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STRUCTURAL TAX REFORM AND THE CYCLICAL BEHAVIOUR OF THE LABOUR MARKET

Abstract

In this study, we quantitatively examine the consequences of structural tax reform in a real business cycle model with frictional unemployment and distortionary tax rates which are increasing in taxable labour income. The parameters of the labour tax schedule are estimated using U.S. data. We find that the cyclical implications of a reduction in the progressivity of the tax system critically depend on whether agents internalise the effects of their actions on the marginal tax rate. Hours per worker unambiguously become more volatile upon the removal of tax progressivity but unemployment fluctuations become more volatile only when agents do not internalise the slope of the tax schedule. Labour market instability therefore need not necessarily constitute a cost of tax reform to policy authorities who care about macroeconomic stability. The consequences of tax reform for expansionary fiscal stimulus are also considered.

Key words:

Real business cycles, tax reform, unemployment.

JEL: E32, E62.

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1. Introduction

In a comprehensive critique of U.S. tax policy, Hall and Rabushka (1995) make the case for a dramatic reform of the U.S. federal income tax system which would shift the economy from a progressive to a flat tax schedule. Progressive tax systems are usually justified by an appeal to fairness. Consequently, most of the attention in the literature focuses on the distributional impact of structural tax reform, as well as efficiency and long-run growth issues associated with lowering or flattening tax rates (Heer and Trede 2003, and Cassou and Lansing 2003).

In contrast to the literature on distribution and growth, the objective of this study is to quantitatively determine the short-run cyclical implications of tax reform, particularly with respect to central labour market variables. More specifically, this paper focuses on the consequences of labour income taxation for the dynamics of unemployment and average hours worked per employee in a real business cycle (RBC) model that is extended to allow for two additional features – matching frictions in the labour market and a graduated tax schedule in which the tax rate rises endogenously with increases in the taxpayer's own level of income. The key parameters of the tax rate function that determine the structure of the tax system are not calibrated arbitrarily, but are estimated using actual U.S. data. The central tax policy experiment is then represented as a shift from the empirically estimated U.S. tax schedule to a flat tax programme.

This study builds on Vanhala (2006) and Zanetti (2010) who examine the role of labour taxation in shaping the response of frictional labour markets to shocks. Both studies introduce a graduated tax schedule by combining a constant marginal tax rate with a «tax subsidy» as in Pissarides (2000) and find that tax progressivity reduces unemployment volatility by promoting wage moderation. This is consistent with the well-known result of Shimer (2005) which links wage rigidity to unemployment volatility. Wage flexibility erodes incentives for job creation during productivity booms in standard equilibrium matching models. Despite the virtue of simplicity of the Vanhala-Zanetti approach, their specification is difficult to calibrate empirically and so the authors are restricted to making only qualitative inferences. In this study, the tax code is estimated from U.S. data and benchmarked against other estimates in the literature, allowing for a quantitative prediction of tax reform. More importantly, our specification of progressive tax policy is endogenous, in the sense that the marginal tax rate is time dependent and increasing in taxable income. This allows for tax internalisation behaviour, or the explicit recognition by agents that their actions influence their tax burden according to the structure of the tax system.

Whether or not tax reform contributes to a quantitatively meaningful extent to increased labour market fluctuations depends on whether agents internalise the tax code in our model. When agents ignore the positive effect of wage increases on the *marginal* tax rate, reducing the progressivity of the tax system generates larger unemployment fluctuations because wages become significantly less volatile. In contrast, it is demonstrated that tax internalisation introduces opposing effects on the wage rate that could either increase or decrease wage volatility. On the one hand, agents recognise the incentive to keep wages low after a positive shock. But on the other hand, the tax distortion on the worker's outside option becomes amplified, prompting agents to demand greater compensation for working given an increase in the tax rate. Our quantitative analysis demonstrates that the two effects cancel out so that wage dynamics are largely unaffected by tax reform in the internalisation equilibrium. As a result, unemployment dynamics are also unaffected. In contrast, fluctuations in intensive adjustment (i. e. hours worked) are found to be more volatile under a flat tax system regardless of tax internalisation, and actually increase to a greater extent when the tax code is internalised. Intuitively, a more progressive tax system reduces the incentive to work longer hours when taxes are progressive, an effect which becomes amplified when agents internalise the gradient of the tax system.

Related work on fiscal policy in the context of frictional labour markets by Arseneau and Chugh (2008) examines optimal tax policy over the business cycle, finding that the optimal tax rate is typically quite volatile. The authors, however, do not discuss tax progressivity or the consequences of structural tax reform for shock propagation, which is our main focus. Relatively little attention has been devoted in the literature to the subject of progressive taxation in cyclical matching equilibria, with most of the focus being on stationary state analysis. Previous work in this area includes Pissarides (1998) and Sinko (2005) who demonstrate that an increase in tax progression reduces stationary state unemployment if wages are determined through bargaining.

