dominates when there are many bands, in which case OLS estimates of β_1 would be expected to be downward biased. In any event we treat $\tilde{v}$ as endogenous and use as instruments variables where the current year's tax system is applied to lagged wages. The average tax rates are also treated as endogenous.

Table 3 presents some of the basic facts concerning real earnings and tax progressivity. There is a pronounced decline in after-tax real earnings for all groups except the first quintile during the period 1975–83. The fall in real earnings is strongest for the top quintile, amounting to 12 percent between 1975 and 1983. There is thus a marked earnings compression during the late 1970s and early 1980s, a pattern that is completely

Table 4. Estimated real wage equations, 1975–92. Dependent variable: ln $(W/P)_t$

	Quintile					Quintile				
	1	2	3	4	5	1	2	3	4	5
Constant	4.446 (25.55)	5.177 (59.67)	5.243 (66.02)	5.562 (70.99)	5.221 (36.17)	4.380 (12.55)	5.200 (67.77)	5.335 (82.90)	5.565 (95.41)	5.560 (29.25)
$\tilde{v}_t$	0.381 (4.08)	−0.041 (1.31)	0.088 (3.77)	0.117 (3.73)	0.541 (9.11)	0.361 (2.48)	−0.050 (1.68)	0.028 (1.47)	0.077 (3.18)	0.336 (3.41)
$\ln(1-t)_t$	−1	−1	−1	−1	−1	−0.831 (2.96) [0.60]	−0.552 (6.01) [4.87]	−0.590 (6.68) [4.66]	−0.582 (6.83) [4.92]	−0.577 (3.60) [2.64]
$\ln B_t$	0.240 (3.60)	0.273 (10.06)	0.295 (11.14)	0.391 (14.87)	0.258 (5.66)	0.172 (1.92)	0.209 (8.19)	0.245 (9.78)	0.298 (11.16)	0.227 (5.66)
u_{t-1}	−0.026 (2.20)	−0.035 (4.66)	−0.039 (5.09)	−0.025 (3.22)	−0.027 (3.07)	−0.029 (2.45)	−0.035 (5.64)	−0.038 (6.19)	−0.035 (5.52)	−0.041 (4.65)
$\bar{R}^2$	0.617	0.700	0.798	0.816	0.840	0.556	0.778	0.855	0.884	0.889
SE	0.031	0.021	0.019	0.021	0.022	0.034	0.018	0.016	0.016	0.019
DW	1.99	1.55	1.67	1.59	1.83	2.04	1.99	2.05	1.87	1.46

Notes: The estimation method is 3SLS, with $\tilde{v}$ and $\ln(1-t)$ treated as endogenous. The instruments vary by equation and include $\ln(1-t)$ lagged one year (quintile-specific) as well as measures of predicted progressivity based on the previous year's earnings and the current year's tax system. The coefficients on $\ln(1-t)$ are constrained in the first five columns. Absolute t-values in parentheses and brackets; numbers in brackets are t-values corresponding to the hypothesis that the coefficients on $\ln(1-t)$ are equal to minus one.

reversed during the period 1983–92. During this latter period there are particularly strong real wage increases at the top end of the distribution. The pattern would be rather similar if we had instead looked at pre-tax earnings. As has been documented elsewhere, the period of pay compression came to an end in the early 1980s and the past ten years or so have seen a widening of the wage differentials (see Edin and Holmlund, 1995).

The results of the estimations are displayed in Table 4. The first set of estimations shows results with the tax restriction $\beta_{2i} = -1$ imposed. In four out of the five cases there is a significant effect of the progressivity variable in the expected direction, i.e., a rise in progressivity (a decline in $\tilde{v}$) is associated with a reduction in the real wage. The restriction on $\ln(1-t)$ is not generally supported by the data, however, as is seen from the second set of estimates in Table 4. The estimates of β_2 are in the range of -0.55 to -0.83, significantly different from minus one in all cases but one. The estimated progressivity effects are somewhat weaker in the second set of regressions.

We also note that the effects of benefits and unemployment are as expected; real wages are pushed up by higher benefits and reduced by higher unemployment. The estimated benefit parameters are typically in a range from 0.2 to 0.3, much smaller than what is implied by some popular models (and sometimes also *imposed* in estimation of wage equations). Note, however, that the basic theory does not neccessarily imply a unitary elasticity if we allow utility functions to differ between the states of employment and unemployment. The estimated unemployment coefficients are centered around -0.03. Interpreted as slopes of the wage-setting funtions, the estimates imply that an increase in the unemployment rate by one percentage point would entail a real wage reduction of 3 percent. These estimates are somewhat lower than those reported in other studies of Swedish wage behavior (for example, Holmlund, 1990 or Calmfors and Forslund, 1990).

The estimation results thus give some modest support for the theory. Taking an unweighted mean of the estimated parameters on $\tilde{v}$ in Table 4 yields $\hat{\beta}_1 = 0.18$. At face value, this estimate implies that an increase in the marginal tax by 10 percentage points would reduce the pre-tax wage by roughly 2.5 percent, holding unemployment and the average tax rate constant (assuming an average tax rate of 30 percent). There is some evidence that the effect is strongest in the top quintile, where $\hat{\beta}_1$ varies between 0.34 and 0.54. But the results are not as robust as one might wish in order to have strong confidence in them. More confidence would be gained if similar results could be found in analyses that use other data, in particular microdata.

3.3. Evidence from microdata

In the previous section we used time series obtained from repeated cross sections of HINK data. There is also panel information in the HINK data, however. In particular, one panel is designed to evaluate the tax reform and covers the two years 1989 and 1992. Microdata from HINK contain substantial information from tax and income registers on various income sources, tax payments and actual marginal tax rates. There is also information on annual hours of work from survey questionnaires. For 1992 there are also data on a number of human capital characteristics, such as years of education, years of work experience, and years of tenure.

