Do Taxes Explain European Employment?

Indivisible Labor, Human Capital, Lotteries, and Savings*

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Abstract

Adding generous government supplied benefits to Prescott's (2002) model with employment lotteries and private consumption insurance causes employment to implode and prevents the model from matching outcomes observed in Europe. To understand the role of a 'not-so-well-known aggregation theory' that Prescott uses to rationalize the high labor supply elasticity that underlies his finding that higher taxes on labor have depressed Europe relative to the U.S., this paper compares aggregate outcomes for economies with two arrangements for coping with indivisible labor: (1) employment lotteries plus complete consumption insurance, and (2) individual consumption smoothing via borrowing and lending at a risk-free interest rate. The two arrangements support equivalent outcomes when human capital is not present; when it is present, allocations differ because households' reliance on personal savings in the incomplete markets model constrains the 'career choices' that are implicit in their human capital acquisition plans relative to those that can be supported by lotteries and consumption insurance in the complete markets model. Nevertheless, the responses of *aggregate* outcomes to *changes* in tax rates are quantitatively similar across the two market structures. Thus, under both aggregation theories, the high disutility that Prescott assigns to labor is an impediment to explaining European nonemployment and benefits levels. Moreover, while the identities of the nonemployed under Prescott's tax hypothesis differ between the two aggregation theories, they all seem counterfactual.

KEY WORDS: Employment lotteries, indivisible labor, human capital, labor taxation, social and private insurance, aggregation theories, labor supply elasticity.

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"The differences in the consumption and labor tax rates in France and the United States account for virtually all of the 30-percent difference in the labor input per working-age person. ... if France modified its intratemporal tax wedge so that its value was the same as the U.S. value, French welfare in consumption equivalents would increase by 19 percent." Prescott (2002, p. 13, p. 1)

"*The Achilles' Heel? Europe's generous unemployment benefits ...*

German workers typically receive 70% of their take-home pay in the first month of unemployment, and 62% in the 60th month, according to the Paris-based Organization for Economic Cooperation and Development. And the percentages are roughly similar for most of the Continent.

In the U.S., by contrast, benefits plunge over time. Comparable U.S. workers receive 58% of their take-home pay in the first month, but just 7% in the 60th month, the OECD says." Wall Street Journal (1998, p. R.17)

1 Introduction

Prescott (2002) used a growth model with a stand-in household and the assumption that the government transfers all tax revenues to the household to argue that cross-country differences in taxes on labor account for cross-country differences in hours per capita. This paper examines the sensitivity of Prescott's analysis to his assumptions about private risk sharing arrangements, labor markets, human capital acquisition, the government's disposition of tax revenues, the absence of government supplied benefits to people who withdraw from work, and the high disutility of labor.[1]

Section 2 adds an important aspect of the European landscape that Prescott ignored: government supplied non-employment benefits in the form of a replacement ratio times foregone labor income. Martin (1996) documents that European governments offer benefits with high replacement rates and long durations. In our modification of his model, a benefit rate works just like Prescott's labor-tax wedge (see the multiplication of wedges that appears in our equation (4)). With the high disutility of labor set by Prescott, benefit wedges of magnitudes estimated by Martin (1996) lead to depressions much deeper than Europe has experienced. This good news for Europe is bad news for the fit of Prescott's model. Prescott says that the high labor supply elasticity responsible for these outcomes comes from his use of a "not-so-well-known" aggregation theory due to Hansen (1985) and Rogerson (1988) that assumes indivisible labor, employment lotteries, and perfect private consumption insurance. How do Prescott's conclusions, and the bad fits that result after we extend his analysis to include those generous European inactivity benefits, depend on that aggregation theory?

[1] We confess to being biased readers of Prescott's work because in Ljungqvist and Sargent (2005), we assert that it is better to account for cross-country differences in employment rates by emphasizing cross-country differences in benefits rather than taxes.

Mulligan (2001) suggested that Hansen's and Rogerson's aggregation theory is not necessary for Prescott's results because by borrowing and lending a risk-free asset that bears a sufficiently high interest rate, a worker can smooth consumption across alternating periods of work and nonwork.[2] Section 3 formulates a version of Mulligan's argument in a single-agent setting. We show that whether Mulligan's time averaging leads to outcomes equivalent to Hansen's and Rogerson's depends on whether human capital is absent (here the answer is yes) or present (now the answer is no). Introducing a stylized human capital acquisition technology like those of Shaw (1989) and Imai and Keane (2004) creates a nonconvexity over careers and allows a stand-in household to achieve allocations with employment lotteries that individuals cannot attain by time averaging.[3] Furthermore, the employment lotteries and time-averaging models have different implications about the identities of the nonemployed and how their consumption compares to those who are working.[4] The models thus point in different directions for microeconomic verification. Nevertheless in the small open economy equilibrium setting of section 4, we show that the two market structures ('aggregation theories' in Prescott's language) give rise to virtually identical responses of aggregate nonemployment to increases in tax rates on labor income. In both market structures, the high disutility of labor calibrated by Prescott, which we adopt and hold fixed across the two market structures, delivers a high elasticity of aggregate nonemployment to after tax real wages (when the government transfers all tax revenues to the households). This finding is also confirmed in the general equilibrium extension of Ljungqvist and Sargent (2006a), as summarized in section 5.

Why do generous government supplied benefits for nonemployment cause aggregate activity to implode in the model of section 2 and the employment lotteries model of Ljungqvist and Sargent (2006b)?[5] After all, even when those government benefits are absent, these models already include perfect 'nonemployment' or 'inactivity' insurance in the employment lotteries model, and that causes no such problems. But this insurance is *private* and the stand-in household internalizes its costs. In contrast, government supplied inactivity ben-

[2]Jones (1988, p. 13) anticipated Mulligan's idea when he wrote: "A natural question to raise here is that if the time horizons we are considering are sufficiently divisible, why cannot timing perform the same function as lotteries?" Jones showed that timing could replace lotteries for an example without discounting.

[3]As emphasized by Imai and Keane (2004), when we add human capital, the marginal condition describing leisure-consumption tradeoffs acquires an additional term that measures the effect of current work experience on the continuation value via the accumulation of human capital. From the vantage of models with human capital, the marginal condition in the model of section 2 is misspecified, creating an apparent 'wedge'. Manuelli and Seshadri (2005) adapt the Ben-Porath model to generate cross-country differences in wealth. Their model features a different technology for accumulating human capital than the one in this paper.

[4]Alesina et al. (2005) documented that the European deficit in hours worked per capita relative to the U.S. can be decomposed into fewer hours in a normal work week, fewer weeks worked in a year, and fewer people employed. Our analysis focuses on the last component. The large number of nonemployed who are supported with government funds especially concerns European policy makers. Our analysis of indivisible labor says nothing about the other two components that reflect the intensive rather than the extensive margin in labor supply.

[5]For an early analysis of large employment effects of government supplied benefits in a time-averaging model, see Hansen and Imrohoroglu (1992).

efits induce distortions because households do not internalize their costs. As we shall see, in the models of this paper, the high disutility of labor and the resulting high labor supply elasticity that give labor taxes such potency in Prescott's model also enhance the distortion in nonemployment that come from government supplied benefits. They form a package.