We also consider the implications of the tax structure for fiscal policy. This subject has gained renewed interest in the literature given recent fiscal developments in the U.S. and Europe. Examples include Monacelli et al (2010) and Bruckner and Pappa (2010). The current study contributes to this related literature by concentrating on how the degree of tax progressivity on labour income determines the ability of the government to expand output through public expenditure. In a similar manner as for productivity shocks, we find that reducing tax progressivity increases the size of the fiscal multipliers with respect to output and unemployment, since hours and job creation respond more elastically to fiscal stimulus when the employee's tax burden does not rise commensurately, but only when agents do not exhibit internalisation behaviour. In the internalisation equilibrium, wage flexibility remains quantitatively unaffected by tax reform so that the transmission mechanism of fiscal intervention to job creation is not influenced by the change in tax policy.

The rest of the paper is organised as follows. The next section builds the model. Section 3 describes the calibration procedure and solution algorithm. Baseline results are reported in Section 4. Section 5 concludes and discusses prospects for further research.

2. Model

This section extends the baseline real business cycle framework with matching frictions (Merz (1995) and Andolfatto (1996)) by introducing a progressive tax policy. Following Guo and Chen (2010), we specify an endogenously determined progressive tax schedule that is increasing in taxable labour income. Business taxation is abstracted from. We begin with the household's problem.

2.1. Households

Time is discrete and indexed by a *t* subscript. There is a single representative household with a continuum of members who pool their income in order to insure away employment risk. The household chooses consumption, c_t, in order to maximise lifetime utility described by the objective function

$$max_{c_t} \sum_{t=0}^{\infty} \beta^t E_t \left[\frac{c_t^{1-\sigma}}{1-\sigma}\right] \quad (1)$$

where $0 < \sigma$ is the coefficient of relative risk aversion. β is a discount factor and E is the conditional expectations operator. Unemployed agents search for jobs with constant intensity taking aggregate labour market conditions as given, implying that employment is determined according to the matching technology in a process to be described below. Hours are determined not at the level of the representative household, but via decentralised Nash bargaining of individual agents, as in Trigari (2009) and Holt (2008). The measure of the household's members currently in employment is given by n_t. Labour force participation is abstracted from so that unemployment is $u_t = 1 - n_t$, where the labour force is normalised to unity. Optimisation is subject to a budget constraint given by

$$c_t + i_t = L_t + r_t k_t + UI_t + T_t + D_t \quad (2)$$

where i_t denotes private investment, the return on capital is r_t, k_t represents the private capital stock and $\boldsymbol{UI_t}$ is unemployment income (specified below). T_t and D_t are, respectively, a lump-sum transfer from the government and dividend income that the household receives as the diversified owner of firms.

L_t is net labour income of the household. It may either be assumed that the household's gross labour income is pooled prior to filing taxes or alternatively that tax is levied at the level of the individual match. In the latter case, agents must *internalise* the structure of the tax system, since the negotiated wage determines the marginal tax rate paid. In the absence of idiosyncratic heterogeneity, in equilibrium each individual will receive the same wage and work the same number of hours so that each individual's taxable income is the same. Assuming that taxes are filed jointly, the household's gross taxable income is then $n_t w_t h_t$, where average hours that each household member works is indexed by h_t and the hourly wage rate is w_t. The household's tax rate is endogenously determined by the function

$$\tau_t = 1 - \zeta \left(\frac{nwh}{n_t w_t h_t}\right)^{\phi} \tag{3}$$

where steady state values are denoted by removing time subscripts. This functional form follows Guo and Chen (2010). When $\varphi > 0$ the marginal tax rate is increasing in taxable labour income and the tax system is progressive, as appears in U.S. data. If φ is zero then the tax system is flat.

If tax liabilities are assumed to be settled at the individual match level, then equation (3) is expressed as

$$\tau_t = 1 - \zeta \left(\frac{wh}{w_t h_t}\right)^{\phi} \tag{4}$$

where the equilibrium condition that wages and hours are homogenous has been applied. In either case, equilibrium household net labour income is $L_t = n_t(1 - \tau_t)w_t h_t$. The difference in behaviour that tax internalisation induces occurs through Nash bargaining over wages and hours as discussed subsequently.