We continue to restrict the analysis to full-time employees in order to come as close as possible to a measure of earnings from work. It is possible to get some idea of the quality of our HINK-based measure of hourly earnings by comparisons with data on wages and salaries that have been collected from employers for the 1989–92 HINK panel. It turns out that the HINK measure of hourly earnings exhibits more dispersion than the employer based measure; the standard deviation for a matched sample in 1992 is 0.300 for the HINK measure and 0.253 for the other measure. This is as expected for several reasons; one is that annual hours in HINK, and thereby also hourly earnings (computed by dividing annual earnings by annual hours), are likely to be plagued by the usual type of errors found in survey data.

We have estimated a number of Mincer-type earnings equations on a matched sample. The estimation results are very similar irrespective of the chosen measure of hourly earnings. The major difference is that a variable measuring overtime hours is significantly positive in the HINK regressions, whereas the variable is insignificant in the regressions with the employer-based measure of hourly earnings. This suggests that one should control for overtime hours in estimating wage equations on HINK data. All in all, however, the comparisons between the two measures of hourly earnings indicate that HINK data convey useful information about hourly wages for at least full-time workers.

The empirical analysis focuses on wage changes between 1989 and 1992. One drawback of the data is that information on education and work experience is only given for 1992. There is, however, information on a number of personal characteristics for both years. We have tried to check whether this data limitation would be important in practice by means of a number of alternative specifications and samples. For example, if we restrict the analysis to workers who have worked continuously for the same employer during the period, we should minimize the risk of not accounting for changes in education.

To motivate the empirical specification, consider a real-wage equation relevant for a particular bargaining unit i of the form:

$$\ln W_i^c = \beta_1 \tilde{v}_i + \Gamma_{0i} \quad (13)$$

where Γ_{0i} is the worker's fall-back income. Think of the worker's fall-back income as affected by two sets of variables. The first set captures human capital characteristics such as education and work experience (Z); the second set includes relevant labor market characteristics such as unemployment and the general level of real wages (Q). In first differences, and with changes in nominal pre-tax wages on the left-hand side, we have

$$\Delta \ln W_i = const. + \beta_1 \Delta \tilde{v}_i + \beta_2 \Delta \ln(1-t_i) + \mu_1 \Delta Z_i + \mu_2 \Delta Q_i + \varepsilon_i \quad (14)$$

where ε_i is a stochastic error term. The theory in its strong form implies $\beta_2 = -1$. Note that the constant captures general inflation and that individual-specific fixed effects are differenced out in (14). Think of Z as including the usual human capital characteristics, in particular years of education, years of work experience (linear and squared). Suppose further that there is no change in education during the three-year period 1989–92, that workers are in continuous employment during the period, and that there are no changes in the *returns* to human capital characteristics (i.e., μ_1 remains constant). Under these assumptions it follows that ΔZ_i will primarily include a variable that captures the concavity of the experience-earnings profile, and there is no role for the usual human capital variables in levels.

The assumptions made are strong and need some motivation. It is probably not unresonable to regard education as largely constant during the 1989–92 period for workers that work full-time both years. This applies even more to workers who had already been hired by their 1992 employer prior to 1989, in which case changes in work experience also can be taken as equal to three years. We checked whether the restriction of the sample to the latter category made a difference; it turned out that it did not.

Turning next to changes in labor market opportunities, i.e., ΔQ_i, we note that the period 1989–92 includes an initial phase with an unusually strong labor market with very low unemployment, followed by a sharp macroeconomic downturn in the early 1990s. The impact of changes in general labor market opportunities is taken care of by the intercept in the wage change equation. There are sectoral differences in labor market tightness, however, in particular a marked deterioration in private-sector employment. To account for these differences, we included three dummies for the (initial) sectoral affiliation of the worker: central government, local government and manufacturing. (In some alternative specifications we included a full set of one-digit industry dummies, with results very similar to those obtained with only a dummy for manufacturing.) As additional controls for time-varying labor market prospects (and job changes), we included dummies for year of hire among workers hired during the period 1989–92. We also report results pertaining to workers who stayed with the same employer during the period 1989–92.

The variable of particular interest is the measure of progressivity, $\tilde{v}$. We observe actual marginal tax rates for workers in the sample. In the (pre-tax reform) year 1989, the marginal tax rate is based on "total income" including, in addition to labor income, also income from capital and imputed income on owner-occupied housing. The marginal tax rate in 1992 is based on labor income only, with differences across individuals depending on variations in the local government (proportional) tax rate, and whether or not their labor income is above or below the threshold for the 20 percent state tax.

There are several ways of computing average tax rates in these data. For 1992 it is reasonably straightforward; we divide total taxes pertaining to earned income by total earned income (*inkomst av tjänst*). For 1989 we divide total taxes on income by a measure of total income that includes labor income, income from capital, imputed income on owner-occupied housing and income from realized capital gains.

The measure of tax progressivity as well as average tax rates are clearly endogenous so we need to think of suitable instruments. We use mainly two sets of instruments. The first set includes initial human capital and personal characteristics, whereas the second consists of measures of non-labor income in 1989 (income from capital, owner-occupied housing and realized capital gains). In addition, we use the local tax rates in 1989 and

1992 as instruments. The proportional local tax rates are valid instruments under the assumption that workers' locational choices are predetermined during the process of wage bargaining. The human capital characteristics can be regarded as affecting the worker's fall-back position, and in this way they will influence the range of feasible wages.

