Tax and Transfer Programs in an Incomplete Markets Model

Alonso Ortiz, Jorge and Rogerson, Richard

Arizona State University, W.P. Carey School of Business

June 2009

Tax and Transfer Programs in an Incomplete Markets Model*

Jorge Alonso-Ortiz

Arizona State University

Richard Rogerson

Arizona State University

June 2009

Abstract

We assess the consequences of increases in the scale of tax and transfer programs in the context of a model with idiosyncratic productivity shocks and incomplete markets. We contrast the outcomes for both hours worked and welfare relative to the results obtained in a stand-in household model, featuring no idiosyncratic shocks and complete markets. Our main finding is that the impact on hours remains very large, but the welfare consequences are very different. The analysis also suggests that tax and transfer policies may have large effects on average labor productivty via selection effects on employment.

*We thank seminar participants at the CEPR conference held in Budapest in October 2008. Rogerson thanks the NSF for financial support.

1. Introduction

Following Prescott (2004), a recent literature has sought to assess the extent to which cross-country differences in the size of tax and transfer systems can account for the large differences in hours of work across countries.[1] Much of this work takes place in the context of the neoclassical growth model with a stand-in household. Given that this model is the benchmark model of modern macroeconomics, it is natural to use it as a starting point for thinking about the aggregate effects of tax and transfer programs. However, it is also of interest to analyze the extent to which deviations from this model might influence our assessment of the effects of tax and transfer programs on aggregate allocations and welfare. The goal of this paper is to carry out such an analysis in another framework that has become very popular for addressing macroeconomic issues: the incomplete markets model of Huggett (1993) and Aiyagari (1994), extended to allow for an endogenous labor supply decision.[2]

The key feature of this model is that individuals face idiosyncratic shocks to their productivity in the market sector, but do not have access to insurance markets. To smooth consumption in the face of these productivity shocks, individuals can vary their saving behavior and their labor supply behavior. Previous work using this model suggests that it may have interesting implications for the analysis of tax and transfer programs. First, from the perspective of how tax and transfer

[1] See also Rogerson (2006, 2008), Ragan (2006), Ohanian et al (2008), and Ljungqvist and Sargent (2006, 2008), and McDaniel (2008) for related work.

[2] Our exercise can be seen as analogous to the exercise of Krusell and Smith (1998), who assessed the extent to which productivity shocks had different effects in the incomplete markets model relative to the stand-in household model.

programs affect allocations, Chang and Kim (2006, 2007) find that the heterogeneity induced by idiosyncratic productivity shocks plays an important role in determining the aggregate labor supply elasticity. Second, from the perspective of how tax and transfer programs affect welfare, Pijoan-Mas (2006) shows that in the absence of taxes, the competitive equilibrium in this model has inefficiently high labor supply, due to the fact that individuals rely at least partly on labor supply to smooth consumption in the face of negative productivity shocks. Floden and Linde (2001) have previously carried out an analysis of tax programs in such a model and highlight some interesting properties. Our calculations are very similar to theirs, with the main difference between the focus of the analysis.

We calibrate the model and analyze the effects of a simple tax and transfer scheme that places a proportional tax on labor earnings that is used to fund a lump sum transfer that is uniform across all individuals. Our main findings are as follows. First, from the perspective of accounting for differences in hours worked between the US and European countries such as Belgium, France, Germany and Italy, then the results are similar to the stand-in household model. That is, we find that an increase in the tax rate from .30 to .50 leads to a drop in hours worked of 27%, versus 29% in the stand-in household model. Second, the welfare implications are very different. Whereas the stand-in household model implies that optimal allocations are achieved with zero taxes and transfers, the model with idiosyncratic shocks implies that a substantial tax and transfer program has the ability to enhance steady state welfare. While moving from an American sized tax and transfer scheme to a European sized tax and transfer scheme still implies a welfare loss, the magnitude of the loss is much smaller. Third, we find that tax and transfer programs have a substantial positive impact on average labor productivity, measured as output per hour, due to the selection effects associated with the effects of tax and transfer schemes on employment. In light of this result we suggest that the apparent catchup of several European countries to the US in terms of productivity may be an illusion.

We also explore how the properties of the stochastic process describing idiosyncratic shocks influences these results. There are two effects of interest, which we illustrate by considering a change in the persistence of the idiosyncratic shocks. An increase in persistence implies that a given expansion of the tax and transfer system leads to larger effects on hours and smaller effects on welfare. The reason for this is that increases in persistence lead individual agents to make more use of labor supply to smooth consumption, leading to more work being done by workers with low productivity realizations. In this case a larger tax and transfer system will have large effects on hours worked, but the decrease in hours worked by low productivity workers moves the equilibrium allocation closer to the efficient allocation. The other effect is the one emphasized by Chang and Kim–the more spread out is the distribution of individual state variables, the smaller is the aggregate response to a change in the aggregate return to work, since fewer individuals will be close to the threshold which has them change their labor supply decision from working to not working.

The objective of this paper is similar in spirit to recent work by Ljungqvist and Sargent (2006, 2008). They also investigate the extent to which uncertainty and incomplete markets affect the findings of earlier studies. The key difference between their analysis and ours is in the type of uncertainty that is considered. Whereas Ljungqvist and Sargent consider stochastic transitions between two levels of skill in a life cycle model, we calibrate our model to match all movements in productivity. Similar to us, they find that uncertainty and incomplete markets has relatively little effect on the magnitude of the response of aggregate employment. As noted earlier, our paper is most similar to Floden and Linde (2001). They also assess the impact of changes in tax and transfer programs in a model with idiosyncratic shocks and incomplete markets. Our model differs from theirs in that we do not allow for permanent heterogeneity and we assume that labor is indivisible. Most importantly, we also focus on different aspects of the implications, including, for example, the implications for labor productivity.