The remaining constraint on household optimisation is a standard capital accumulation equation, given by

$$k_{t+1} = (1 - \delta)k_t + i_t. \tag{5}$$

Household optimisation then gives rise to the standard Euler condition

$$c_t^{-\sigma} = \beta E_t c_{t+1}^{-\sigma}(r_{t+1} + 1 - \delta). \tag{6}$$

2.2. Firms and the Labour Market

Without loss of generality, it is assumed that the output market is competitive and comprised of a large number of small firms with each firm posting a single job. Output in each match i is given by

$$y_{it} = A_t k_{it}^{\alpha} h_{it}^{1-\alpha} \tag{7}$$

where A_t is an aggregate productivity shock common to all matches and $\alpha \geq 0$ denotes the elasticity of match output with respect to capital. Matches are destroyed exogenously at the rate ρ. In the absence of idiosyncratic heterogeneity, equilibrium hours worked will also be the same across all matches. It follows that the quantity of capital in each match will also be the same.

The measure of successful matches in period t is given by an aggregate matching function which randomly pairs job seekers with vacancies. Denote the aggregate measure of measure of vacancies v_t. The aggregate matching function $M(v_t, u_t)$ is increasing in both of its arguments, concave and homogenous of degree 1. Labour market tightness is defined as

$$\theta_t = \frac{v_t}{u_t}. \tag{8}$$

Random matching implies that the probability that a vacant job is filled at time t is

$$q(\theta_t) = \frac{M(v_t, u_t)}{v_t} = M(1, \theta_t). \tag{9}$$

A firm's asset value of an occupied job, J_t, and a vacancy, V_t, are given respectively by

$$J_t = A_t\left(\frac{k_t}{n_t}\right)^{\alpha} h_t^{1-\alpha} - w_t h_t - r_t\left(\frac{k_t}{n_t}\right) + E_t\beta_{t+1}[(1-\rho)J_{t+1} + \rho V_{t+1}] \tag{10}$$

and

$$V_t = -\kappa + q(\theta_t)E_t\beta_{t+1}J_{t+1} + (1 - q(\theta_t))E_t\beta_{t+1}V_{t+1} \tag{11}$$

where in equation (11) vacancy posting entails a flow cost $-\kappa$. The stochastic discount factor is defined as $\beta_t = \beta_t\,(c_t / c_{t+1})^{\sigma}$. The above asset equations are standard in the literature. The firm decides on the quantity of capital to rent in order to maximise J_t, requiring that

$$r_t = \alpha\frac{y_{it}}{k_{it}}. \tag{12}$$

The Bellman equations describing the asset values of an employed agent, W_t, and an unemployed agent, U_t, are, respectively,

$$W_t = (1-\tau_t)w_t h_t - \frac{h_t^{1+\varphi}}{1+\varphi}c_t^{\sigma} + E_t\beta_{t-1}[(1-\rho)W_{t+1} + \rho U_{t+1}] \tag{13}$$

and

$$U_t = b_1 + b_2 c_t^{\sigma} + p(\theta_t)E_t\beta_{t+1}W_{t+1} + (1 - p(\theta_t))E_t\beta_{t+1}U_{t+1}. \tag{14}$$

In equation (14), b_1 denotes the consumption value of government funded unemployment benefits obtained during job search, which are not subject to taxation. The term $b_2 \; c_t^{\sigma}$ represents the consumption value of leisure (or the costs of search) that the agent enjoys whilst not at work. Unemployment income in (2) is therefore defined as $\boldsymbol{UI_t} = b_1 u_t$. With probability $p(\theta_t)$ the unemployed agent at time t encounters a match that will operate successfully in period $t + 1$.

A free entry condition on the supply of vacancies ensures that

$$\frac{\kappa}{q(\theta_t)} = E_t\beta_{t+1}J_{t+1}. \tag{15}$$

The above expression requires the average cost of vacancy creation to equal the expected discounted asset value of a job.

2.3. Wage and Hours Determination

Costly search frictions give rise to a joint surplus value of maintaining current matches. Define this surplus as

$$S_t = (W_t - U_t) + (J_t - V_t) \tag{16}$$

The surplus is shared according to the Nash product

$$w_t = argmax\,(W_t - U_t)^{\eta}(J_t - V_t)^{1-\eta} \tag{17}$$

where η and $1 - \eta$ are the bargaining power of the worker and the firm, respectively. Under the assumption that agents do not internalise the structure of the tax schedule, the perceived benefit of a marginal increase in the wage is $\partial W_t / \partial w_t = 1 - \tau_t$. The first-order condition for wages is then

$$W_t - U_t = \frac{\eta}{1-\eta}(1 - \tau_t)J_t. \tag{18}$$

Substituting the respective Bellman equations into the first-order condition (18) yields an explicit solution for the equilibrium wage,

$$w_t h_t = \eta\left[A_t\left(\frac{k_t}{n_t}\right)^{\alpha} h_t^{1-\alpha} - r_t\left(\frac{k_t}{n_t}\right) + (1-\rho)\frac{\kappa}{q(\theta_t)}\right] + (1-\eta)\left\{\frac{1}{1-\tau_t}\left(b_1 + b_2 c_t^g + \frac{h_t^{1+\varphi}}{1+\varphi} c_t^{\sigma}\right) - (1 - p(\theta_t))\frac{\eta}{1-\eta}E_t\frac{1-\tau_{t+1}}{1-\tau_t}(1-\rho)\frac{\kappa}{q(\theta_t)}\right\} \tag{19}$$