Section 6 discusses what to make of the common aggregate outcomes that characterize the employment lottery and time-averaging models presented in sections 3, 4 and 5. We describe how the aggregate outcomes conceal important differences in the lives of the individual workers whose actions underly the aggregates and how those differences would lead us in different directions when it comes to calibrating key parameters and seeking microeconomic verification.

Section 7 reiterates why we answer 'no' to the question asked in our title, then describes additional model features whose inclusion we think will explain the cross-country employment data.

2 Breakdown of Prescott's model with government supplied benefits

2.1 The model and equilibrium relationships

To explain international differences in hours worked, Prescott (2002) uses the standard growth model with a labor supply elasticity set high enough to make employment vary substantially over the business cycle. In this section, we describe how Prescott alludes to an employment lotteries model to justify a representative household whose choices exhibit a high labor supply elasticity; how that high labor supply elasticity also makes Prescott's representative household's leisure choice very sensitive to government supplied benefits for those not working; and how Prescott's assumption about what the government does with its tax revenues disarms an income effect that would substantially affect outcomes. We point out that adding government benefits while retaining Prescott's calibrated labor supply elasticity causes the fit of the model to deteriorate substantially, creating the 'puzzle' of why Europeans work so *much*.

Prescott's stand-in household has preferences ordered by

$$\sum_{t=0}^{\infty} \beta^t N_t \Big[\log(c_t) + \alpha \log(1-h_t)\Big]. \tag{1}$$

There is a Cobb-Douglas production function with capital share parameter θ and flat rate taxes $\tau_{kt}, \tau_{ht}, \tau_{ct}$ on earnings from capital and labor, and on consumption, respectively.

2.1.1 The stand-in household's budget set with benefits

Prescott's supply side analysis succeeds in explaining cross-country differences in hours while ignoring cross-country differences in government supplied benefits to people not working.

To probe Prescott's statement that he had expected "... the nature of the unemployment benefits system to be more important" (Prescott 2002, p. 9), we add publicly supplied inactivity benefits to Prescott's model. Following Prescott, let p_t be the time 0 price of a unit of consumption at time t, w_t the pre-tax wage, T_t the government lump-sum transfer, δ the depreciation rate, and r_t the pre-tax rental rate on capital, and let k_t, h_t, c_t, respectively, be capital, hours, and consumption per person. Assume that population $N_{t+1} = \eta N_t$, $\eta > 0$, and that there is a constant geometric gross rate of Harrod neutral technical progress of γ. We augment Prescott's version of the stand-in household's intertemporal budget constraint to include a contribution from government supplied inactivity benefits:

$$\sum_{t=0}^{\infty} p_t N_t \Big[(1+\tau_{ct})c_t + \eta k_{t+1} - [1 + (r_t - \delta)(1-\tau_{kt})]k_t \\ -(1-\tau_{ht})w_t h_t - \rho(1-\tau_{ht})w_t \max\{0, \bar{h} - h_t\} - T_t \Big] \leq 0\,, \tag{2}$$

where $\rho(1-\tau_{ht})w_t \max\{0, \bar{h} - h_t\}$ represents government benefits, which we intend to stand for a broad set of programs for rewarding people who are said to be disabled, prematurely retired, and unemployed. The stand-in household receives government supplied subsidies for time spent not working in the form of a replacement rate $\rho \in [0, 1)$ times after tax earnings that it forgoes when it sets $h < \bar{h}$. If the household's hours fall short of $\bar{h}$, the government replaces a fraction ρ of the deficiency of after-tax labor income relative to $w(1-\tau_h)\bar{h}$. We suppose that parameter values are such that the household chooses to supply labor h_t in an amount strictly less than $\bar{h}$.

By using Abel's summation formula, the terms in capital in (2) can be expressed as

$$\begin{aligned}\sum_{t=0}^{\infty} p_t N_t \Big[\eta k_{t+1} - (1 + (r_t - \delta)(1-\tau_{kt}))\, k_t \Big] &= -p_0 N_0 [1 + (r_0 - \delta)(1-\tau_{k0})]k_0 \\ &+ \sum_{t=1}^{\infty} \Big(\eta p_{t-1} N_{t-1} - p_t N_t [1 + (r_t - \delta)(1-\tau_{kt})] \Big) k_t.\end{aligned}$$

A no arbitrage argument[6] implies that the coefficients on k_t should be zero for $t \geq 0$, so that

$$\frac{p_{t-1}}{p_t} = [1 + (r_t - \delta)(1-\tau_{kt})] \tag{3}$$

for $t \geq 1$, with the value of the stand-in household's initial capital being $p_0[1 + (r - \delta)(1 - \tau_{k0})]N_0 k_0$. The marginal conditions for consumption imply $\frac{p_{t-1}}{p_t} = \frac{c_t}{\beta c_{t-1}}$. In a steady state, $c_t = \gamma c_{t-1}$, so that $\frac{p_{t-1}}{p_t} = \frac{\gamma}{\beta}$. Substituting this into (3) and imposing $\tau_{kt} = \tau_k$ gives Prescott's equation (10):

$$r = \delta + \frac{i}{1-\tau_k},$$

where $1 + i = \frac{\gamma}{\beta}$ would be the gross interest rate on a tax-free one period bond in this economy.

[6] For example, see Ljungqvist and Sargent (2004b, ch. 11).

2.1.2 An altered $h - c/y$ relationship

Prescott's conclusion that cross-country differences in tax wedges account for cross-country differences in hours depends sensitively on how he treats the consumption-output ratio c/y. We follow Prescott (2002) and use the household's first-order conditions with respect to consumption and leisure, and also the constant labor share implied by the Cobb-Douglas production function, to derive an equilibrium relationship between h and c/y:

$$h_t = \left[1 + \frac{\alpha c_t/y_t}{1-\theta}\frac{1+\tau_{ct}}{1-\tau_{ht}}\frac{1}{1-\rho}\right]^{-1}. \tag{4}$$

When $\rho = 0$, this is the same as expression (12) in Prescott (2002, p. 7). Prescott called this an 'equilibrium relationship' because the consumption-output ratio c/y is endogenous. In the spirit of Prescott (2004), we define the *intratemporal tax-benefit wedge* as

$$\frac{1+\tau_{ct}}{1-\tau_{ht}}\frac{1}{1-\rho} \equiv \frac{1}{1-\tau_t}\frac{1}{1-\rho}, \tag{5}$$

which is a product of a benefit rate and Prescott's intratemporal tax wedge $\frac{1}{1-\tau_t} \equiv \frac{1+\tau_{ct}}{1-\tau_{ht}}$, where $\tau_t \equiv \frac{\tau_{ht}+\tau_{ct}}{1+\tau_{ct}}$.

2.2 Why do French people work so much?

We use the same parameter values that underlie Prescott's computations (2002, table 4) to construct our figure 1.[7] We take the United States as the benchmark economy against which to measure the employment effects of taxes and benefits. Setting the effective marginal tax rate equal to 40 per cent for the U.S., Prescott argues that the French effective marginal tax rate is 20 percentage points higher than the American tax rate. Prescott confines himself to the back of figure 1, where the replacement rate is $\rho = 0$. There, a tax rate differential of 20 percentage sends the employment index down to 0.73. So we have reproduced Prescott's finding that this tax differential can indeed explain why France is depressed by 30 percent relative to the United States when we suppose along with Prescott that $\rho = 0$.