The human capital attributes are valid instruments under the assumption that they do not belong to the structural wage change equation. This exclusion restriction is violated, however, if there are changes in the returns to human capital characteristics during the period. We have estimated a variety of cross-section Mincer-type earnings equations for 1989 and 1992 to look for changes in the returns to human capital attributes among workers who had remained with the same employer during the period 1989–92 (in which case the measures of education, experience and tenure should be of good quality). The results for the two years look very similar. This lends some support to the identifying assumption.

The use of measures of non-labor income in 1989 as instruments reflects the fact the income tax rates in 1989 were based on "total" income, including income from capital. Again, the validity of these instruments requires that the variables do not belong to the structural wage change equation. The Sargan test will provide some information on the validity of non-labor income as instrument for the endogenous tax rates. The basic results are relatively insensitive to the inclusion or exclusion of initial non-labor income among the instruments.

Some sample characteristics are given in Table 5, while the estimation results are set out in Table 6. The hypothesis that β_2 is equal to minus one is clearly rejected by the data. In fact, the results suggest that the pre-tax wage is largely unresponsive to changes in the average tax rate, holding progressivity constant. Our measures of tax progressivity where, as an alternative to $\Delta \tilde{v}_i$, we also use $\Delta \ln \tilde{v}_i$, are in general significant and with expected signs; reductions in progressivity, i.e., increases in $\tilde{v}_i$, are associated with increases in the pre-tax wage. The estimated parameter in column (2) implies that a rise in the marginal tax rate by 10 percentage points would reduce the pre-tax wage by 6 percent for an average worker. The implied wage reduction would be 4 percent if we had used the estimated coefficient on $\Delta \ln \tilde{v}_i$ in column (4). These effects are larger than those implied by (the average of) the time series estimates.

There has recently been an econometrics discussion concerning the use of instrumental variables in cases where the instruments are weak, in the sense that they explain little of the variation in the endogenous vari-

Table 5. Sample characteristics, taxes and wages, 1989–92 (means, standard deviations in parentheses)

	1989		1992
$\ln W$	4.330 (0.285)		4.546 (0.313)
$\Delta \ln W$		0.216 (0.170)	
t	0.361 (0.058)		0.302 (0.035)
m	0.559 (0.101)		0.389 (0.096)
$\bar{v}$	0.685 (0.122)		0.872 (0.110)
$\Delta \bar{v}$		0.187 (0.109)	
$\Delta \ln \bar{v}$		0.250 (0.160)	
# observations	2147	2147	2147

Source: HINK.

ables. Following the suggestion of Bound *et al.* (1993) we report the F statistics on the excluded instruments from the first-stage regressions and the associated p-values. If the F statistic is very low (and insignificant), one might question the quality of the instruments. As is seen from Table 6, the excluded instruments do make a significant and non-negligible contribution to the first-stage regression, so we should at least have some confidence in the instruments. Note also that the Sargan tests for instrument validity are easily passed.

An alternative interpretation of our estimation results is that they reflect a positive relationship between earnings and workers' effort, and that lower tax progressivity may have encouraged an increased supply of effort. This interpretation is plausible and cannot easily be disregarded, although it can be made almost immune to falsification by the difficulty of measuring effort. One dimension of effort is observable in our data, however, namely hours of overtime work. Column (5) presents results based on a subsample of workers with no reported overtime in 1989 or 1992. The result regarding the effect of tax progressivity is similar to what is obtained on the full sample. (In regressions not reported we included overtime as an additional endogenous regressor and obtained rather similar

Table 6. Estimated wage equations on individual panel data, 1989–92. Dependent variable: $\Delta \ln W_i$.

					No	Hired	Private	Public	Years of education	
					overtime	before 1989	sector	sector	< 12	≥ 12
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Constant	0.167	0.174	0.192	0.200	0.179	0.209	0.210	0.237	0.189	0.224
	(5.04)	(5.42)	(8.61)	(9.94)	(6.81)	(10.43)	(8.71)	(8.34)	(6.17)	(6.95)
$\Delta \bar{v}_i$	0.377	0.443								
	(2.06)	(2.59)								
$\Delta \ln \bar{v}_i$			0.193	0.222	0.286	0.185	0.222	0.195	0.184	0.221
			(2.38)	(2.99)	(3.02)	(2.53)	(2.48)	(1.71)	(1.37)	(1.96)
$\Delta \ln (1-t_i)$	0.255		0.211							
	(1.20)		(1.01)							
Experience/100	−0.267	−0.251	−0.259	−0.245	−0.207	−0.203	−0.278	−0.178	−0.160	−0.372
	(5.96)	(5.97)	(6.18)	(6.31)	(3.78)	(5.56)	(5.65)	(2.91)	(3.11)	(4.72)
F (first stage)										
$\Delta \bar{v}_i$	9.36	9.36								
	[0.000]	[0.000]								
$\Delta \ln \bar{v}_i$			23.13	23.13	15.32	18.47	15.06	10.82	6.56	10.25
			[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\Delta \ln (1-t_i)$	15.00		15.00							
	[0.000]		[0.000]							
Sargan	11.11	13.04	11.11	12.61	6.59	12.83	9.66	9.65	5.96	8.98
Crit. value(5%)	[16.92]	[18.31]	[16.92]	[18.31]	[18.31]	[18.31]	[18.31]	[18.31]	[18.31]	[18.31]
SE	0.187	0.183	0.179	0.176	0.178	0.155	0.179	0.168	0.165	0.185
# observations	2147	2147	2147	2147	1146	1788	1314	833	1202	945

Notes: The estimation method is 2SLS, with $\Delta \bar{v}$, $\Delta \ln \bar{v}$ and $\Delta \ln(1-t)$ treated as endogenous. The basic specifications (columns 1–5 and 9–10) include dummies for sector 1989 (central government, local government, manufacturing) and four dummies for year of hire (1989, 1990, 1991 and 1992). The sets of instruments include education, tenure, experience squared, dummies for sex and marital status, income from capital (interest, dividends), capital gains, and imputed income from owner occupied housing (all pertaining to 1989); the local tax rates in 1989 and 1992 are also included as instruments. F (first stage) is the F-value for the inclusion of the instruments in the first stage of the IV estimation (p-values in brackets). Sargan refers to is the Sargan test for instrument validity. Absolute t-values in parentheses.

results.) Of course, the results do not rule out the possibility that lower tax progressivity has increased work effort in dimensions other than overtime hours, but (as usual) the hypothesis cannot be tested unless it is formulated in terms of observables.