Equation (19) is similar in nature to the standard expression derived in Pissarides (2000), except for the presence of the endogenous progressive tax policy and disutility of hours. The equilibrium wage rate is a weighted average of the contribution of the worker to the match and the worker's outside option, where the weights are given by the bargaining power of the worker and the firm, respectively. The current tax rate distorts the relative consumption value of non-employment while the time path of the tax rate influences the current value of the match relative to its continuation value.

If the tax structure is internalised, agents explicitly recognise the effect of their wage negotiations on the marginal tax rate. Thus, $\partial W_t / \partial w_t = (1 - \phi)(1 - \tau_t)$. The perceived benefit of a marginal increase in the wage is smaller when φ is positive. The equilibrium wage becomes

$$w_t h_t = \eta\frac{1-\phi}{1-\eta\phi}\left[A_t\left(\frac{k_t}{n_t}\right)^{\alpha} h_t^{1-\alpha} - r_t\left(\frac{k_t}{n_t}\right) + (1-\rho)\frac{\kappa}{q(\theta_t)}\right] + (1-\eta)\frac{1-\phi}{1-\eta\phi}\left\{\frac{1}{(1-\phi)(1-\tau_t)}\left(b_1 + b_2 c_t^g + \frac{h_t^{1+\varphi}}{1+\varphi} c_t^{\sigma}\right) - (1 - p(\theta_t))\frac{\eta}{1-\eta}E_t\frac{1-\tau_{t+1}}{1-\tau_t}(1-\rho)\frac{\kappa}{q(\theta_t)}\right\} \tag{20}$$

The entire right side of (20) is scaled by the factor $\frac{(1-\phi)}{(1-\eta\phi)}$ which is less than 1 if taxes are progressive. This reflects the joint incentive facing the worker and firm to keep wages low the more progressive the tax system is. Note also that the tax distortion on the worker's outside option is also amplified by the factor $(1-\phi)^{-1}$, which puts upward pressure on the wage. Therefore, on the one hand, the wage rate becomes less sensitive to productivity shocks the more progressive the tax system is, but on the other hand the effect of tax fluctuations on the worker's outside option becomes amplified. The impact of tax reform on wage volatility in the internalisation equilibrium is therefore ambiguous. When taxes are not internalised, fluctuations in the tax rate unambiguously increase wage volatility by reinforcing the positive effect of productivity shocks on the wage through an increase in the tax-adjusted value of non-employment since τ_t moves in the same direction as the productivity shock. Flat tax reform which eliminates tax fluctuations results in increased wage stability in this case. As will be demonstrated subsequently, the effect of tax reform on unemployment dynamics depends crucially on wage behaviour.

Hours are similarly determined through decentralised Nash bargaining at the level of the individual match. Hours are set so as to maximise

$$h_t = argmax\,(W_t - U_t)^{\eta}(J_t - V_t)^{1-\eta}. \qquad (21)$$

This results in the equilibrium condition

$$\frac{h_t^{\varphi}}{1-\tau_t}c_t^{\sigma} = (1-\alpha)A_t\left(\frac{k_t}{n_t}\right)^{\alpha}h_t^{-\alpha} \qquad (22)$$

if taxes are not internalised, and

$$\frac{h_t^{\varphi}}{(1-\phi)(1-\tau_t)}c_t^{\sigma} = (1-\alpha)A_t\left(\frac{k_t}{n_t}\right)^{\alpha}h_t^{-\alpha} \qquad (23)$$

in the internalisation equilibrium. Similar intuition applies as for wages. In particular, the tax distortion on the labour supply decision is amplified when agents recognise the positive effect that an increase in hours has on the marginal tax rate.

3. Solution and Calibration

To close the model we note that aggregate employment evolves according to

$$n_{t+1} = (1-\rho)n_t + M_t \qquad (24)$$

and the government balances its budget in each period so that

$$b_1 u_t + T_t = n_t \tau_t w_t h_t. \qquad (25)$$

The aggregate resource constraint is thus $c_t + i_t - \kappa v_t = y_t$. It is assumed that the aggregate productivity shock is lognormally distributed and follows an exogenous stochastic process given by

$$logA_t = P_A logA_{t-1} + \xi_{A,t} \quad (26)$$

where $\xi_{A,t} \sim N(0,\sigma_A{}^2)$ and $0 \leq P_A \leq 1$.