When we move forward from the back of figure 1, we see dramatic effects of publicly provided benefits.[8] At Prescott's calibration of .2 for the French tax wedge differential relative to the U.S., as we raise the social insurance replacement rate ρ above 0, employment plummets. The model sets the employment index equal to 0.55, 0.41, and 0.25 when the replacement rate is equal to 0.30, 0.50, and 0.70, respectively. Of course, the French economy was not depressed by 45, 59 or 75 per cent relative to the United States. With Prescott's calibration of the other parameters, setting the replacement rate ρ to one of the values reported by Martin (1996) makes the puzzle become: why do French people work so much?

[7] Prescott's (2002) calibration can be extracted from the numbers reported in his Table 4 together with equilibrium relationship (4). In particular, we can deduce that $\alpha(c_t/y_t)/(1-\theta) \approx 1.65$.

[8] In the spirit of Prescott's (2002) analysis, lump sum transfers to households are adjusted to ensure government budget balance.

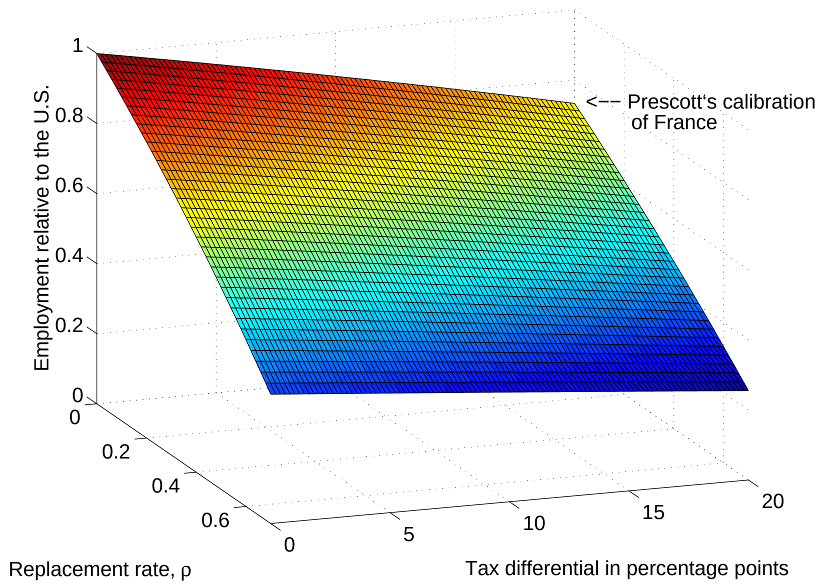


Figure 1: Employment effects of taxation and social insurance in Prescott's (2002) framework. Prescott's calibration of the United States serves as the benchmark economy where the effective marginal tax rate on labor income is 40 per cent and there is no social insurance ($\rho = 0$).

2.3 Government expenditures, income effects of taxes, and c/y

Prescott's calibration of c/y is a big part of his supply side story. His treatment of government expenditures influences how he estimates c/y in the $\rho = 0$ version of his workhorse formula (4). Let g denote 'government expenditures' that are not substitutes for private consumption and assume that g is a constant fraction ζ of tax revenues:

$$g = \zeta[\tau_c c + \tau_h wh + \tau_k(r - \delta)k].$$

We assume that the government returns lump sum rebates of $(1 - \zeta)$ times its tax revenues to the stand-in household. The above formula for g, feasibility, and the formula for the equilibrium capital stock can be combined to yield the following formula for the equilibrium value of c/y:

$$c/y = \frac{(1-\theta)(1-\zeta\tau_h) + \theta(1-\zeta\tau_k)\left(\dfrac{i}{i+(1-\tau_k)\delta}\right)}{1+\zeta\tau_c}. \tag{6}$$

Under Prescott's preferred value of $\zeta = 0$, this formula simplifies to

$$c/y = (1-\theta) + \theta\left(\frac{i}{i+(1-\tau_k)\delta}\right), \tag{7}$$

which makes c/y independent of the intratemporal tax wedge (there remains an effect from capital taxation). But with $\zeta > 0$, formula (6) activates income effects from the intratemporal wedge to c/y, income effects that Prescott's $\zeta = 0$ assumption disables.

Prescott (2002, p. 7) acknowledges that his assumption about c/y substantially affects outcomes:

> "The assumption that the tax revenues are given back to households either as transfers or as goods and services matters. If these revenues are used for some public good or are squandered, private consumption will fall, and the tax wedge will have little consequence for labor supply. If, as I assume, it is used to finance substitutes for private consumption, such as highways, public schools, health care, parks, and police protection, then the c_t/w_t factor will not change when the intratemporal tax factor changes. In this case, changes in this tax factor will have large consequences for labor supply."

Prescott assumes not only that all public expenditures are substitutes for private consumption but also that the government allocates resources as efficiently as when households choose for themselves.

Although the calculations in figure 1 accept Prescott's (2002) assumption that "all [tax] receipts are distributed lump-sum back to the stand-in household," it is worth noting that Prescott (2004) proceeded differently when he studied the time series evidence for the tax explanation of the European employment experience:

> "All tax revenue except for that used to finance the pure public consumption is given back to the households either as transfer payments or in-kind. These transfers are lump sum, being independent of a household's income. Most public expenditure are substitutes for private consumption in the G-7 countries. Here I will assume that they substitute on a one-to-one basis for private consumption with the exception of military expenditures. The goods and services in question consist mostly of publicly provided education, health care, protection services, and even judiciary services. My estimate of pure public consumption g is two times military's share of employment times GDP." Prescott (2004, p. 4)

The cross-country differences in c/y that result from that assumption contribute to the success that Prescott (2004) ascribes to the tax explanation of the European employment experience.

Thus, as described by Ljungqvist (2005), Prescott's (2004, Table 2) time series analysis of the European employment experience rests on variations in *both* the tax wedge *and* the ratio c/y. For example, even in the 1970s, France and Germany had tax wedges 9 and 12 percentage points higher than the United States, respectively. Prescott fits French and German employment levels that are comparable to those in the United States in the 1970s only by plugging in c/y's for the 1970s that were 8 percentage points lower in the two European countries than in the United States. Thus, a significant qualification applies to

Prescott's conclusion that "an important observation is that when European and U.S. tax rates were comparable, European and U.S. labor supplies were comparable." We could instead say of the 1970s that while French and German tax rates already exceeded the U.S. rate by about half of the tax differential of 20 percentage points that were later to prevail during the 1990s, Prescott's estimates of low c/y ratios for France and Germany in the 1970s allow the model to fit the outcomes then. If it had not been for those low c/y ratios, the model would have predicted significantly depressed employment levels during the 1970s instead of the observed outcomes in which both countries' employment rates exceeded that in the United States.