An outline of the paper follows. In the next section we summarize the effects of changes in tax and transfer programs in the stand-in household model. Section 3 describes the incomplete markets model with idiosyncratic shocks. Section four calibrates this model and reports the results of how changes in tax and transfer programs will influence aggregate allocations and welfare. Section 5 focuses on some of the other aspects of the analysis, and Section 6 concludes.

2. Tax and Transfers in the Stand-in Household Model

For purposes of comparison it is of interest to consider the case which has been the benchmark for the previous literature. There is a continuum of mass one of identical individuals, each with preferences defined by:

$$\sum_{t=0}^{\infty} \beta^t [\log(c_t) + v(1 - h_t)]$$

where v is an increasing function. Labor is assumed to be indivisible, so that in any period h_t is restricted to take on the values of 0 or 1. It follows that the only aspect of $v(1-h)$ that matters are the two values $v(0)$ and $v(1)$. It is convenient to normalize $v(1)$ to be zero and to let $v(0) = -\alpha$. As is well known, if we assume that individuals can trade employment lotteries, then we can consider an economy with a single household with preferences given by[3]:

$$\sum_{t=0}^{\infty} \beta^t [\log(c_t) - \alpha h_t]$$

where h_t now represents the fraction of the households that are employed in period t.

Technology is described by an aggregate production function $F(k_t, h_t)$, assumed to be Cobb-Douglas:

$$y_t = k_t^{\theta} h_t^{1-\theta}.$$

Output can be used as either consumption or investment, and capital depreciates at rate δ.

Following Prescott (2004) we assume a government that taxes labor earnings at the constant proportional rate τ and uses the proceeds to finance a lump-sum

[3]Ljungqvist and Sargent (2006) show that lotteries are not essential in achieving this result in a continuous time version of the model. Krusell et al (2008) show this is also true for characterizing steady state outcomes in a discrete time model.

transfer T using a period-by-period balanced budget rule:

$$T_t = \tau w_t h$$

where w_t is the period t wage.

We focus on the steady state of this economy. Assuming that the solution for h is interior, the three following conditions characterize the steady state equilibrium:

$$F_1(k,h) = \frac{1}{\beta} - (1-\delta) \tag{2.1}$$

$$\alpha c = (1-\tau)F_2(k,h) \tag{2.2}$$

$$c = F(k,h) - \delta k \tag{2.3}$$

It is easy to infer the effects of an increase in the tax and transfer program, indexed by τ. Equation (2.1) implies that τ has no impact on the steady state value of k/h. Given k/h, the right hand side of equation () is decreasing in τ, so that c is proportional to $(1-\tau)$. Moreover, given a value for k/h, equation (2.3) implies a linear relationship between h and c, so that h is also proportional to $(1-\tau)$.

To assess the quantitative implications, consider a standard calibration of the above model to the US economy. Specifically, letting a period denote a year, choose values for β, θ, and δ so as to match targets for the real rate of return to capital (4%) , the capital-output ratio (2.5) and the investment-output ratio (.2) in the steady state. The implied values are $\beta = .96$, $\theta = 1/3$, $\delta = .08$. Letting $\tau = .3$ represent the average effective tax on labor income in the US, α is chosen so that steady state employment is .80. We can then ask what happens to steady state h as we consider different values of τ.

To compute the (steady state) welfare consequences of different tax rates we compute the proportional increase in consumption, denoted by Δ, required to leave the household indifferent between the two steady state allocations. A positive value of Δ indicates that welfare is lower than in the $\tau = .3$ steady state, while a negative value for Δ indicates that welfare is higher than in the $\tau = .3$ steady state. Table 1 presents results.

Table 1

Effect of Taxes in the Stand-in Household Model

	$\tau = 0$	$\tau = .1$	$\tau = .2$	$\tau = .3$	$\tau = .4$	$\tau = .5$
$h(\tau)/h(.3)$	1.25	1.25	1.14	1.00	.85	.71
Δ	-.08	-.08	-.05	.00	.07	.18

As noted earlier, changes in τ do not have any effect on k/h and as a result do not have any impact on either k/y or y/h, so we do not report these statistics. The effect of taxes on hours worked is large: starting from the $\tau = .3$ steady state, the effect of a ten percentage point change in tax rates is a change of roughly 15% in aggregate hours worked, independently of whether taxes are increased or decreased. We note that when τ is reduced to .1, the steady state allocation has everyone working, so that further reductions in taxes do not have any impact on steady state hours worked. In this model the equilibrium without taxes yields a Pareto efficient allocation. The steady state welfare measure abstracts from transition dynamics, but nonetheless the table shows that steady state welfare is highest when taxes are set to zero, though for this calibration a tax rate of $\tau = .1$ yields the same allocation. The same studies that produce estimates of the average tax rate on labor equal to .30 in the US suggest a value of .50 for the continental European economies of Belgium, France, Germany and Italy.[4] From the above table we see that this model predicts almost a thirty percent reduction in hours of work and a welfare cost equal to 18% of steady state consumption.

3. The Incomplete Markets Model

In this section we describe the incomplete markets model that is the focus of this study. Our model is in the spirit of the incomplete markets models of Huggett (1993) and Aiyagari (1994), and is basically the same as the one in Chang and Kim (2007). It is very similar to that in Floden and Linde (2001), and Pijoan-Mas (2006) with the main difference being that we assume indivisible labor. Because coordination problems within organizations often restrict the ability of individuals to work significantly different hours than their coworkers, we believe that the indivisible labor assumption is an appropriate one in contexts that stress idiosyncratic cross-sectional heterogeneity. Pijoan-Mas (2006) concludes that the labor supply elasticity must be very small in order to reconcile the large cross-sectional differences in productivity with the relatively small cross-sectional differences in hours. However, if the low variance in hours is due to technological factors that require some degree of coordination of hours across workers, this procedure will bias the

[4] Mendoza et al (1994) was an early contribution to this literature. More recently McDaniel (2006) has produced longer time series using a variation on the method used by Mendoza et al along the lines of what Prescott (2004) did.

estimated preference parameters. For this reason we think that the indivisible labor assumption is preferable in this context.