The aggregate model is log-linearised around a stationary state and the resulting linear, rational expectations equilibrium is solved for using the method of undetermined coefficients, as described in Uhlig (1997). Artificial time series are then computed by iterating the linearised equilibrium laws of motion. 200 random samples of 300 periods each are obtained and the first observations of each sample are discarded to match the corresponding sample period of U.S. quarterly data. We consider a sample period spanning quarterly data from 1965:1 to 2005:4. All data, simulated and actual, are logged and detrended using an HP filter with smoothing parameter 1600. The model's cyclical properties are then computed under different tax regimes.

Our calibration strategy for the labour income tax schedule follows the general methodology of Cassou and Lansing (2003) and Guo and Chen (2010). Specifically, we use non-linear least squares regressions to estimate the tax code parameters ζ and φ from (3). The difference to the previous authors is that we only consider taxation on wage income, whereas they allow for a richer tax specification that includes business income. To be able to estimate the parameters, data on average tax rates and an empirical counterpart to the inverse ratio of taxable labour income to its mean level are needed. Marginal federal tax rates on wage income are computed using the TAXSIM model which is available at the website of the National Bureau of Economic Research. The empirical counterpart to the taxable income ratio is obtained from average salaries and wages data reported on W-2 Forms, available at the website of the Internal Revenue Service.

In order to account for changes to the federal income tax law that have occurred during the sample period in question, we estimate regressions for the tax years 1965, 1975, 1985, 1995 and 2005. The results are reported in Table 1. The results indicate that there has been a certain degree of variation in both the level and slope of the estimated labour tax function. There have been at least two notable tax reforms during our sample period, the Tax Reform Act of 1969 (TRA-69) and the Tax Reform Act of 1986 (TRA-86). TRA-69 appears to have resulted in a lower level parameter (higher average tax), which decreases from 0.89 in 1965 to 0.80 in 1975 and 1985. The slope of the schedule increased slightly from 0.14 to 0.15, but then fell back to 0.14 over the same period. In contrast, TRA-86 appears to have resulted in both a slight decrease in average taxes and a notable decrease in progressivity, with the slope parameter falling from 0.14 to 0.10 from 1985 to 1995. Comparing our results to those of Guo and Chen (2010), their finding of a tendency for progressivity in total income tax to decrease over time in post-war U.S. data still holds when isolating wage taxes.

Their estimates are slightly different to ours, but not excessively so. They estimate the slope parameter for the period 1966 to 1986 to be about 0.17, falling to about 0.06 from 1987 to 2005. This suggests that the reduction in the progressivity of business income tax has been somewhat sharper than for wage income. They also find little variation in the level parameter, which is roughly constant at 0.8 according to their estimates. Our results suggest that the variation in the average level of wage taxes has been more noticeable. Nevertheless, the difference to Guo and Chen's estimates is not drastic.

Because we are interested in expounding the predictions of a real business cycle model for a general reduction in tax progressivity, and less interested in the repercussions of a particular tax reform episode, the use of an average measure is most convenient for our purposes. As a benchmark, we therefore set $\zeta = 0.84$ and $\varphi = 0.13$, the averages of our estimates in Table 1. This gives a steady state tax rate of $\tau = 0.16$.

Table 1

Estimated U.S. Labour Income Tax Schedule.

	Year				
	1965	1975	1985	1995	2005
Estimated Level, ζ	0.89	0.80	0.80	0.83	0.86
(Standard Error)	(0.007)	(0.003)	(0.003)	(0.002)	(0.002)
Estimated Slope, φ	0.14	0.15	0.14	0.10	0.10
(Standard Error)	(0.004)	(0.002)	(0.002)	(0.001)	(0.001)
R^2	0.86	0.96	0.97	0.97	0.97

Our main focus is on tax progressivity, keeping ζ fixed across policy experiments. The hypothetical tax reform experiment that we concentrate on involves a reduction in the parameter φ from its initial baseline value of 0.13 to zero, thereby entirely eliminating tax progressivity. All other parameters are unchanged, including the variance of the productivity shock. In this manner, we attempt to approximate what the U.S. business cycle moments may have looked like had labour tax not been progressive, holding all other factors constant. The implications of varying ζ within the bounds of the empirical estimates are negligible and therefore not reported.