2.4 Prescott's appeal to an aggregation theory

To justify the high labor supply elasticity that he attributes to the stand-in household, Prescott (2002, p. 4) refers to "some not-so-well-known aggregation theory behind the stand-in household utility function (1) (see Gary D. Hansen, 1985; Richard Rogerson, 1988; Andreas Hornstein and Prescott, 1993)." Hansen (1985) and Rogerson (1988) assume indivisibilities in households' choice sets for labor, like the models to be described in sections 3 and 4. Employment lotteries and complete consumption insurance markets imply a stand-in household that wants to maximize

$$\sum_{t=0}^{\infty} \beta^t N_t \Big[\log(c_t) + \phi_t \alpha \log(1 - \hat{h})\Big], \tag{8}$$

where ϕ_t is a choice variable that represents the fraction of people working and the parameter $\hat{h}$ equals the indivisible number of hours supplied by each worker. This functional form obviously differs from (1). However, we understand Prescott's point really to be that the aggregation theory underlying (8) rationalizes his decision to use a value of α in (1) that gives a high labor supply elasticity.

Prescott (2006) assigns the same high importance to the aggregation theory underlying the stand-in household that he attaches to the aggregation theory behind the aggregate production function. He emphasizes that both types of aggregation divorce essential properties of the aggregated function from the properties of the individual functions being aggregated:[9]

> "Rogerson's aggregation result is every bit as important as the one giving rise to the aggregate production function. In the case of production technology, the nature of the aggregate production function in the empirically interesting cases is very different from that of the individual production units being aggregated. The same is true for the aggregate or a stand-in household's utility function in the empirically interesting case."

[9]For an alternate view that emphasizes the differences between using lotteries as an aggregation theory for firms versus households, see Ljungqvist and Sargent (2004a).

2.4.1 Insensitivity of results to making disutility linear in labor

We studied how Prescott's (2002) results would be affected were we to adopt the Hansen-Rogerson objective function (8). That preference specification implies the following equilibrium relationship for the fraction of employed households:

$$\phi_t = -\frac{1-\theta}{\alpha \log(1-\hat{h})\, c_t/y_t} \, \frac{(1-\tau_{ht})(1-\rho)}{1+\tau_{ct}}. \tag{9}$$

Because Prescott (2002) did not provide a complete account of his parameter settings, we also use the reported findings of Prescott (2004) when calibrating the Hansen-Rogerson framework.[10] Our computations indicate that the outcomes associated with preference specifications (1) and (8) are similar. As one would expect, because the Hansen-Rogerson framework has a more elastic labor supply, increases in the tax wedge lead to larger negative employment effects. But the differences across the two preference specifications are not too big in our general equilibrium analysis. For example, a calculation from (9) that corresponds to Prescott's calibration of France yields an employment effect that is 6.5 percentage points more depressed with the Hansen-Rogerson utility function (8) than with Prescott's utility function (1).[11]

2.4.2 Are employment lotteries necessary?

A high labor supply elasticity is an important part of the reasoning that leads to Prescott's interpretation of how cross-country differences in the intratemporal tax wedge can account for observed differences in employment rates. In the next two sections, we study employment lotteries in more depth with the aim of understanding whether the Hansen-Rogerson aggregation theory is necessary to justify Prescott's approach or whether it would work just as well to use an alternative aggregation theory proposed by Mulligan (2001) that allows each individual to choose alternating spells of work and leisure. Our answer is that Mulligan's aggregation theory will do just as well, though as we shall see, the presence of a human capital acquisition technology that features learning by working affects many interesting details.[12] In particular, we shall see that while the responses of aggregate nonemployment to labor

[10]Prescott (2002) uses a capital-share parameter $\theta = 0.3$ but he reports on neither the parameter α nor the ratio c/y. On the basis of Prescott (2004, Table 2), we proceed here with the value $c/y = 0.75$. We set $\hat{h} = 0.4$ as implied by a work week length of 40 hours and Prescott's (2004) assertion that "on a per person basis a household has about 100 hours of productive time per week." Given these parameter values, we can match the U.S. outcome in Prescott's (2002) Table 4 by choosing the utility of leisure parameter $\alpha = 1.64$. (For comparison, our calibration of $\alpha = 1.64$ for the utility function (8) is almost the same as the Prescott (2004) calibration of $\alpha = 1.54$ in a study using utility function (1).)

[11]Prescott (2002, p. 8) multiplies an average tax rate by 1.6 to obtain a marginal tax rate. That procedure fails to follow the recommendation of Mulligan (2001), who noted that because the social planner is considering variations in the extensive rather than the intensive margin, the average rather than the marginal tax rate is relevant in the Hansen-Rogerson framework.

[12]Shaw (1989) and Imai and Keane (2004) are good examples of studies that econometrically estimate technologies by which work now builds human capital later.

taxes are similar, the two aggregation theories promote different views about the types of workers we should expect not to be working and when.

To economize on notation in the next two sections, we set benefits $\rho = 0$, with the understanding that were we to include a nonemployment benefit like the one in this section, i.e., as an entitlement to compensation for time not worked up to some threshold $\bar{h}$, ρ would continue to augment the tax wedge as in (5). Therefore, in our quest to understand how that high labor supply elasticity depends on the market structure, i.e., the aggregation theory, that underpins it, it suffices to focus on the $\rho = 0$ case. However, in section 6 we return to the issue of social insurance when discussing what to make out of the forces behind Prescott's high aggregate labor supply elasticity.

3 Aggregation theories: time averaging and lotteries

In this section we show that without human capital, lotteries and time-averaging-with-savings give similar outcomes at the aggregate level, and in an ex-ante sense at the individual level too. In contrast, when work leads to human capital accumulation, lotteries give an allocation that differs from, and in terms of ex ante utility is superior to, the one attained with time averaging. But in section 4, we show that, despite these differences in outcomes when there is human capital, the responses of nonemployment to labor tax *changes* are quantitatively similar under both employment lotteries and time-averaging with incomplete markets. Thus, we conclude that the Hansen-Rogerson aggregation theory that Prescott (2002) emphasizes is not really necessary for his quantitative results. The high value at which he calibrates the disutility of labor makes nonemployment just as sensitive to after tax real wages under time-averaging as it is with lotteries.

We study two arrangements that allow an individual to attain a smooth consumption path when he faces a zero-one labor supply indivisibility at each moment. One arrangement was proposed by Hansen (1985) and Rogerson (1988), namely, an employment lottery supplemented with perfect consumption insurance. Another arrangement was discussed by Jones (1988) and Mulligan (2001) and allows an individual who alternates between spells of work and leisure to achieve intertemporal consumption smoothing by engaging in risk-free borrowing and lending subject to a 'natural' borrowing constraint.[13] Subsections 3.1 and 3.2 describe a basic labor market participation decision and a static lottery model, respectively; while subsections 3.4 and 3.3 set forth dynamics models without and with lotteries, respectively, all in a physical environment purposefully set up so that all intertemporal tie-ins come from the presence of the employment indivisibility. In particular, in all of these subsections, there is no opportunity to acquire human capital. Although there is an indeterminacy in designing lotteries in the dynamic economy, comparable outcomes can emerge regardless of the presence of lotteries in the dynamic environment.