Columns (6)–(10) present estimation results for alternative subsamples. A restriction of the sample to workers hired before 1989 means that we can effectively rule out changes in education and work experience between 1989 and 1992. Such changes might cause omitted variable bias in the full sample; as is seen from the table, the results for this subsample in column (6) are very similar to those for the full sample in column (4). The differences between private and public sectors are also small, although the effect of progressivity is more precisely estimated for private-sector workers. Finally, we split the sample by years of education (less than 12 vs greater than or equal to 12 years of education). The point estimates do not differ much but the standard errors are much larger for the group with lower education.

3.4. Discussion

The investigations on microdata provide additional support for the basic theme of this paper, namely that tax progressivity may produce wage moderation. The results thus suggest that a rise in the marginal tax rate, holding the average tax rate constant, would reduce wage pressure. The result confirms a very general implication from bargaining models, an implication that does not require particular assumptions about iso-elastic utility and profit functions. The results are less robust concerning the effects of a rise in the average tax rate. The results clearly suggest that a rise in the average tax rate, holding the *marginal tax rate* constant, would increase the pre-tax wage. The particular mark-up type form of real wage equation we used is not generally supported by the empirical results, however. The real consumption wage does seem responsive to changes in the average tax rate. This may seem unsurprising although it is at variance with some popular models.

What implications for employment and unemployment follow from our results? A full treatment of these issues would require estimation of labor demand (or price-setting) equations, which we did not attempt in this study. We can, however, get some idea of the magnitudes involved by means of a few simple calculations. Consider a simple aggregate two-equation model with a wage equation and a labor demand equation:

$$\ln W = \beta_1 \Delta \tilde{v} + \beta_3 B + \beta_4 u + X_W \quad (15)$$

$$\ln N = -\varepsilon^d \ln W + X_N \quad (16)$$

where X_W and X_N include other variables, such as consumer and output prices as well as components of the tax wedge. Let L denote the labor force and use the approximation $\ln(N/L) \approx -u$ to rewrite the labor demand equation as an equation with the unemployment rate on the left-hand side. A decline in progressivity would then affect unemployment as given by

$$\frac{du}{dv} = \frac{\varepsilon^d \beta_1}{1-\beta_3-\varepsilon^d \beta_4} \quad (17)$$

if there is a fixed replacement ratio, $\rho = B/W$. We have treated average tax rates as fixed and ignored repercussions on prices (corresponding to a small open economy).

What magnitudes are implied by (17)? We have estimates of the β-parameters and can apply alternative estimates of the wage elasticity of labor demand. Empirical studies have often found estimates of ε^d around unity, which we take as our benchmark. We set $\beta_3 = 0.23$, which is the mean of the estimates in the five last columns of Table 4. The mean of the unemployment coefficients in the five last columns of Table 4 is –0.035, which would imply $\beta_4 = 3.5$ if u is measured as a ratio rather than in percentage points. The value of β_1 is set at either 0.15 or 0.30.

Consider a decline in tax progressivity that involves a reduction in the marginal tax rate by 10 percentage points. This would imply an increase in unemployment in the range between one half and one percentage point, depending on the assumed value of β_1. If we alternatively consider an increase in v of 0.2 units, which roughly corresponds to the average change between 1989 and 1992, we obtain an increase in the unemployment rate by 0.7 and 1.4 percentage points. These effects on (equilibrium) unemployment are small relative to the huge increase that has taken place in the early 1990s, although they are not negligible relative to the unemployment rates ranging between 1.5 and 3.5 percent that Sweden experienced throughout most of the postwar years.

In conclusion, there is some evidence in favor of the basic contention of this paper, namely that higher tax progressivity is conducive to wage moderation. The tax reforms that have reduced progressivity over the 1980s and the early 1990s may therefore have increased equilibrium unemployment in Sweden. It is difficult, however, to obtain robust direct evidence on the effects on unemployment.[16] This is hardly surprising given that there are only two major swings in aggregate time series on tax progressivity, an increase in progressivity up to the late 1970s, and a trend decline thereafter (cf. Figure 2).

4. Concluding remarks

We have examined the claim that progressive taxation may be conducive to wage moderation, an idea that is supported by bargaining theories of wage setting. The empirical analyses have provided some support for this claim, although the results may perhaps be given alternative interpretations. As usual, the empirics cannot prove the theory.

Although the analysis suggests that tax progressivity may be good for employment, there are a number of reasons to exercise caution in policy prescriptions. As we have emphasized, there are important dimensions of labor supply that are responsive to changes in progressivity. These considerations would have to be taken into account in a complete welfare analysis and in discussions of policy reforms. The consequences for investements in human capital would seem to be particularly relevant in this context. The Swedish tax reform of 1990/91 has had a significant impact on the returns to higher education, and would therefore also encourage the demand for investments in human capital.

There are aspects of wage formation that we have not dealt with and which should be treated in future work. The effects of taxes on the structure of compensation is one important aspect, in particular the incentives to substitute untaxed fringe benefits for taxable earned income. The tax system may also have potentially important effects on firms' internal pay policies with regard to the steepness of the earnings profiles. A progressive tax system penalizes steep wage profiles, which may induce firms to choose other forms of remuneration systems to elicit work effort and influence labor turnover. These and other issues remain to be considered in future research on taxation and wage formation.