As emphasised by Merz (1995) and Trigari (2009), there is no consensus regarding the convexity parameter φ for the disutility of hours. This parameter governs the intertemporal elasticity of substitution of labour effort, defined as its reciprocal. Micro estimates of φ^{-1} range from practically zero to 0.5 (Trigari 2009), whereas representative agent macro studies typically assume much larger values of up to 3 (Merz 1995). The RBC literature also contains examples in which utility is linear in hours (for instance, Christiano and Eichenbaum 1992), which can be theoretically justified by an appeal to labour indivisibilities (Hansen 1985). Our strategy is to set φ = 0.33, which lies at the upper end of the values considered in the literature, in order to replicate realistic hours variation. We also set φ = 100 to essentially shut down hours variation in order to examine the role of intensive adjustment in the transmission process.

Aside from the parameterisation of the tax schedule and disutility of work, parameter values are largely standard in the RBC-matching literature. Given the use of quarterly data, the discount factor is set to β = 0.99. As in Andolfatto (1996), Merz (1995) and Holt (2008), amongst others, we asssume log utility such that σ = 1. Following Prescott (1986), the quarterly depreciation rate on capital is δ = 0.025 and the elasticity of output with respect to capital is α = 0.36. Steady state values for aggregate output, capital, hours and consumption must then jointly satisfy the production function, law of motion for capital, first-order condition for hours and the aggregate resource constraint.

Turning now to the labour market, it is standard to assume symmetric bargaining, η = 0.5. We follow Andolfatto (1996) in setting the vacancy transition probability to $q(\theta)$ = 0.9, consistent with the evidence on average vacancy duration reported in van Ours and Ridder (1992). The elasticity of the matching function with respect to v is γ = 0.6, as suggested by the empirical study by Blanchard and Diamond (1989). The quarterly separation rate ρ = 0.05 and is obtained from data on labour market transition probabilities used in Shimer (2007), made available at the author's personal webpage[1]. It is given by the sum of the employment-unemployment and employment-inactivity transition probabilities. Given $q(\theta)$ and ρ, v is determined from the steady state version of the employment law of motion once n is specified. We set n in order to target a realistic value for $p(\theta)$ which is calibrated in order to match average unemployment duration. The latter is calculated to be 1.17 quarters for the whole sample[2]. This results in a slightly larger unemployment-population ratio than found in the data for our sample (5.5% versus slightly less than 4%). Nevertheless, this calibration strategy has been adopted by other authors (Cole and Rogerson 1999 and Krause and Lubik 2007) and is consistent with the notion that measured unemployment understates the true intensity of search effort because non-participants are ignored.

Given our focus on unemployment fluctuations, the vacancy cost κ is treated as a free parameter that is adjusted in order to generate realistic unemployment. The precise value varies slightly according to the model specification,

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1 For additional details, please see Shimer (2007) and his webpage http://sites.google.com/site/robertshimer/research/flows. The data from June 1967 and December 1975 were tabulated by Joe Ritter and made available by Hoyt Bleakley. Data are not available for 1965-6.

2 Data on average unemployment duration are available from the Bureau of Labor Statistics, www.bls.gov.

but all lie within the range from about 0.02 to 0.05. Given κ, the total flow value from unemployment $b_1 + b_2 c^{\sigma}$ is then determined residually from equation (13). We set b_1 and b_2 so as to ensure that the net replacement ratio is 40%, the assumption in Shimer (2005).

Finally, it remains to calibrate the shock process for aggregate productivity. The persistence of productivity is set to $P_A = 0.95$. σ_A is adjusted so that each model is consistent with the volatility of output for the sample period in question, taking values between 0.0065 and 0.0075.

4. Results

Simulation-based business cycle statistics for the baseline and inelastic hours models are presented in Table 2. We report mean simulation standard deviations with sample standard deviations in parentheses. For each model economy, the relative volatilities of the economic variables of interest are reported prior to the simulated removal of tax progressivity, and after tax reform keeping all parameters apart from φ unchanged. In particular, the variance of the shock process is held constant post-reform. Recall that taxes do not fluctuate under a proportional system.

Consider the non-internalisation equilibrium with elastic hours first. Flat tax reform is associated with increased amplification of all labour market variables except the wage rate. Despite larger responses in output and market tightness, the wage rate fluctuates less in the flat tax model. The positive effect that increases in the tax rate have on the outside option of the worker translates into more volatile wages under progressive taxation. The impact on unemployment and market tightness is more significant than for hours, with the relative standard deviations of unemployment and tightness increasing by more than 10%. Hours become slightly more volatile, but significantly more procyclical as well. We observe that despite different cyclical behaviour in both vacancies and unemployment, the gradient of the vacancy-unemployment curve is not influenced by tax reform. Overall, endogenous increases in the tax rate under a progressive system offset the incentive to engage in productive activity in response to an improvement in technology, thereby stabilising the economy's adjustment to shocks.