As earlier, we assume that there is a continuum of mass one of individuals, indexed by i, each of whom has preferences described by:

$$\sum_{t=0}^{\infty} \beta^t [\log(c_{it}) - \alpha h_{it}]$$

where h_{it} can take on the values 0 or 1. There is a Cobb-Douglas aggregate production function that uses capital (K_t) and labor (L_t) to produce output:

$$Y_t = K_t^{\theta} L_t^{1-\theta}$$

where we now use upper case letters to denote aggregate values, since individual and aggregate values will no longer be the same. We assume that individual productivity is stochastic. Let e_{it} denote individual productivity for individual i in period t. We assume that it follows an AR(1) process in logs: The persistent component follows a process of the form:

$$\log e_{it+1} = \rho \log e_{it} + \varepsilon_{it}.$$

where ε_{it} is normally distributed, with mean and standard deviation given by μ_{ε} and σ_{ε} respectively. We denote the density functions of ε by $f^{\varepsilon}(\varepsilon)$. Realizations are assumed to be *iid* across individuals. We assume that period t productivity is realized before any period t decisions are made. Because of the idiosyncratic productivity shocks, aggregate labor input L_t is not simply the aggregate input of time, but is instead a weighted integral of time inputs:

$$L_t = \int_0^1 e_{it} h_{it} di$$

As before, output can be used as either consumption or investment and capital depreciates at rate δ. We again consider a government that taxes labor income at constant rate τ and uses the proceeds to fund a lump-sum transfer that is uniform across all individuals, subject to a period-by-period balanced budget constraint.

We consider the following market structure. At each date t there are factor markets for capital and labor services, and a market for output. There are no insurance markets, but individuals can self-insure by accumulating capital. We require that individual capital holdings be non-negative, which implies that there are effectively no markets for borrowing and lending, i.e., capital accumulation is the only channel through which individuals can move resources across periods. Once again we focus on steady state equilibrium. Let w and r denote the steady state equilibrium rental prices for labor services and capital services. An individual with idiosyncratic productivity e who chooses to work will then earn labor income equal to ew. An individual who enters the period with capital holdings k and has current realization of e for productivity faces the following one period budget constraint:

$$c + k' = (1 - \delta)k + rk + (1 - \tau)ewh + T$$

where k' is next period's capital.

The state vector for an individual is $s = (k, e)$. Denoting the individual value function by $V(k, e)$, the Bellman equation for an individual in steady state is given by:

$$\begin{aligned} V(k,e) &= \max_{c,h,k'} \{\log c - ah + \beta \int V(k', \exp(\rho e)\exp(\varepsilon)) f^{\varepsilon}(\varepsilon') d\varepsilon' \\ s.t. \;\; c + k' &= (1-\delta)k + rk + (1-\tau)ewh + T, \;\; c \geq 0, \;\; k' \geq 0, \;\; h \in \{0,1\} \end{aligned}$$

In what follows we will consider how changes in τ affect the steady state equilibrium, so it will be useful to include τ as a parameter of functions that describe the equilibrium. Specifically, let $c(s;\tau)$, $k'(s;\tau)$, and $h(s;\tau)$ denote the individual decision rules in steady state for a given value of τ, and let $\mu(s;\tau)$ be the measure that describes the distribution of individuals across state vectors as a function of τ. Steady state aggregates are then expressed as:

$$H(\tau) = \int h(s;\tau) d\mu, \;\; L(\tau) = \int eh(s;\tau) d\mu, \;\; K(\tau) = \int k d\mu$$

and steady state prices satisfy:

$$r(\tau) = F_1(K(\tau), L(\tau)), \; w(\tau) = F_2(K(\tau), L(\tau))$$

Steady-state welfare will be given by:

$$W(\tau) = \frac{1}{1-\beta} \int [\log(c(s;\tau)) - \alpha h(s;\tau)] d\mu$$

Relative to a baseline value of τ, the steady state change in welfare associated with a change of τ to some other value τ' is again defined as the proportional increase in consumption for all agents that would be required to equate the welfare measures, i.e., the value of Δ that solves:

$$\frac{1}{1-\beta}\int[\log(c(s;\tau))-\alpha h(s;\tau)]d\mu=\frac{1}{1-\beta}\int[\log((1+\Delta)c(s;\tau'))-\alpha h(s;\tau')]d\mu'$$

where μ' is the measure of individuals over state vectors for τ'. As before, a negative value of Δ indicates a welfare gain and a positive value of Δ indicates a welfare loss relative to the baseline.

4. Quantitative Effects of Tax and Transfer Programs

In this section we consider the quantitative effects of a change in the magnitude of the tax and transfer system in the context of the incomplete markets model.

4.1. Calibration

Relative to the benchmark model described in Section 2, the only additional parameters introduced in the incomplete markets model are the parameters that describe the stochastic processes for the idiosyncratic productivity shocks. Subject to choosing these parameters, we will then choose the remaining parameters so that we match the same aggregate targets as in Section 2, though of course we note that the mapping from parameters to steady state values is more complex in the incomplete markets model. There is a sizeable literature that estimates idiosyncratic shock processes, including Card (1994), Floden and Linde (2001), Heathcote et al (2004), French (2005), Chang and Kim (2006) and Low et al (2009). These papers typically estimate this process for prime aged males. The common feature of this literature is that the process is found to be very persistent, with most estimates .9 or higher. For our benchmark case in which we adopt an intermediate value of .94, which happens to coincide with the point estimate of Heathcote et al (2004). For the variance of the idiosyncratic shock we assume a value of .21. We also explore how the model behaves when $\rho = .50$.

The approximation method used to find the steady state equilibrium is standard. To solve the individual decision problem we use value function iteration. The value function is approximated by a piece-wise linear function. Golden section search is used on a discrete grid over the state space. Montecarlo simulation is used to approximate the distribution of the economy and we search over prices and transfers until the market clearing condition and budget balance conditions are satisfied.[5]

4.2. Results

Table 2 reports the results for the benchmark specification.