[16] Forslund (1995) does not find significant effects of tax progressivity in reduced-form unemployment equations on aggregate Swedish time series.

Appendix

The formal model

Nominal profits for firm i are given by

$$\Pi_i = Q(N_i) - [W_i + S(W_i)]N_i \qquad \text{(A.1)}$$

where Q_i is real output, N_i is employment, W_i is the nominal wage, and S is the payroll tax. The nominal wage is determined by bargaining between a union and a firm (or a number of identical firms in a particular sector represented by an employer organization). The union's objective function is taken to be of the form

$$\Gamma(N_i, W_i^c) \equiv N_i\left[(1/\sigma)\,(W_i^c)^\sigma - \Gamma_0\right] \qquad \text{(A.2)}$$

where W_i^c is the real after-tax consumption wage and Γ_0 is the utility available to a worker who fails to become employed in the sector. The concavity of the utility function is captured by the parameter σ, where $\sigma \leq 1$. The real after-tax consumption wage is given by $W_i^c \equiv W_i - T(W_i)$, where $T(W_i)$ is the amount of taxes paid by the worker. The wage is chosen to maximize the Nash product

$$\Omega \equiv \left[\Gamma(N_i, W_i^c)\right]^\lambda [\Pi(W_i)]^{1-\lambda} \qquad \text{(A.3)}$$

where it is assumed that profit-maximizing firms determine employment given the negotiated wage. The first-order condition takes the form

$$\Omega_{w_i} = \lambda\,\frac{\partial \ln \Gamma(.)}{\partial W_i} + (1-\lambda)\,\frac{\partial \ln \Pi(.)}{\partial W_i} = 0 \qquad \text{(A.4)}$$

It is straightforward to check that the first-order condition implies that the wage is reduced by an increase in the marginal income tax rate $T'(.)$ or the marginal payroll tax rate $S'(.)$, holding the average income or payroll tax rate constant. A rise in the marginal income tax rate with the average rate unchanged reduces the marginal gain to the union of a wage increase; a rise in the marginal payroll tax rate with the average rate constant increases the marginal cost to the firm of a wage increase. The rise in progressivity induces wage setters to substitute employment for real wages. This result holds even if the union is exclusively concerned with real wages and assigns no weight to employment. The utility of real wages is iso-elastic in our formulation, but the results do not depend on this restriction.

The first-order condition can be written as a mark-up type wage equation:

$$(W_i^c)^\sigma = \left[\frac{1}{\sigma} - \frac{v\lambda(1-\gamma)}{(1-\lambda)\gamma+\lambda}\right]^{-1} \cdot \Gamma_0 = \left[\frac{1}{\sigma} - v\kappa\right]^{-1} \cdot \Gamma_0 \qquad \text{(A.5)}$$

The progressivity of the tax system is captured by v (explained in the main text), and $\kappa \equiv \lambda(1-\gamma)/[(1-\lambda)\gamma+\lambda]$ can be regarded as a measure of the union's bargaining power, in a broad sense. The power of the union increases in λ and decreases in the labor share, since a higher labor share implies a more wage-elastic labor demand schedule.

To analyze the general equilibrium implications we take Γ_0 to be a weighted average of real wages outside the firm and real unemployment benefits, with the weights determined by the aggregate unemployment rate in the economy. More precisely we assume

$$\Gamma_0 = [1-\varphi(u)](1/\sigma)(W^c)^\sigma + \varphi(u)(1/\sigma')B^{\sigma'} \qquad \text{(A.6)}$$

where $\varphi(u)$ is an increasing function of the unemployment rate (u) and B is real after-tax unemployment benefits.

By imposing symmetry, $W_i = W$, we obtain from eqs. (A.5) and (A.6):

$$(W^c)^\sigma = B^{\sigma'}[\sigma'/\sigma - v\kappa\sigma'/\varphi(u)]^{-1} \qquad \text{(A.7)}$$

Eq. (A.7) gives the basic aggregate wage-setting schedule, an inverse relationship between the real consumption wage and unemployment. The wage-settting schedule can be written as a non-linear equation in logarithms, i.e.,

$$\ln W^c = const + \sigma^* \ln B - (1/\sigma)\ln[1-\sigma\kappa v/\phi u)] \qquad \text{(A.8)}$$

where we have assumed $\varphi(u) = \phi u$ and $\sigma^* \equiv \sigma'/\sigma$. Note that the benefit coefficient in the wage equation need not equal one when we allow for state-specific utility functions.

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Comment on Bertil Holmlund and Ann-Sofie Kolm: Progressive Taxation, Wage Setting, and Unemployment: Theory and Swedish Evidence

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In the popular policy debate it has often been taken for granted that progressive taxes, by reducing labour supply, exert a negative effect on output. Indeed, this was one of the prime motivations for the Swedish tax reform in 1991. But recent theoretical research has also suggested an effect in the opposite direction: by making wage increases less "profitable" for wage earners, tax progressivity may promote real wage moderation with positive employment and output effects as a consequence. The paper by Holmlund and Kolm examines these issues. Their conclusion is that high tax progressivity does seem to reduce wage pressure and unemployment, at the same time as there are negative effects on the supply of hours per employee (and most likely on other dimensions of labour supply as well).

On the whole I find the Holmlund–Kolm analysis careful and balanced. The paper represents a nice mix between theory and empirical testing. Nevertheless I shall play the devil's advocate and raise a number of critical questions.