Subsections 3.5 and 3.6 study the dynamic models without and with lotteries, respec-

[13]The natural borrowing constraint is weak enough to make the loan market perfect. See Aiyagari (1994) and Ljungqvist and Sargent (2004b) for discussions of the natural borrowing constraint.

tively, in an environment that allows human capital acquisition. Now the outcomes from the two market structures differ. Relative to the lotteries arrangement, the isolated-individual intertemporal smoothing model gives worse allocations: depending on parameter values, an individual consumes either too much or too little. The human capital acquisition technology confronts the 'invisible hand' or planner with a 'mother of all indivisibilities' and, if lotteries are available, causes the planner to preside over a dual labor market in which some people specialize in work and others in leisure. While this outcome mimics outcomes in Europe in the sense that a significant fraction of workers seem to have withdrawn from labor market activity for long spells, it differs from what is going on in Europe because in the model such 'careers' that specialize in leisure are not carried on *at government expense*, as many of them seem to be in Europe. Throughout this section, we set labor taxes to zero. Section 4 adds taxes to the analysis.

3.1 A static participation decision model

As a warmup, consider a setting in which a person chooses $c \geq 0$ and $n \in \{0, 1\}$ to maximize

$$u(c) - v(n) \tag{10}$$

subject to $c \leq wn$ where u is strictly concave, increasing, and twice continuously differentiable and v is increasing, and, by a normalization, satisfies $v(0) = 0$. The following equation determines a reservation wage $\bar{w}$:

$$u(0) - v(0) = u(\bar{w}) - v(1).$$

A person chooses to work if and only if $w \geq \bar{w}$.

In this and all the other models with indivisible labor that we present below, $v(0)$ and $v(1)$ are the only relevant aspects of v. However, the curvature of u will be important.

3.2 A static lotteries model

Each of a continuum of ex ante identical workers indexed by $j \in [0, 1]$ has preferences ordered by (10). A planner (or stand-in household) chooses an employment, consumption plan that respects $n^j \in \{0, 1\}$ and that maximizes

$$\int_0^1 [u(c^j) - v(n^j)]dj = \int_0^1 u(c^j)dj - v(1) \int_0^1 n^j dj \tag{11}$$

subject to

$$\int_0^1 c^j dj \leq w \int_0^1 n^j dj.$$

The planner assigns consumption $\bar{c}$ to each individual j and administers a lottery that exposes each individual j to an identical probability $\phi = \int_0^1 n_j dj$ of working. Letting $B = v(1)$, the planner chooses $(\bar{c}, \phi)$ to maximize

$$u(\bar{c}) - B\phi$$

subject to $\bar{c} = w\phi$, a problem whose solution satisfies the first-order condition

$$u'(\phi w) = B/w \tag{12}$$

that evidently determines the fraction ϕ of people working as a function of the wage w, the utility of consumption $u(\cdot)$, and the disutility of work. Ex post, the utility of those who work is $u(\bar{c}) - v(1)$ and of those who do not is $u(\bar{c}) - v(0)$. Thus, the winners of the employment lottery are assigned to leisure.

From now on, we let $u(c) = \ln c$ to simplify some formulas.

3.3 An individual time averaging model

Mulligan (2001) pointed out that the passage of time and the opportunity to borrow and lend can generate outcomes similar to those supported by the social arrangements of an employment lottery plus complete consumption insurance. Mulligan's idea is that with enough time, averaging over time can imitate the lottery's averaging across events.[14] We guarantee that there is enough time by making time continuous.

A worker chooses $c_t, n_t, t \in [0,1]$, $c_t \geq 0, n_t \in \{0,1\}$ to maximize

$$\int_0^1 e^{-\delta t}[\ln c_t - B n_t]dt \tag{13}$$

subject to

$$\int_0^1 e^{-rt}(w n_t - c_t)dt \geq 0 \tag{14}$$

where $\delta \geq 0$ and $r \geq 0$. We focus on the case $r = \delta$. The solution of this problem equates consumption to the level (12) that emerges in the static lotteries problem, namely,

$$c_t = \bar{c} = w/B, \tag{15}$$

and makes the present value of the individual's labor supply over $[0,1]$ satisfy:

$$w\int_0^1 e^{-rt} n_t dt = \bar{c}\int_0^1 e^{-rt}dt. \tag{16}$$

The right side is the present value of consumption. The left side, the present value of wages, restricts the 'discounted time' spent working, $\int_0^1 e^{-rt} n_t dt$, but leaves its allocation over time indeterminate. Since $\delta = r$, the individual with preference specification (13) is also indifferent between these alternative labor allocations. For example, the individual is indifferent between working steadily for the first $\triangle$ moments and working steadily for the last $\tilde{\triangle}$ moments, provided that $\triangle$ and $\tilde{\triangle}$ satisfy

$$\left[e^{-\triangle\delta} - 1\right]/\delta = [e^{-\delta} - e^{(1-\tilde{\triangle})\delta}]/\delta.$$

[14]The individual time-averaging models in the following subsections can be viewed as adaptations of a model of occupational choice by Nosal and Rupert (2005).

Of course, many other employment patterns also work, including ones that "chatter" by having the worker rapidly move back and forth between employment and leisure.[15]

3.4 An intertemporal lotteries model

Now consider a continuum $j \in [0,1]$ of ex ante identical workers like those in subsection 3.3. A planner chooses a consumption and employment allocation $c_t^j \geq 0$, $n_t^j \in \{0,1\}$ to maximize

$$\int_0^1 \int_0^1 e^{-\delta t}[\ln c_t^j - Bn_t^j]dt\,dj \tag{17}$$

subject to

$$\int_0^1 e^{-rt}\left[w\int_0^1 n_t^j dj - \int_0^1 c_t^j dj\right] dt \geq 0. \tag{18}$$

Thus, the planner can borrow and lend at an instantaneous rate r. We again assume that $r = \delta$. The planner solves this problem by setting $c_t^j = \bar{c}_t$ for all $j \in [0,1]$ and $\phi_t = \int_0^1 n_t^j dj$, exposing each household at time t to a lottery that sends him to work with probability ϕ_t. The planner chooses $\bar{c}_t$ and ϕ_t to maximize

$$\int_0^1 e^{-rt}[\ln \bar{c}_t - B\phi_t]dt \tag{19}$$

subject to

$$\int_0^1 e^{-rt}[w\phi_t - \bar{c}_t]dt \geq 0. \tag{20}$$

This is obviously equivalent to problem (13)-(14). It follows that there are many intertemporal lottery patterns that support the optimal consumption allocation $c_t^j = w/B$. Only the present value of time spent working is determined. Among the alternative types of lotteries that work are these:

1. *One lottery before time* 0*:* Before time 0, the planner can randomize over a constant fraction of people $\bar{\phi}$ who are assigned to work for every $t \in [0,1]$, and a fraction $1-\bar{\phi}$ who are asked to specialize in leisure, where $\bar{\phi}$ is chosen to satisfy the planner's intertemporal budget constraint (20).

2. *A lottery at each t:* At each time $t \in [0,1]$, the planner can run a lottery that sends a time invariant fraction $\bar{\phi}$ to work and a fraction $1-\bar{\phi}$ to leisure at instant t.

3. *Another lottery at each t:* At each time $t \in [0,1]$, the planner can run a lottery that sends a fraction ϕ_t to work and $1-\phi_t$ to leisure at instant t, where ϕ_t is free to be any function that satisfies the planner's intertemporal budget constraint (20). Only the present value of ϕ_t is determined.

[15] Nosal and Rupert (2005) study cases in which $r \neq \delta$, so that consumption and working schedules are tilted toward either the beginning or the end of the interval $[0,1]$.