[5] In solving the model we assume a grid with 91 points for assets and 21 values for the idiosyncratic shocks.

Table 2

The Effect of Taxes (All Variables are Relative to $\tau = .30$)

	$\tau = 0$	$\tau = .10$	$\tau = .20$	$\tau = .30$	$\tau = .40$	$\tau = .50$
H	1.15	1.12	1.08	1.00	.89	.73
L	1.08	1.06	1.04	1.00	.94	.85
K	1.13	1.09	1.05	1.00	.93	.83
Y	1.10	1.07	1.04	1.00	.94	.84
Y/H	.96	.96	.97	1.00	1.05	1.15
Y/K	.97	.98	.99	1.00	1.01	1.01
K/L	1.05	1.03	1.01	1.00	.98	.98
Δ	.044	.022	.007	0.00	.010	.041

We begin by looking at the effects on aggregate hours of work. Hours of work are again decreasing in the scale of the tax and transfer program. Moreover, the magnitude of this effect is very similar to that found in the benchmark analysis in Section 2. There we found that an increase of taxes from .3 to .5 led to a decline in hours worked of roughly 29%, while in the above table the effect is slightly smaller at 27%. So from the narrow perspective of assessing the extent to which differences in taxes account for the differences in hours of work between the US and the high-tax economies of continental Europe, this model provides basically the same answer as the stand-in household model. But if one looks beyond this specific calculation, the two models do offer some different predictions. Previously we found that a ten percent change in taxes starting from $\tau = .30$ lead to approximately a 15% change in hours for both tax increases and decreases.

Now the effect is not so close to symmetric and somewhat smaller; a ten percent decrease in taxes leads to an increase in hours of 8%, whereas a ten percent increase in taxes leads to a decrease in hours of 11%. Finally, the effect of taxes increases is less linear: the effect of increasing taxes from .4 to .5 is now much larger than the effect of an increase from .3 to .4.

In the stand-in household model changes in hours worked were the same as changes in labor input. A key feature of this model is that these two are not necessarily the same. In fact, the table shows that there is a very striking difference in the extent of the change in the two quantities. Specifically, changes in hours worked are much larger than changes in labor input. For the case of a change in τ from .3 to .5, the decrease in hours worked is almost twice as large as the decrease in labor input. This discrepancy is due to the fact that as the tax and transfer system is expanded, the response in hours worked is concentrated among workers with low productivity. Intuitively, the tax and transfer program provides partial insurance against idiosyncratic productivity shocks–payments into the system are highest when productivity is highest, and the transfer payment is the same independent of individual productivity. As emphasized by Pijoan-Mas (2006), in the incomplete markets model individuals use both labor supply and asset accumulation to self insure, leading to excessive hours worked by low productivity workers relative to what would happen in a complete markets equilibrium. Basically, some workers are following strategies in which they use labor supply to help smooth consumption during periods of low productivity rather than accumulate sufficient capital. The transfer payment reduces the need to rely on both labor and capital as a way to smooth consumption during periods of low productivity. As a result, the increase in the tax and transfer system has a disproportionate effect on labor supply of workers with low productivity shocks.

Because of the very significant difference in the size of the decrease in H and L, the increase in the tax and transfer program has a very significant effect on output per hour. When τ increases from .3 to .5, output per hour increases by about 15%, while if τ were reduced to 0, output per hour would fall by 5%. This suggests that studies which do not control for selection into employment when comparing productivity of countries with very different tax and transfer systems and large differences in employment ratios may produce very biased estimates of relative TFPs. For example, when comparing the $\tau = .3$ and $\tau = .5$ economies, failure to control at all for selection into employment would lead one to conclude that TFP was roughly 15% higher in the $\tau = .5$ economy. We consider this in more detail in the next section.

In the stand-in household model the tax and transfer system had no impact on either K/L or Y/K. Because the tax and transfer program now offers an alternative to self insurance, one would expect that a tax and transfer system in the incomplete markets model would impact on precautionary savings and hence impact both K/L and Y/K. The table reveals that K/L is decreasing while Y/K is increasing in the size of the tax system. However, considering the changes associated with taxes between .30 and .50, the size of these effects is quite small.

Lastly, we consider the (steady state) welfare effects. In the representative agent model, increasing τ from .3 to .5 entails a welfare loss of 18%. In the incomplete markets model, this same increase in τ also entails a welfare loss, but now it is only equal to 4%. Moreover, steady state welfare is no longer highest when $\tau = 0$. Because the tax and transfer program analyzed here has the potential to partially substitute for missing insurance markets, it is plausible that such a system can improve welfare even if it is financed by a distorting tax. In fact, the table shows that the $\tau = .3$ steady state is substantially better than the $\tau = 0$ steady state, even though output and hours worked are much lower in the $\tau = .3$ steady state. Conditional upon starting at the tax rate that maximizes steady state welfare, the welfare losses associated with incremental increases in the tax rate are substantially smaller between the stand-in household model and the incomplete markets model. In the stand-in household model, tax increases of 10% and 20% relative to $\tau = .1$ lead to welfare losses of 3% and 8% respectively, whereas in the incomplete markets model these values are 1% and 4% respectively. In both cases the incremental loss is increasing as we move farther away from the optimal tax. To understand this discrepancy one needs to note that in the incomplete markets model, even at tax rates of .40 and .50 there are some individuals who find themselves in situations where they benefit from the larger transfer.

Our main objective in this analysis has been to assess how the choice of model influences our conclusions regarding the effects of tax and transfer programs of the magnitude found in several continental European countries on allocations and welfare relative to the US scenario. We believe that the above analysis points to two key findings. First, the effect on hours of work of increases in tax and transfer programs above US is broadly similar in the two different models. Second, the welfare implications are dramatically different. In the stand-in household model, the larger tax and transfer system imposes a very large welfare burden, equivalent to almost 20% of consumption. While the incomplete market/heterogeneous agent economy also implies a welfare loss associated with the larger tax and transfer system, the welfare loss is roughly one fifth as large. An important implication of this model is that tax and transfer programs can be welfare improving. The US scale tax and transfer system represents a significant improvement relative to the case of no tax and transfer system, whereas the European scale system is roughly equivalent in terms of welfare to the case of no tax and transfer system. In view of this finding, it is perhaps much less of a challenge to account for the different scales of the tax and transfer programs found in the US and continental Europe.