1. The theoretical analysis

A simple way of showing that tax progressivity can exert a moderating influence on real wages in the class of models used by Holmlund and Kolm is as follows. Assume that the wage in a sector is set by a monopoly union

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($\lambda = 0$ in equation A.3 in the paper), that workers are risk neutral ($\sigma = 1$ in equation A.2 in the paper) and that there is no mobility of labour between sectors, so that the utility of a laid-off worker is simply the (exogenous) unemployment benefit. It is well known that if taxes are proportional, a utility-maximising trade union will then set the real after-tax consumption wage (the nominal after-tax wage deflated by the consumer price index) as a mark-up on the real (after-tax) unemployment benefit (see e.g. Layard *et al.*, 1991). More precisely, it will hold that

$$w_c = \left(1 - \frac{1}{\varepsilon}\right)^{-1} B, \tag{1}$$

where w_c = the real after-tax consumption wage, B = the real after-tax unemployment benefit and ε = the labour-demand elasticity. The intuition is simple: the higher the elasticity, the larger the employment loss caused by a given percentage wage increase and thus the stronger the incentive for wage moderation.

With a progressive income tax, it is straightforward to show, as I do in Appendix A.1, that a utility-maximising union will instead choose the wage

$$w_c = \left(1 - \frac{v}{\varepsilon}\right)^{-1} B, \tag{2}$$

where v = (1 – the marginal tax rate)/(1 – the average tax rate) is the elasticity of the after-tax wage with respect to the before-tax wage (the Holmlund–Kolm measure of income tax progressivity). It is immediately seen that higher tax progressivity (a lower v) reduces the mark-up in the same way as a higher labour-demand elasticity. Again the intuition is simple. When a union contemplates a wage rise, it must take into account that if the after-tax wage is to increase by, say, 1 percent, the before-tax wage must increase by $1/v$ percent. This means that the accompanying employment loss will be ε/v percent. Hence, since wage increases become more costly with progressive taxes, rational unions will choose not to push wages so high as with a proportional tax schedule.

The conclusion that tax progressivity can contribute to real wage moderation and employment is quite general. As shown by Holmlund and Kolm, it carries over to a model of bargaining between employers and unions (also if unions care only about after-tax wages but not about employment). The conclusion would also hold in a model with bargaining between employers and *individual* employees (such as in Mortensen and

Pissarides, 1994). Similar results would be obtained in a search model, too, although the mechanism is different: high marginal tax rates reduce the expected return for the unemployed of turning down present job offers in order to preserve the option of receiving even better offers in the future (Ljungkvist and Sargent, 1995).

A natural question to ask is how the models discussed above go together with the notion that high marginal tax rates may cause high wage increases in order to achieve after-tax real wage targets. This idea was first formalised by Lundberg (1953) in his analysis of the "wage multiplier" and later elaborated by Calmfors and Lundberg (1974) and Calmfors (1977). It is true, as pointed out by Holmlund and Kolm, that this framework ignored the possibility of a link between tax progressivity and real wage targets. But the wage multiplier analysis also addressed another problem than the one analysed by Holmlund and Kolm: Which *nominal* wage increases are required to achieve given targets for after-tax real wages under *inflation* and *non-indexed* taxes (the Swedish situation for many years)? As I show in Appendix A.2, the conclusion from this literature that tax progressivity is likely to cause large compensating nominal wage increases in the case of, for instance, import price rises still holds. The simple explanation is that the nominal pre-tax wage increases required to reach a certain real wage target are larger than the nominal after-tax wage increases when taxes are progressive.[1]

Going back to the Holmlund–Kolm case with indexed taxes, the main limitation of the analysis in Sections 1.1 and 1.2 of the paper is its *partial* character. It neglects the supply effects of taxes that formed the principal motivation for the Swedish tax reform. This is the reason why Holmlund and Kolm in Section 1.3 evaluate the impact of tax progressivity on the expected *welfare* of workers taking the effects on hours of work into account. Their conclusion is that the positive effect of high tax progressivity on the number of employed *persons* (which follows from the analysis above) has to be traded off against the negative welfare effects resulting from

[1] Note also the possibility in the wage-multiplier analysis that real wage targets cannot be reached through nominal wage *increases* (because nominal after-tax wage increases turn out to be smaller than the induced price increases). The way to reach the after-tax real wage targets may therefore be to *reduce* nominal wages (Calmfors and Lundberg, 1974; Calmfors, 1977). Such an outcome would, however, seem to imply an improbable degree of co-ordination between different wage setters under decentralised bargaining. In a centralised system it is theoretically possible that progressive and non-indexed taxes could contribute to wage restraint (Agell and Ysander, 1993).

fewer hours and thus lower wage income per employed worker. Although no explicit solutions can be derived, the numerical examples suggest that a certain – and perhaps quite high – degree of progressivity $(0 < v < 1)$ is optimal.