Suppressing hours variation induces greater adjustment in the extensive margin and market tightness becomes even more volatile after tax reform. We also note that when hours variation is suppressed, the wage absorbs the productivity shock to a greater extent compared with a more elastic labour supply in which the increase in productivity is partially transmitted to increased working hours.

Table 2

Simulation Results.

	Non-Internalisation Equilibrium				
	U.S. Data	Elastic Hours		Inelastic Hours	
φ		0.33	0.33	100	100
φ		0.13	0	0.13	0
St. Dev.					
Output	1.28%	1.26% (.14%)	1.40% (.14%)	1.29% (.16%)	1.37% (.18%)
Wage	0.72	0.46 (.007)	0.36 (.008)	0.56 (.013)	0.49 (.014)
Unempl.	8.63	8.81 (.086)	9.94 (.093)	8.53 (.142)	10.15 (.170)
Tightness	18.84	15.98 (0.126)	18.04 (.173)	15.50 (.344)	18.44 (.403)
Hours	0.37	0.35 (.019)	.38 (.022)	-	-
Correlations					
Vacan.,Unem.	-0.94	-0.19 (.083)	-0.19 (.082)	-0.16 (.094)	-0.16 (.088)
Hours,Output	0.67	0.43 (.042)	0.51 (.030)		-
	Internalisation Equilibrium				
	U.S. Data	Elastic Hours		Inelastic Hours	
St. Dev.					
Output	1.28%	1.31% (.14%)	1.37% (.15%)	1.29% (.15%)	1.32% (.17%)
Wage	0.72	0.42 (.009)	0.37 (.007)	0.57 (.014)	0.56 (.015)
Unempl.	8.63	8.60 (.085)	8.54 (.091)	8.48 (.126)	8.73 (.141)
Tightness	18.84	15.60 (0.186)	15.47 (.134)	15.40 (.296)	15.83 (.323)
Hours	0.37	0.32 (.020)	0.39 (.021)	-	-
Correlations					
Vacan.,Unem.	-0.94	-0.18 (.097)	-0.19 (.090)	-0.17 (.087)	-0.18 (.095)
Hours,Output	0.67	0.59 (.027)	0.64 (.026)	-	-

Notes: Notes: Standard deviations are expressed relative to output. Sample standard deviations in brackets. U.S. data are from the BEA and BLS. Hours and employment data are for the non-farm business sector.

Consider now the effect of tax internalisation behaviour. Flattening the tax schedule is no longer associated with exacerbated volatility in market tightness. If anything, both unemployment and vacancies become slightly less volatile, though the change is insignificant. Hours variation is still more volatile under a flat tax, as was the case in the baseline model without tax internalisation, and the increase in the relative standard deviation of hours from 0.32 to 0.39 is larger than the baseline. Because unemployment behaviour does not change substantially, the only output effects are due to the increase in hours volatility. As a result, the effect of tax reform on output fluctuations is not as large as in the baseline model.

That unemployment does not respond to flat tax reform suggests that the opposing effects of φ in the wage equation tend to cancel each other out, causing wage volatility to be largely independent of φ. On balance, if tax reform does not influence the volatility of the wage, unemployment dynamics will also be unaffected. In Table 2 wage volatility does decline as φ is set to zero, but this is largely due to the effect of increased hours variation which reduces the volatility of the wage rate (per hour). This can be deduced by observing that wage volatility in the absence of hours variation is completely unresponsive to flat tax reform in the internalisation equilibrium, corroborating the intuition that the decline in wage volatility in the elastic hours case is due to the increase in hours fluctuations. In the absence of intensive adjustment, unemployment volatility increases very slightly but the change is insignificant.

4.1. Fiscal Multipliers

In this section, we consider the implications of the structure of the tax system for the propagation of government expenditure shocks. The study by Monacelli et al. (2010) demonstrated that a standard neoclassical model with matching frictions encounters difficulty in generating realistic effects of government purchases on output and unemployment. The latter authors assume that government purchases are intrinsically useless and enter the aggregate resource constraint as a pure drain on resources. In recognition of this, we follow Guo and Chen (2010) by allowing for productive government purchases in order to obtain fiscal multipliers of a realistic order of magnitude. For simplicity, we assume that government purchases, g_t, reflect a non-rival, public good which is freely accessed by all matches. The aggregate output function in this economy becomes

$$y_t = A_t k_t^{\alpha} h_t^{1-\alpha} g_t^{\chi} \quad (27)$$

where χ is the elasticity of output with respect to government spending. The government does not invest in capital; all capital remains privately owned. The first-order condition for hours and the government's budget constraint are adjusted accordingly.