4.3. The Role of Persistence

The fact that an increase in taxes from 30% to 50% produces decreases in hours worked that are roughly similar in the two models may at first seem surprising to many. Chang and Kim (2006, 2007) emphasize the fact that in a model with heterogeneity and incomplete markets, the idiosyncratic shocks generate a distribution of "reservation wages" across the population, and that as this distribution becomes more spread out there are fewer workers who change employment status in response to a given change in the economic environment. In view of this, one might have expected that tax changes in the incomplete markets model would have substantially smaller effects. While this effect is present, there is another effect at work. In particular, in the incomplete markets model the employment of workers in low productivity states is greater than what it would be in an economy with complete insurance markets. These workers are particularly responsive to increases in the tax and transfer program because of the partial insurance that they offer. The extent of this over-employment of workers in the low productivity state is in turn dependent on the nature of the productivity shocks that affect workers. The more persistent is the productivity shock process, the greater is the extent to which workers will rely on labor supply to help smooth consumption in response to negative shocks. Put somewhat differently, in a world in which a worker faces only small shocks that are purely transitory, we know that capital accumulation is very effective at smoothing consumption. As the shocks become more persistent, capital accumulation becomes less effective because it takes a very large amount of capital to smooth consumption in the face of persistent shocks, and maintaining such a large stock of capital is costly. In this case, workers will rely more on labor supply to help smooth consumption, implying that they will more end up working in low productivity states with greater probability. If this is the case, then the employment decisions of these workers will be very responsive to increases in partial insurance.

To see these effects it is of interest to examine the responses to higher taxes when the shock process is less persistent. In particular, we proceed as before, calibrating all parameters according to the same procedure, but assuming now that the shock process has $\rho = .50$ instead of $\rho = .94$. Table 3 presents a subset of results of interest.

Table 3

The Effect of Taxes (All Variables are Relative to $\tau = .30$)

	$\tau = 0$	$\tau = .10$	$\tau = .20$	$\tau = .30$	$\tau = .40$	$\tau = .50$
H	1.13	1.10	1.06	1.00	.94	.85
L	1.08	1.06	1.04	1.00	.96	.89
Y/H	.98	.98	.99	1.00	1.02	1.04
Δ	$-.022$	$-.020$	$-.015$	0.00	.022	.063

Several differences from the previous case are worth noting. First, we see that the magnitude of the effect on hours worked is much smaller. For example, an increase in taxes from .30 to .50 now reduces hours worked by only 15%, whereas in the previous calculations the decrease was 27%. We also see that the productivity effects are smaller; for this same tax increase the increase in output per hour is now only 4%, versus 15% in the previous calculations. And finally, the welfare implications are both quantitatively and qualitatively different. In the current context, steady state welfare is now maximized by having taxes set equal to zero. And the welfare cost of moving from $\tau = .30$ to $\tau = .50$ is higher by a factor of 1.5 (.063 versus .041). Interestingly, this effect is still dramatically smaller than in the case of the stand-in household model.

All of these differences relative to the benchmark case can be understood by noting that the extent of employment by workers in the low productivity state is much lower in the economy with less persistence. This in turn has several consequences. First, because the insurance effect is much smaller, we see that the overall response in hours is indeed significantly less than it was in the case of the stand-in household model. This reflects the mechanism highlighted by Chang and Kim (2006, 2007) that the distribution of reservation wages is now more dispersed relative to the stand-in model, thereby leading to smaller labor supply responses. Second, because the insurance effect is smaller, the effect of selection is not as pronounced, implying that the gap between changes in hours and changes in labor input is not as large. In a world with complete insurance, workers would adopt a reservation productivity and only work when productivity is above that threshold. And in such an economy a tax and transfer system would raise the reservation productivity. But this channel is not as powerful a force in affecting average labor productivity because it involves workers at the reservation value, whereas the model with persistent shocks has some people with productivity far below this level working, and it is these people that respond to the partial insurance offered through the tax and transfer system.

One way to assess the extent to which there is "too much" employment at low productivity states is to compare the level of employment in the incomplete markets model with the level of employment that would result in a world with complete insurance markets. When $\rho = .94$ it turns out that the $\tau = 0$ equilibrium has employment that is 20% higher than the complete markets equilibrium. When $\rho = .50$ the $\tau = 0$ equilibrium has the same level of employment as the complete markets equilibrium.

This also helps us understand the very different welfare effects. The reason that we found a welfare role for a positive tax and transfer system in the previous model was precisely because the insurance aspects of this policy were valued highly. If the shocks are not as persistent, then the insurance role is not as valuable, and so for the same reason that the hours effects are smaller, the negative welfare effects become larger. However, even though the welfare effects of taxes become more negative, they are still much smaller than in the stand-in household model. As noted in the previous subsection, this is because there are still some individuals who find themselves in situations where the insurance is valuable.

The main messages that we want the reader to take away from this subsection is that the effects of tax increases on both allocations and welfare in the incomplete markets model is very dependent on the nature of the idiosyncratic shock process. There are two key channels that are relevant for the effects of taxes. One has to do with dispersion of individuals in terms of their distance from a reservation productivity level. The second has to do with the extent to which individuals are using labor to help smooth consumption in low productivity states. The more important is the second channel, the larger are the effects of taxes on hours of work. But this also implies a greater role for taxes and transfers to increase welfare. Existing empirical work suggests that idiosyncratic wage shocks are very persistent, so that our benchmark case seems the empirically interesting case to focus on. But it is important to note that the results are sensitive to the shock process.