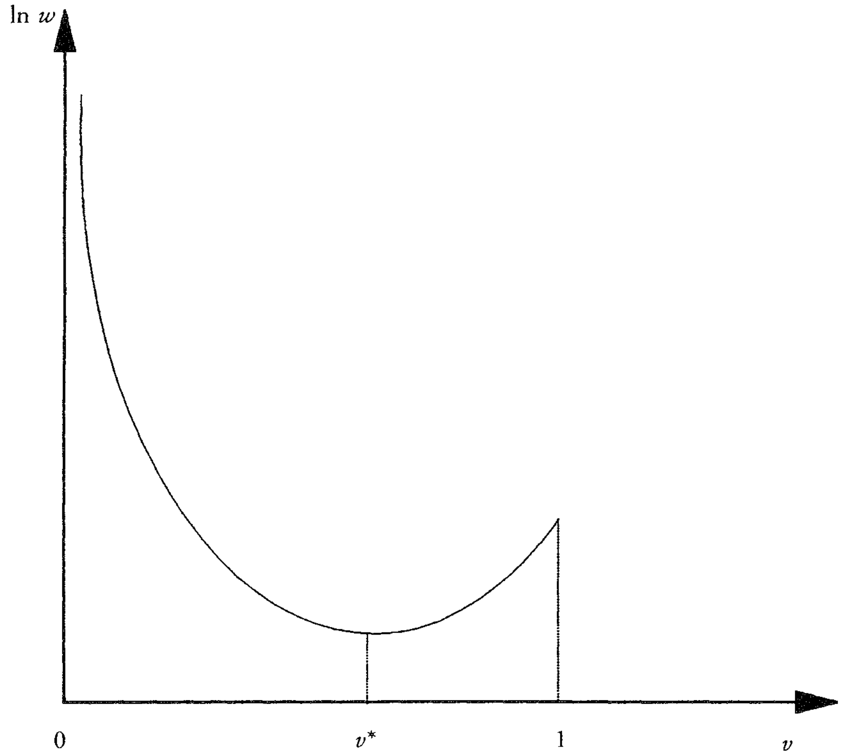
However, the Holmlund–Kolm exposition in Section 1.3 fails to bring out a few crucial points. One can get a clearer picture by simplifying the analysis somewhat. I am especially interested in how the *pre-tax wage per hour* is affected. Since hours and workers are assumed to be perfect substitutes in production, this wage rate determines the total number of hours worked in the economy and thus also output. In Appendix A.3 I again let a monopoly union (with the same utility function as in the paper) set wages in a situation with no labour mobility between sectors and an exogenous benefit level.[2]

I show in equation (A.8) that the after-tax wage *income* of an employed worker will in this case be set as a mark-up on the sum of the unemployment benefit and the perceived disutility of work (which is assumed larger the longer working time is and thus the more "leisure" that has to be given up when employed). As in the analysis above, an increase in tax progressivity reduces the mark-up. In addition an increase in progressivity lowers the number of working hours per employee. This decreases the disutility from having a job, which will make the union more anxious to avoid employment losses. Both these effects work in the direction of reducing the pre-tax wage per hour. But against this must be set that shorter working time tends to reduce wage income, so that an incentive is also created for the union to raise the pre-tax wage rate in order to compensate for this effect.

There will thus be forces working in opposite directions on the pre-tax wage per hour. It is shown in the Appendix that the wage-reducing effects of higher progressivity (lower v) dominate at low levels of progressivity (high v), whereas the wage-increasing effects dominate at high levels of progressivity (low v). The relationship between tax progressivity and the pre-tax real wage rate will look as in Figure 1. The sign of the effect of a change in tax progressivity thus depends on the initial position of the economy. It also follows that there is a certain degree of tax progressivity

[2] Holmlund and Kolm assume bargaining, an exogenous replacement rate and that laid-off workers can move to other sectors. My modifications leave all the important mechanisms in the model intact.

Figure 1. Tax progressivity and hourly real wages



w = the hourly real wage
v = tax progressivity (the elasticity of the after-tax wage with respect to the pre-tax wage)

($0 < v^* < 1$), which *minimises* the hourly wage. This degree of progressivity maximises the total number of hours worked in the economy and thus also output.

2. The empirical analysis

In an empirical section Holmlund and Kolm test the hypothesis that higher tax progressivity leads to lower real wages. Two sets of wage equations are estimated. The first set exploits time-series data for different *quintiles* of the income distribution for the period 1975–1992. The second set of estimations instead aims at explaining cross-section wage changes between 1989 and 1992 in a sample of *individuals*. Both types of regressions seem to support the hypothesis that high tax progressivity is conducive to real wage moderation. There are, however, a few issues that could be raised in this context.

There is a certain lack of consistency in the paper between the theoretical formulations and the empirical applications. The former assume a constant replacement rate (i.e., that unemployment benefits make up a certain fraction of wages), whereas exogenous benefit levels are assumed in the estimations. Another problem is whether the observational units in the estimations can be taken to correspond to the trade unions of the theoretical analysis. It may perhaps be reasonable to approximate unions with the different quintiles of the income distribution. But it is more problematic to use the model of bargaining between unions and employers as the theoretical basis for explaining cross-section differences in wage changes among *individuals*. This may in fact be quite inappropriate. One might instead base the empirical analysis here on a model of bargaining between individual employees and firms of the Mortensen-Pissarides (1994) type. But it is not clear to me how relevant such an approach is in the Swedish context with its emphasis on collective bargaining. So the question remains as to how much the empirical cross-section analysis of differences in wage changes says about the effect of tax progressivity on the *aggregate* wage level. It may very well be, as the authors themselves note, that the negative relationship between tax progressivity and wage changes in the cross-section analysis instead reflects that effort (and thus earnings) are negatively related to tax progressivity.

There is also the econometric problem of non-stationarity of at least real wages and unemployment benefits in the time-series regressions. Even though the time series are short, an attempt could have been made to examine the co-integration properties of the variables and to make the estimations in error-correction form.

I also see a risk that omitted-variable bias may have affected the results in the time-series regressions. The results are likely to be governed mainly by the coincidence of real wage cuts and high tax progressivity in the late 1970s and early 1980s. But we know that there are a number of other possible explanations for these real wage reductions: oil-price shocks, lower productivity growth, the world recession in general, and pay-roll tax rises. The exclusion of such variables from the regressions may have exaggerated the role of variations in income tax progressivity for the explanation of wages.

Finally, the earnings measures used as dependent variables in the regressions have been derived by help of very crude assumptions on working time. The estimated wage equations are therefore not well suited to analyse the issue discussed above of how *pre-tax wage rates* (and hence output) is likely to respond to tax progressivity, once the endogenous response of hours supplied is taken into account. An extension in this direction would seem worthwhile.