The indeterminacy among such lotteries evaporates in the next section when by adding human capital we confront people with career choices.

3.5 Time averaging with human capital

We return to an isolated consumer who copes with the instantaneous labor supply indivisibility by borrowing and lending. We alter the consumer's choice set in the model of subsection 3.3 by adding a very simple technology that describes how work experience promotes the accumulation of human capital. Where $\check{h} \in (0,1)$, the household's budget constraint is now

$$\int_0^1 e^{-rt}[w\psi(h_t)n_t - c_t]dt \geq 0 \tag{21}$$

where

$$\begin{aligned} h_t &= \int_0^t n_s ds && (22) \\ \psi(h) &= \begin{cases} 1 & \text{if } h_t < \check{h}, \\ H > 1 & \text{if } h_t \geq \check{h}. \end{cases} && (23) \end{aligned}$$

Two solutions interest us:

- A corner solution in which $(\check{h}, B, H)$ are such that the person chooses to set $\int_0^1 n_t dt < \check{h}$. In this case, the model becomes equivalent with the model of subsection 3.3. The individual chooses to set
$$\bar{c} = wB^{-1} \tag{24}$$
and to work a present value of time at a low skilled wage that is sufficient to support this constant level of consumption.

- An interior solution for which $(\check{h}, B, H)$ are such that the household chooses to set $\check{h} < \int_0^1 n_t dt < 1$; i.e., the household chooses to become high skilled but also to enjoy some leisure. In such an interior solution, consumption $c_t = \bar{c}$ will satisfy[16]
$$\bar{c} = wHB^{-1}. \tag{25}$$

[16] The individual's first-order conditions for labor choice can be expressed as $-B + w\psi(h_t) + \theta_t > 0$ or < 0 or $= 1$ if $n_t = 1$ or $n_t = 0$ or he is indifferent between working and taking leisure, respectively, and where the Lagrange multiplier θ_t obeys the generalized differential equation $\frac{d}{dt}\theta = -w\psi'(h_t)n_t + \theta_t\delta$, where $\psi'(h_t)$ is the generalized derivative of ψ. (The generalized derivative of g is the delta function $-w(H-1)\delta_D(h-\check{h})$, where δ_D is the Dirac delta generalized function.) At our interior solution in which the worker chooses eventually to become skilled, $\theta_0 > 0$ and θ_t rises over time at a constant geometric rate δ until $\check{h}$, then jumps once and for all to zero. The multiplier θ_t is a (current value) component of the worker's indirect utility contributed by accumulating human capital at date t.

Time spent working when unskilled and skilled satisfy

$$\bar{c}\int_0^1 e^{-rt}dt = w\left[\int_0^1 e^{-rt}n_t^L dt + H\int_0^1 e^{-rt}n_t^H dt\right] \tag{26}$$

where

$$n_t^L = \begin{cases} 1 & \text{if } n_t = 1 \text{ and } h_t < \check{h}, \\ 0 & \text{otherwise} \end{cases} \tag{27}$$

and

$$n_t^H = \begin{cases} 1 & \text{if } n_t = 1 \text{ and } h_t \geq \check{h}, \\ 0 & \text{otherwise.} \end{cases} \tag{28}$$

The first term on the right side of (26) is the marginal product of a low productivity person times the present value of the time that a worker works when unskilled. The second term is the marginal product of a high productivity person times the present value of working time when skilled.

Backloading: When $r = \delta > 0$ and $(\check{h}, B, H)$ call for a solution that is interior in the sense that $1 > \int_0^1 n_t dt > \check{h}$, the problem of maximizing (13) subject to (21) and (22) has the following solution. There exists an s that solves

$$\bar{c}\int_0^1 e^{-rt}dt = w\left[\int_s^{s+\check{h}} e^{-rt}dt + H\int_{s+\check{h}}^1 e^{-rt}dt\right]$$

and such that the household sets $n_t = 0$ for $t < s$ and $n_t = 1$ for $t \geq s$. Thus, the household 'back loads' all of its work and takes leisure early. To understand why this is the solution, consider the disutility of work associated with this solution:

$$\bar{B} = B\int_s^1 e^{-rt}dt. \tag{29}$$

Starting from this allocation, consider a perturbation in which the household supplies some labor earlier and takes some leisure later, but keeps the disutility of labor fixed at $\bar{B}$. Because of discounting, such a shift allows the household to work less total time over the interval $[0, 1]$ (i.e., $\int_0^1 n_t dt$ would be smaller), but involves working a smaller *proportion* of its time as a high skill worker. That would lower the present value of income associated with a given disutility of labor and so is suboptimal.

3.6 Lotteries with human capital

Now suppose that a planner designs a consumption sharing plan and an intertemporal employment lottery to maximize (17) subject to

$$\int_0^1 e^{-rt}\int_0^1 [w\psi(h_t^j)n_t^j - c_t^j]dj\; dt \geq 0 \tag{30}$$

where each household j has the skill accumulation technology described in subsection 3.5.

A perturbation argument leads to the conclusion that the planner administers a life-time employment lottery once and for all before time 0 and assigns a fraction ϕ of people to work always ($n_t^j = 1$ for all $t \in [0,1]$ for these unlucky people) and a fraction $1-\phi$ always to enjoy leisure ($n_t^j = 0$ for all $t \in [0,1]$ for these lucky ones).[17] The planner's problem then becomes to choose $\bar{c}$ and $\phi \in [0,1]$ to maximize

$$(\ln \bar{c} - B\phi) \int_0^1 e^{-\delta t} dt$$

subject to

$$\phi w \left[\int_0^{\check{h}} e^{-rt} dt + H \int_{\check{h}}^1 e^{-rt} dt \right] \geq \bar{c} \int_0^1 e^{-rt} dt. \tag{31}$$

An interior solution sets ϕ to satisfy

$$\bar{c}[1 - e^{-r}]/r = \phi w \left[\int_0^{\check{h}} e^{-rt} dt + H \int_{\check{h}}^1 e^{-rt} dt \right]. \tag{32}$$

Consumption $\bar{c}$ satisfies

$$\bar{c} = w \left(B \int_0^1 e^{-rt} \right)^{-1} \left[\int_0^{\check{h}} e^{-rt} dt + H \int_{\check{h}}^1 e^{-rt} dt \right]. \tag{33}$$

3.6.1 Comparison of outcomes

In the individual time averaging model of subsection 3.5, when $(\check{h}, B, H)$ are such that the worker chooses the corner solution $\int_0^1 n_t dt < \check{h}$ (i.e., he chooses not to acquire skills), consumption given by (24) is less than given in formula (33) for the lotteries economy. But when $(\bar{h}, B, H)$ are such that the worker chooses an interior solution $\int_0^1 n_t > \check{h}$ (i.e., he chooses to acquire skills), his consumption level under time-averaging (25) exceeds that attained in (33) under lotteries. It follows that in the model with human capital, lotteries significantly change allocations relative to the individual time averaging model. In the presence of human capital, the lottery model supports an allocation with a higher ex ante utility than can be attained by having the individual alternate between work and leisure and smooth consumption by borrowing and lending. It does so by convexifying a 'mother of all indivisibilities', the decision to acquire skills over individual lifetimes.