5. Additional Implications

While our main objective was to examine how the incomplete markets model would influence predictions regarding the effect of labor tax increases on hours worked and welfare, in this section we would like to pursue some of the additional implications a bit further. The first of these is the implications for average labor productivity. The second concerns the implications for tax revenue. And the third concerns the implications for calculating wedges. We consider each in turn.

5.1. Taxes and Productivity

It is somewhat of a stylized fact that although hours of work are much less in continental Europe than in the US, labor productivity in these countries is very nearly equal (and in some cases even higher) than in the US. Somewhat less publicized is the fact that in several countries, including Australia and Canada, hours of work are very similar to US levels, whereas the level of labor productivity is roughly 15% lower. One could argue that these productivity comparisons seem puzzling. Theories have not yet been developed that can successfully account for the differences in productivity levels observed across countries. But there is some consensus that various types of factors might serve as barriers to technology adoption, or efficient operation of technologies. Examples include various forms of regulation, the role of government, the presence of unions etc... For the most part, these factors are more prevalent in the economies of Europe than they are in the US. Countries such as Australia and Canada would seem to be intermediate cases. Viewed from this perspective it is perhaps puzzling that productivity in many European countries is so close to US levels and higher than in countries such as Canada and Australia. Our benchmark model offers a perspective on these cross country comparisons that challenges the conventional wisdom regarding the productivity catch up of continental Europe.

To explore this in more detail we examine the relationship between output per hour and total hours worked per person of working age in a recent cross section. For each series we compute the average over the five year period 2003-2007 so as to eliminate the effect of year to year fluctuations, as well as avoid the effects of the 2001 recession and the recent downturn.[6] We focus on high productivity countries, and adopt a threshold of .60 of the US level as our cutoff. This leaves us with 14 countries.[7] For each country we express its values for each statistic relative to the US. Table 3 presents the data for relative hours of work and relative output per hour. In each case the countries are separated into two bins, those with values less than .85 and those with values greater than .85.[8]

[6]GDP per worker is from the GGDC. Output per hour is then computed using data on annuals hours worked per worker in employment, also from the GGDC. Total hours worked are from the GGDC and the size of the population aged 15-64 is from the OECD.

[7]We have exlcluded Germany from the analysis for the reason that German productivity decreased quite significantly following reunification. Prior to reunification Germany also had productivity levels similar to the US. Relative to the pattern that we identify, Germany pre-unification matches up very well, whereas post unification Germany becomes an outlier.

[8]Given our assumption of indivisible labor it may seem more appropriate to focus on employment rate differences rather than hours. It turns out that the relationship between employment and productivity is similar.

Table 3

Productivity and Hours Relative to the US

Hours Relative to US		Y/H Relative to US	
$\leq .85$	$> .85$	$\leq .85$	$> .85$
$Ita(.65)$	$Swe(.86)$	$NZ(.61)$	$Den(.90)$
$Fra(.67)$	$UK(.87)$	$Jap(.71)$	$Net(.90)$
$Bel(.69)$	$Aus(.92)$	$Swi(.79)$	$Aut(.91)$
$Net(.72)$	$NZ(.94)$	$Aus(.82)$	$Ita(.91)$
$Aut(.78)$	$Can(.94)$	$Can(.82)$	$Bel(1.00)$
$Den(.84)$	$Swi(.96)$	$Swe(.83)$	$Fra(1.01)$
	$Jap(.99)$	$UK(.85)$	

Looking at the table it is striking that the relative positions for the two values are basically flipped. To see this more clearly Figure 1 provides a scatter plot of the two series.

The figure reveals a striking negative correlation, and the correlation coefficient is $-.83$. The one apparent outlier at the bottom of the plot is New Zealand. A simple OLS regression of relative output per hour on relative hours and a constant gives a coefficient of $-.84$ on relative hours with a standard error of .16 and an R^2 of .68. The regression equation "predicts" that average productivity in these countries would would only be about 80% of the US level if hours worked were the same as in the US.

It is of course possible that the above statistical relationship does not reflect any underlying economic connection. But our analysis does offer one explanation

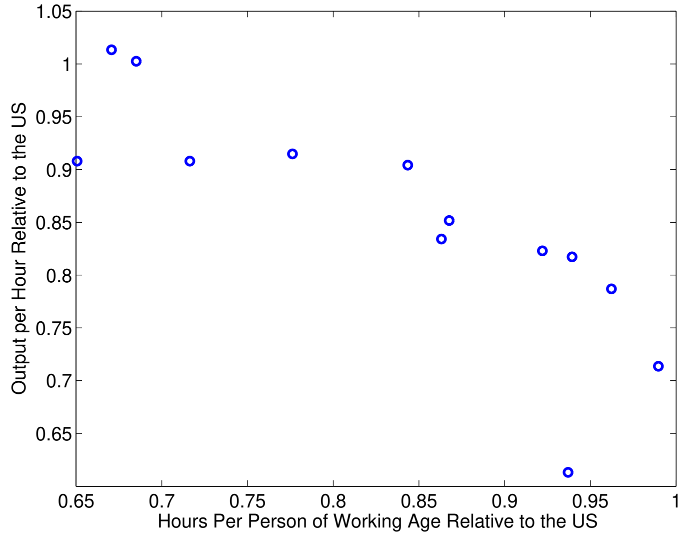

Figure 1: Figure 1: Hours and Productivity Relative to the US

for why this relationship does reflect a common underlying economic mechanism. Countries such as Canada and Australia have hours worked similar to the US and between 25 and 30 percent higher than countries like Belgium, France and Italy. At the same time, output per hour in Australia and Canada is roughly 15% lower than in these other countries. If differences in hours of work are due to differences in the scale of tax and transfer systems, then our model suggests that countries such as Belgium, France and Italy should have productivity levels about 15% higher than those in Australia and Canada, which is what is found in the data. In other words, our model supports a view that says that most of these countries have "true" productivity levels that are lower than the US, but that the differences between the US and several European countries is masked by the selection effects associated with more generous transfer systems.[9]

[9] In this exercise we assume that countries are identical except for the tax and transfer scheme.