3. Conclusions

So what is my overall judgement on the evidence presented in the paper? I have – perhaps somewhat inappropriately – focused my comments on factors that weaken the claim that tax progressivity may contribute to wage restraint. Still, once labour supply responses are taken into account, I find the theoretical basis for this hypothesis weaker than Holmlund and Kolm seem to do. The sign of the effect on pre-tax wage rates is likely to depend upon the initial degree of progressivity: a moderating wage effect is more probable if progressivity is raised from a low than from a high level. As for the empirical analysis, the paper does present interesting evidence in favour of wage-moderating effects of progressive taxes, but I would be more convinced if my objections above could be addressed in further work.

Appendix

A.1. Income tax progressivity and the monopoly-union model

Let the utility of an employed worker be equal to the after-tax real wage w_c and the utility of a laid-off worker be equal to the unemployment benefit B. Furthermore let $w_c = \alpha w^v$, where v is the income-tax progressivity parameter discussed above, α is another tax parameter and w is the pre-tax real wage (= the real wage cost to employers). Employment is given by $N = N(w)$. Assume that a monopoly union sets the wage by maximising the expected utility of a representative member

$$EV = \frac{N}{M} w_c + \left(1 - \frac{N}{M}\right) B, \qquad \text{(A.1)}$$

where M is the number of union members. Equation (2) in my text can be derived from the first-order condition for utility maximisation. Note that

$$\frac{\varepsilon}{v} = -\left(\frac{\partial N}{\partial w}\cdot\frac{w}{N}\right) \Big/ \left(\frac{\partial w_c}{\partial w}\cdot\frac{w}{w_c}\right) = -\frac{dN}{dw_c}\cdot\frac{w_c}{N}, \tag{A.2}$$

i.e., ε/v is the elasticity of employment with respect to the after-tax real wage. Note also that $v = 1$ (a proportional income tax) in my equation (2) gives my equation (1).

A.2 Tax progressivity in a non-indexed tax system

Let in this case $w_c = \alpha W^v/P$, where w_c, α and v denote the same variables as before, W is the nominal pre-tax wage and P is the (exogenous) price level (think in terms of traded goods, the prices of which are determined by world market prices and exchange rates that are not explained in the model). If W is set so as to maximise (A.1) given $N = N(w) = N(W/P)$ and the exogenous real benefit level B, equation (2) in my comment can again be derived. But from the definition of w_c in this case, we obtain

$$\ln W = \frac{1}{v}\left[\ln P + \ln B - \ln\left(1 - \frac{v}{\varepsilon}\right) - \ln\alpha\right] \tag{A.3}$$

Hence it follows that a price increase will induce a larger *nominal* pre-tax wage increase, the higher tax progressivity is (the lower v is). This is required in order to achieve the after-tax real wage target, which according to equation (2) is independent of the price level. It also holds that the real product wage ($\ln W - \ln P$) must increase (and thus employment fall) if the price level increases.

A.3. Income tax progressivity and supply of hours

Assume the same utility function for an employed worker as in Section 1.3 of the Holmlund–Kolm paper, i.e.

$$U = \ln\left(\alpha(wh)^v\right) - \frac{h^{1+\delta}}{1+\delta} \tag{A.4}$$

where w is now the pre-tax wage per *hour*, h is hours worked, α and v are tax parameters as above and $\delta > 0$ is a parameter reflecting the evaluation of leisure. As discussed in the paper, utility maximisation on the part of the individual worker gives rise to the hours supply function

$$h = v^{1/(1+\delta)}. \tag{A.5}$$

I again assume that a monopoly union sets the wage so as to maximise the expected utility of a representative worker

$$EV = \frac{N}{M} U + \left(1 - \frac{N}{M}\right) B, \tag{A.6}$$

where now

$$N = \frac{L(w)}{h}, \tag{A.7}$$

by way of an assumption that hours and workers are perfect substitutes in production. Maximisation of (A.6) subject to (A.4), (A.5) and (A.7) gives the wage equation

$$\ln \bar{w}_c = \ln B + \frac{h^{1+\delta}}{1+\delta} + \frac{v}{\bar{\varepsilon}} = \ln B + \left[\frac{1}{1+\delta} + \frac{1}{\bar{\varepsilon}}\right] v, \tag{A.8}$$

where $\bar{w}_c = \alpha(wh)^v$ is the after-tax real wage *income* of an employed worker and $\bar{\varepsilon} = -(\partial L/\partial w) \cdot (w/L)$ is the elasticity of labour demand.

To make things simple, I assume that *net* taxes for the employed are zero, i.e. that

$$N\left[wh - \alpha(wh)^v\right] = 0. \tag{A.9}$$

After substituting (A.9) into (A.8) and rearranging terms, one obtains

$$\ln w = \ln B + v\left(\frac{1}{\bar{\varepsilon}} + \frac{1}{1+\delta}\right) - \frac{1}{1+\delta} \ln v. \tag{A.10}$$

Differentiation with respect to v gives

$$\frac{d \ln w}{dw} = \left(\frac{1}{\bar{\varepsilon}} + \frac{1}{1+\delta}\right) - \frac{1}{(1+\delta)} \gtrless 0. \tag{A.11}$$

The degree of progressivity v^* that minimises the wage (and thus maximises the total number of hours worked $hN = L$) is obtained by setting , $d\ln w/dv = 0$, which gives

$$v^* = \frac{\bar{\varepsilon}}{1+\bar{\varepsilon}+\delta} . \tag{A.12}$$

This is obviously a minimum since $d^2 \ln w/dv^2 = 1/(1+\delta)v^2 > 0$. It follows immediately from (A.12) that $0 < v^* < 1$, i.e., a certain degree of progressivity is always optimal.

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