The path of g_t is determined by an exogenous stochastic process given by

$$log A_t = P_g log A_{t-1} + \xi_{g,t} \quad (28)$$

where $\xi_{g,t} \sim N(0,\sigma_g^2)$ and $0 \leq P_g \leq 1$. As in Monacelli et al. (2010), we consider the effects of a one-off fiscal stimulus package that is defined as a temporary increase in g_t which is normalised to 1% of steady state output. The persistence parameter P_g is set to 0.9 based on the VAR estimates of Monacelli et al (2010). The range of values in the literature for χ is large; from 0.03 (Eberts 1986) to 0.39 (Aschauer 1989). Our calibration strategy is to set χ such that the fiscal multipliers prior to tax reform match the VAR estimates of Monacelli et al.

(2010). This requires slightly different values depending on the model specification, but all lie within the range χ = 0.1 to 0.15, which is towards the lower end of the empirical estimates. The steady state value of g = 0.20 to be consistent with the data over the sample period. The calibration strategy otherwise follows the same procedure as before.

Table 3 reports the output and unemployment multipliers computed for the different model specifications. As in Monacelli et al. (2010), the output multiplier is defined as the cumulative response of output divided by the cumulative amount of government expenditure from the time of the shock up to a specific date. We report impact multipliers and for one and two years after the shock. The unemployment multiplier is computed as the peak fall in unemployment from the steady state expressed in percentage points.

Table 3

Fiscal Multipliers

	Non-Internalisation Model					
	Progressive Tax			Flat Tax		
Multipliers	Impact	1 Year	2 Year	Impact	1 Year	2 Year
Output						
Elastic Hours	1.11	1.18	1.20	1.20	1.32	1.35
Inelastic Hours	0.76	1.21	1.31	0.76	1.32	1.45
	Peak					
Unemployment						
Elastic Hours	-0.34			-0.45		
Inelastic Hours	-0.83			-1.02		
	Tax Internalisation Model					
	Progressive Tax			Flat Tax		
Multipliers	Impact	1 Year	2 Year	Impact	1 Year	2 Year
Output						
Elastic Hours	1.06	1.21	1.24	1.16	1.27	1.30
Inelastic Hours	0.76	1.22	1.32	0.76	1.21	1.32
	Peak					
Unemployment						
Elastic Hours	-0.46			-0.41		
Inelastic Hours	-0.84			-0.83		

Consider first the non-internalisation equilibrium. Regardless of the elasticity of labour supply, flat tax reform is found to increase the effectiveness of expansionary fiscal policy in generating a rise in output and fall in unemployment. The increase in the one year output multiplier is on the order of 10%. Notice also that hours variation significantly raises the output multiplier on impact.

The long-term output multiplier is larger without hours variation as firms increase reliance on extensive adjustment, which takes time to accumulate. Unemployment multipliers are also larger when hours variation is suppressed. The fundamental mechanism driving the impact of tax reform is essentially the same as for a productivity shock: enhanced wage stability upon the removal of tax progressivity encourages greater job creation in response to positive stimulus.

Next, consider how tax internalisation influences these results. With realistic hours variation, tax reform increases the impact output multiplier from 1.06 to 1.16, but the longer term multipliers are largely unchanged. Flat tax reform can thus still hasten the output effects of fiscal stimulus, but the longer term effects are quantitatively weakened. The unemployment multiplier actually decreases slightly. When hours variation is suppressed, tax reform has virtually no impact on fiscal multipliers in the internalisation equilibrium, consistent with our previous simulation results. Again the mechanism is the same as before: since the wage is insensitive to tax reform when the slope of the tax schedule is internalised, the link between tax reform and job creation is quantitatively unimportant.

5. Conclusion

This paper has constructed a real business cycle model that is capable of quantifying the general equilibrium effects of structural tax reform. The principal finding is that the sensitivity of wage fluctuations to tax policy changes critically depends on whether agents internalise the gradient of the tax schedule or not. Wage behaviour in turn determines the implications of tax reform for cyclical unemployment dynamics. Therefore, we find that flat tax reform only leads to a significant increase in unemployment volatility caused by productivity shocks when agents do not internalise the effect of wage formation on the marginal tax rate. Furthermore, we have also demonstrated that the structure of the tax system influences the size of fiscal multipliers only when agents do not exhibit tax internalisation behaviour. These results may be somewhat counter-intuitive, since one may have anticipated the effects of tax reform to be larger when agents explicitly recognise the effect of their behaviour on endogenously determined marginal tax rates. Our findings also stand in contrast to previous work by Vanhala (2006) and Zanetti (2010) who find that flat tax reform unambiguously exacerbates labour market volatility. We conclude that exacerbated labour market instability need not necessarily be associated with flat tax reform.

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