5.2. Tax Rates and Tax Revenues

A key issue for policy makers is the relationship between tax rates and tax revenues. As is well known, if labor supply decreases in response to increases in tax rates this reduces the ability of government to raise additional revenue by raising taxes. The Laffer curve is a simple graphical representation of this. The peak of the Laffer curve corresponds to a tax rate at which the decrease in hours worked perfectly offsets the increase in tax rates.[10] In the stand-in household model, the tax base is proportional to total hours worked, since changes in tax rates do not affect the real wage, and the tax base is simply total hours times the real wage. In this model, looking at the response of hours to a change in taxes can help us gauge how close we are to the peak of the Laffer curve. In the incomplete markets model these calculations are more complex for two reasons. First, changes in tax rates now affect the capital to labor ratio and hence the wage rate. Second, because there is a difference between hours and labor input, changes in hours do not necessarily constitute a good proxy for the change in the labor tax base. Put somewhat differently, if low productivity workers are the first to stop working in response to increases in the size of the tax and transfer system, then the tax base decreases much less quickly than do hours, so tax revenues may not fall as fast as one would predict based on a stand-in household model.

To explore the quantitative significance of these factors we compare the impli-

---

It is possible that the idiosyncratic shock process also differs across countries. Domeij and Floden (2003) focused on differences in this process between Sweden and the US. An important issue to keep in mind is that if the selection effects are large then great care must be exercised in estimating differences in shock processes across countries.

[10] See Trabandt and Uhlig (2006) for a recent analysis of the Laffer curve in the context of cross country comparisons from the pespective of a stand-in household model.

cations for tax revenues of changing taxes from 30% to 50% in the two models. As we noted earlier, the implications for hours worked were quite similar in the two cases. Comparing these two cases provides a good sense of the extent to which the change in hours is misleading regarding the change in tax revenues from a given increase in taxes. In the stand-household model the increase in tax revenues is roughly 17%, whereas in the incomplete markets model the increase in tax revenues is almost 41%. The general equilibrium effect associated with the change in wages is not the reason for this difference, as the increase in taxes actually decreases wages by roughly 1% in the incomplete market model. Thus, this effect is both small and goes in the opposite direction. It follows that these selection effects are very important in predicting changes in tax revenues.

5.3. Wedge Calculations

Following the work of Parkin (1988), several economists have calculated wedges in the context of a standard growth model as way to provide a useful diagnostic about the model's inability to account for the data on different dimensions.[11] Prescott (2004) and Ohanian et al (2008) have recently used this method applied to the "static" first order condition from the growth model as a way to examine differences in hours worked. These authors assumed a stand-in household model to derive the equation that they then took to the data. Given the analysis above,

[11] This same methodology has been profitably employed in the business cycle literature by Parkin (1988), Bencivenga (1992), Ingram, Kocherlakota, Savin (1994), Hall (1997), Gali, Gertler and Lopez-Salido (2002), and Chari, Kehoe and McGrattan (2002). Mulligan (2002) uses this method to analyze changes in hours of work in the US over the 20th century, while Cole and Ohanian (2004) use it to shed light on changes in hours worked during the U.S. Great Depression.

it is of interest to assess the extent to which this method might lead to biased estimates of the wedge associated with taxes. Assuming a period utility function of the form $\alpha \log c + [(1-\alpha)/(1-\gamma)](1-h)^{1-\gamma}$, and a Cobb Douglas production function with capital share θ, the key equation that these studies consider is given by:

$$\frac{(1-\alpha)}{\alpha}\frac{(1-h_{it})^{-\gamma}}{c_{it}} = (1-\Delta_{it})(1-\theta)\frac{y_{it}}{h_{it}}$$

where Δ_{it} is the period t wedge for country i. Assuming that all countries share the same parameters, and normalizing the wedge in one country at one date $\hat{t}$ to equal zero, we can compute relative the relative wedge in country i at any date using only data on h, c, and y since the other parameters will cancel. In a stand-in household model with taxes as the only difference between countries, the wedges will recover the tax rate differences that generated the data. Given the selection effects in the incomplete markets model it is not clear to what extent this method will recover tax rates in that setting.[12] To do this we consider countries with tax rates ranging from .20 to .50, which basically reflects the range of tax rates in the data since 1960, and apply this method to the steady state data. We solve for the wedge in each country relative to the $\tau = .20$ country. Given that we assumed indivisible labor we carry out the calculation assuming $\gamma = 0$. Table 4 presents the results.

Table 4

[12] In a similar model but in the context of business cycle shocks, Chang and Kim (2007) show that the wedge will exhibit a pronounced cyclical pattern even though the model contains no distortions to the labor-consumption tradeoff.

Implied Wedges Relative to $\tau = .20$

$\tau = .20$	$\tau = .30$	$\tau = .40$	$\tau = .50$
0.00	.07	.17	.31

The table shows that bias is in the direction of understating the actual size of the relative distortion. For underlying distortions that are less than 20% the magnitude is probably not of first order importance, but for larger distortions it does become significant. Moreover, when comparing countries with $\tau = .40$ and $\tau = .50$ we see that the bias is in the other direction, with the wedge changing by more than .10 going from one to the other.

6. Conclusion

We have examined the effects of tax and transfer programs in a model characterized by idiosyncratic shocks and incomplete markets, with a particular focus on assessing the extent to which the effects on allocations and welfare differ from those present in the stand-in household model. We find that the effect of say a twenty point increase in the tax rate on hours of work is very similar in the two settings. However, the welfare effects are dramatically different. In the incomplete markets model a positive tax and transfer scheme is optimal, whereas in the stand-in household model the optimal size of the tax and transfer scheme is zero. Moreover, the welfare loss associated with having taxes set too high is much smaller in the incomplete markets model. It is also noteworthy that the incomplete markets model predicts large effects of taxes on average labor productivity, because of the important selection effects present in the model. These effects may imply that countries in continental Europe still face a substantial productivity gap with the US in terms of TFP. We conclude from this exercise idiosyncratic shocks and incomplete markets are important features to be considered in the context of assessing tax and transfer programs.