[17] Consider a deviation from this allocation that withdraws a positive measure of workers, lets them enjoy a small positive measure of leisure, then makes up the deficiency in output by assigning work to some of those who initially specialize in leisure. It can be verified that this perturbation increases the ex ante disutility of work component of (17).

4 Taxation under time averaging versus lotteries

We add labor taxation and lump sum government transfers to the model of section 3 and regard it as describing a small open economy. The government and the agents borrow and lend at the exogenous interest rate r. We continue to focus on the case $r = \delta$. Furthermore, for expositional simplicity, we set $r = \delta = 0$ so that the discounted times above now equal fractions of an individual's time endowment over the unit interval. Let Φ^{avg} and Φ^{lott} denote the fraction of time spent working under time averaging and lotteries, respectively: $\Phi^{avg} = \int_0^1 n_t \, dt$ and $\Phi^{lott} = \int_0^1 \phi_t \, dt$.

The government levies a flat rate tax τ on labor income and balances its budget over the unit interval of time by returning all tax revenues to the agents as equal per-capita lump sum transfers. Let T be the present value of all lump sum transfers to an agent.

4.1 Taxation without human capital

The results of sections 3.3 and 3.4 lead us to anticipate correctly that without human capital, taxation has identical effects on the aggregate labor supply under time averaging and lotteries, i.e., $\Phi^{avg} = \Phi^{lott} = \Phi$. Specifically, the budget constraints in (14) and (18) become

$$(1-\tau)w\Phi - \bar{c} + T \geq 0, \tag{34}$$

and, corresponding to our earlier first-order condition (15) at an interior solution, the optimal consumption level under taxation satisfies

$$\bar{c} = (1-\tau)w \, B^{-1}. \tag{35}$$

After substituting (34) into (35) and invoking $T = \tau \, w \, \Phi$, the equilibrium labor supply is

$$\Phi = \min\{(1-\tau)B^{-1}, \, 1\}, \tag{36}$$

where we have explicitly included the possibility of a corner solution with $\Phi = 1$.

Figure 2 depicts nonemployment, $1-\Phi$, as a function of the tax rate, τ, and the preference parameter for the disutility of working, B.[18]

[18] As noted above, we have excluded benefits from the present analysis with the understanding that were we to include a nonemployment benefit like the one in section 2, the replacement rate ρ would continue to augment the tax wedge and operate in similar ways as before. This can easily be seen in the model without human capital. Adding a benefit term alters the budget constraint (34) to

$$(1-\tau)w\Phi - \bar{c} + T + \rho(1-\tau)w(1-\Phi) \geq 0$$

and makes the equilibrium labor supply become

$$\Phi = \min\{(1-\tau)(1-\rho)B^{-1}, \, 1\} \tag{$\star$}$$

instead of (36). Equation ($\star$) becomes the counterpart to (9). From the life-cycle perspective that is highlighted in the model with indivisible labor and time averaging, everyone who is at an interior solution is also at the margin for taking up those benefits (unless the individual worker is up against a ceiling like $\bar{h}$ in section 2).

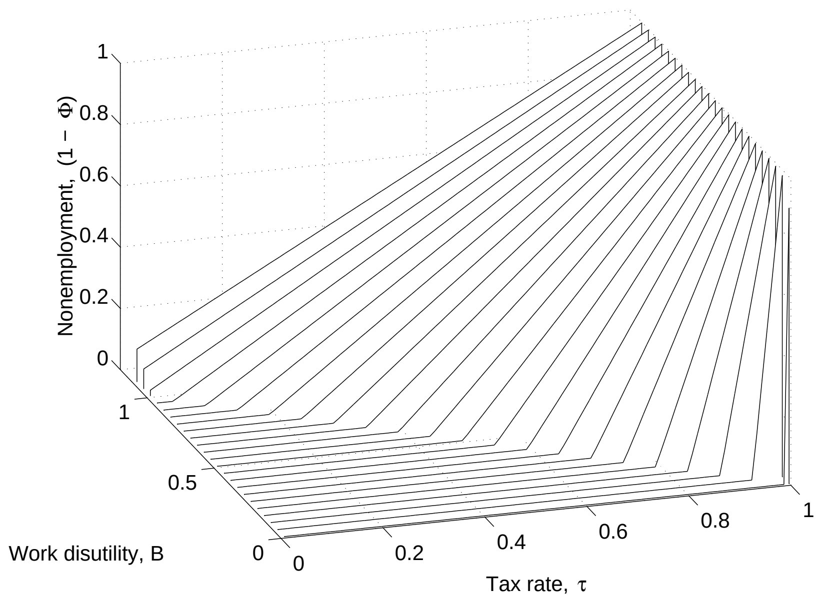


Figure 2: Nonemployment effects of taxation in the absence of human capital, for different values of the preference parameter for the disutility of working (B).

4.2 Taxation with human capital and lotteries

It is easy to modify our earlier analysis of the model with lotteries and human capital to include taxes. With taxation and $r = 0$, the expressions for the budget constraint (31) and the optimality condition (33) at an interior solution in section 3.6 are modified to become

$$(1-\tau)w\left[\check{h} + (1-\check{h})H\right]\Phi^{lott} - \bar{c} + T \geq 0, \tag{37}$$

and

$$\bar{c} = (1-\tau)w\left[\check{h} + (1-\check{h})H\right]\, B^{-1}. \tag{38}$$

After substituting (37) in (38), and invoking $T = \tau\, w\, [\check{h} + (1-\check{h})H]\, \Phi^{lott}$, the equilibrium labor supply is

$$\Phi^{lott} = \min\{(1-\tau)B^{-1},\, 1\}. \tag{39}$$

Figure 3 illustrates an equilibrium outcome when the tax rate is such that the stand-in household chooses an interior solution to its labor supply.

4.3 Taxation with human capital and time averaging

Substantially more interesting possibilities emerge with time averaging. Depending on the parameterization and the tax rate, there are three constellations of outcomes: (1) for low tax rates, everyone chooses to become skilled, $\Phi^{avg} \in [\check{h}, 1]$; (2) for somewhat higher tax rates, equilibria have the property that a fraction of people choose to become skilled and the