References

[1] Aiyagari, R., (1994), "Uninsured Idiosyncratic Risk and Aggregate Saving," *Quarterly Journal of Economics* 109, 659-684.

[2] Bencivenga, Valerie R., (1992),"An Econometric Study of Hours and Output Variation with Preference Shocks," *International Economic Review*, 33(2), 449-71.

[3] Blanchard, O. (2005), "The Economic Future of Europe," *Journal of Economic Perspectives.*

[4] Card, D., (1994), "Intertemporal Labor Supply: An Assessment," in Advances in Econometrics, edited by Christopher Sims, Cambridge University Press, 49-80.

[5] Chang, Y., and Kim S., (2006), "From Individual to Aggregate Labor Supply: A Quantitative Analysis Based on a Heterogeneous Agent Macroeconomy," *International Economic Review* 47, 1-27.

[6] ____________________, (2007), "Heterogeneity and Aggregation in the Labor Market: Implications for Aggregate Preference Shifts," *American Economic Review* 97, 1939-1956.

[7] Chari, V.V., Kehoe Patrick J. and McGrattan Ellen R., (2004), "Business Cycle Accounting", *NBER Working Paper* 10351.

[8] Cole, Harold and Ohanian, Lee E. (2002), "The Great U.S. and U.K. Depressions through the Lens of Neoclassical Theory, *American Economic Review 92,* 28-32.

[9] Floden, M., and J. Linde, (2001), "Idiosyncratic Risk in the United States and Sweden: Is There a Role for Government Insurance?," Review of Economic Dynamics 4, 406-437.

[10] Gali, Jordi, Gertler, Mark and Lopez-Salido, J. David, (2002), "Mark-ups, Gaps, and the Welfare Cost of Business Fluctuations", *NBER Working Paper* 8850.

[11] French, E., (2005), "The Effect of Health, Wealth and Wages on Labour Supply and Retirement Behavior," *Review of Economic Studies* 72, 395-427.

[12] Hall, Robert E, (1997), "Macroeconomic Fluctuations and the Allocation of Time,",*Journal of Labor Economics* 15*,* 223-250.

[13] Heathcote, J., Storesletten, K., and Violante, G., (2004), "The Macroeconomic Implications of Rising Wage Inequality in the US," mimeo, NYU.

[14] Huggett, M., (1993), "The Risk-Free Rate in Heterogeneous-Agent Incomplete-Insurance Economies," *Journal of Economic Dynamics and Control* 17, 953-969.

[15] Ingram, Beth, Kocherlakota, Narayana and Savin, N.E., (1994), "Explaining Business Cycle: A Multiple Shock Approach," *Journal of Monetary Economics* 34, 415-428.

[16] Krusell, P., T. Mukoyama, R. Rogerson, and A. Sahin, (2008), "Aggregate Implications of Indivisible Labor, Incomplete Markets, and Labor Market Frictions," *Journal of Monetary Economics* 55, 961-979.

[17] Krusell, P., A. Smith Jr., (1998), "Income and Wealth Heterogeneity in the Macroeconomy," *Journal of Political Economy* 106, 867-896.

[18] Low, H., Meghir, C., and Pistaferri, l., (2009), "Employment Risk and Wage Risk over the Life Cycle," forthcoming in the *American Economic Review*.

[19] Ljungqvist, L., and Sargent, T., (2006), "Do Taxes Explain European Employment? Indivisible Labor, Human Capital, Lotteries and Savings", in *NBER Macroeconomics Annual*.

[20] _________________________, (2008), "Taxes, Benefits, and Careers: Complete Versus Incomplete Markets," *Journal of Monetary Economics* 55, 98-125.

[21] McDaniel, Cara, (2006), "Effective Tax Rates for 15 OECD Countries: 1950-2003", mimeo, Arizona State University.

[22] ______________ , (2008), "Hours of Work in the OECD 1960-2003: Driving Forces and Propagation Mechanisms," manuscript, Arizona State University.

[23] Mendoza, E., Razin A., and Tesar L., (1994), "Effective Tax Rates in Macroeconomics: Cross-Country Estimates of Tax Rates on Factor Incomes and Consumption," *Journal of Monetary Economics* 34, 297-323.

[24] Mulligan, Casey B., (2002), "A Century of Labor-Leisure Distortions", *NBER Working Paper 8774.*

[25] Ohanian, L., Raffo, A., and Rogerson, R., (2008), "Long-Term Changes in Labor Supply and Taxes: Evidence from OECD Countries, 1956-2004," *Journal of Monetary Economics* 55, 1353-1362.

[26] Parkin, Michael, (1988), "A Method for Determining Whether Parameters in Aggregative Models are Structural", *Carnegie-Rochester Conference Series on Public Policy* 29, 215-52.

[27] Pijoan-Mas, J., (2006), "Precautionary Savings or Working Longer Hours," Review of Economic Dynamics 9, 326-352.

[28] Prescott, Edward C., (2004), "Why Do Americans Work So Much More than Europeans?," *Federal Reserve Bank of Minneapolis Quarterly Review* 28, No. 1, 2-13.

[29] Ragan, K. (2006), "Fiscal Policy and the Family: Explaining Labor Supply in a Model with Household Production." mimeo, Stockholm School of Economics.

[30] Rogerson, Richard, (2006), "Understanding Differences in Hours Worked," *Review of Economic Dynamics* 9, 365-409.

[31] ________________ (2008), "Structural Transformation and the Deterioration of European Labor Market Outcomes," *Journal of Political Economy* 116, 235-259.

[32] Trabandt, M., and Uhlig, H., (2006), "How Far Are We from the Slippery Slope: The Laffer Curve Revisited," mimeo, University of Chicago.