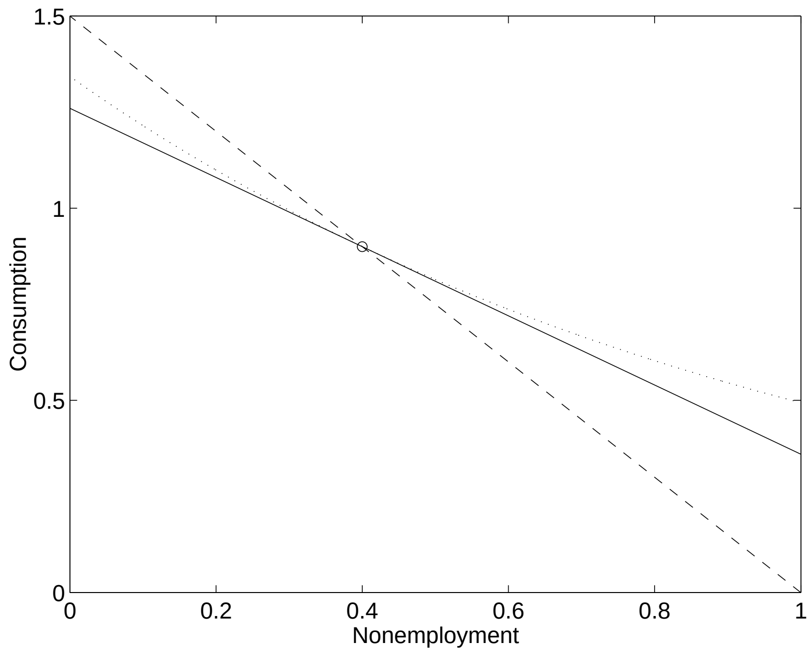


Figure 3: Equilibrium outcome in the lottery model with human capital for tax rate $\tau = 0.40$. The solid line is the stand-in household's budget constraint. The dashed curve is the economy's resource constraint when a fraction Φ of agents specialize in working. Under zero taxation, it is identical to the stand-in household's budget constraint, but not otherwise. The equilibrium allocation is marked by a circle. The dotted line depicts the indifference curve that is attained by agents. The expected value of their leisure is recorded on the x-axis. The parameter values are $B = 1$, $\check{h} = 0.5$ and $H = 2$, with normalization $w = 1$.

remainder choose to stay unskilled; and (3) for a highest range of tax rates, no one chooses to become skilled, $\Phi^{avg} \in (0, \check{h})$. These outcomes are depicted in figures 4 and 5. In the middle region, the invisible hand uses the fraction of people who choose to work long enough to become skilled as an equilibrating variable.

As we shall see, in the first and third regions, the derivative of aggregate nonemployment to labor taxes is the same as in the lotteries model. However, in the middle region, nonemployment is actually even more responsive to taxes than it is in the lotteries model because the fraction of people who choose to work long enough to acquire high skills decreases as taxes increase.

Taxation and lump-sum transfers alter the household's budget constraint (21) to

$$(1-\tau)w\left[\min\{\check{h},\, \Phi^{avg}\} + \max\{0, \Phi^{avg} - \check{h}\}H\right] - \bar{c} + T \geq 0. \tag{40}$$

4.3.1 Low tax rates: everyone chooses to become skilled

Corresponding to the first-order condition (25) at an interior solution, the optimal consumption level satisfies

$$\bar{c} = (1-\tau)w\, H\, B^{-1}, \tag{41}$$

and consumption $\bar{c}$ satisfies budget constraint (40),

$$\bar{c} = (1-\tau)w\left[\check{h} + (\Phi^{avg} - \check{h})H\right] + T = w\left[\check{h} + (\Phi^{avg} - \check{h})H\right], \tag{42}$$

where the second equality invokes goverment budget balance with tax revenues equal to lump-sum transfers. After substituting (41) in (42), the equilibrium labor supply is given by

$$\Phi^{avg} = \min\{(1-\tau)B^{-1} + \check{h}(1 - H^{-1}),\, 1\}. \tag{43}$$

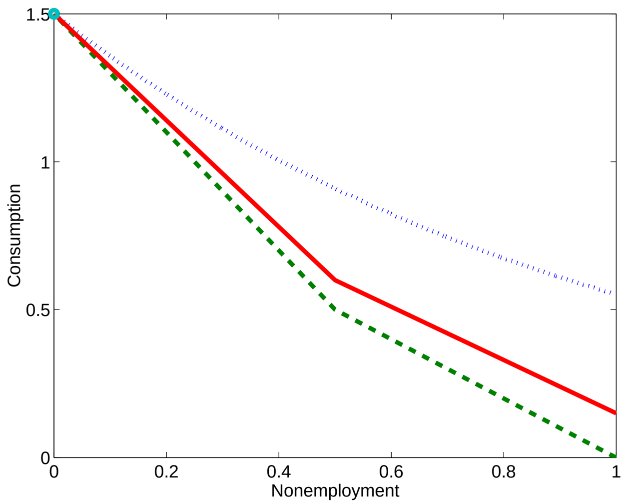
Note that the labor supply exceeds the lottery outcome and that the difference is increasing in the time it takes to accumulate skills, $\check{h}$, and the magnitude of the skill premium, H. But please note that when everyone chooses to become skilled, the derivatives of the labor supply with respect to the tax rate are equal in the time-averaging and lottery models (except when $\Phi^{avg} = 1$ and $\Phi^{lott} < 1$). This feature is reflected in the low tax region of figure 5.

4.3.2 Higher tax rates: some choose to become skilled, others do not

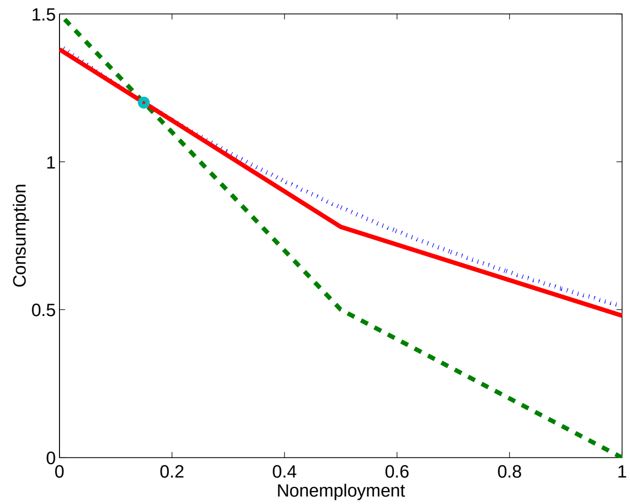
Panel (c) of figure 4 illustrates that the highest attainable indifference curve might have two tangency points with the kinked budget constraint. In fact, that must be the case for intermediate tax rates.

Consider an equilibrium with two interior life-time career choices: $(\bar{c}_-, \Phi_-^{avg})$ and $(\bar{c}_+, \Phi_+^{avg})$ where $0 < \Phi_-^{avg} < \check{h} < \Phi_+^{avg} < 1$. These allocations must be such that they yield the same life-time utilities,

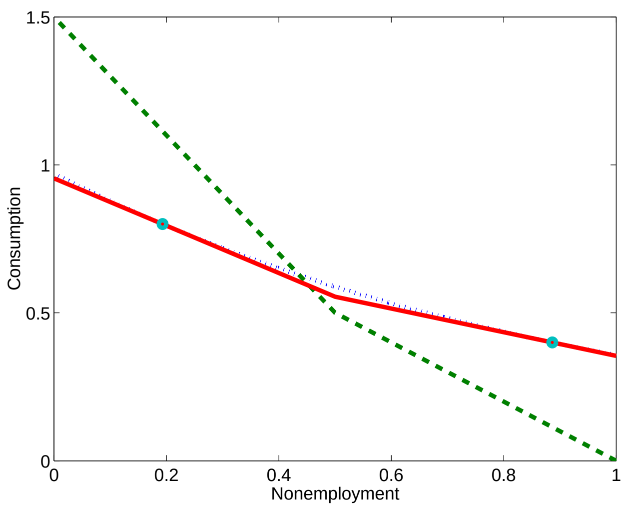
$$\ln \bar{c}_- - B\,\Phi_-^{avg} = \ln \bar{c}_+ - B\,\Phi_+^{avg}; \tag{44}$$



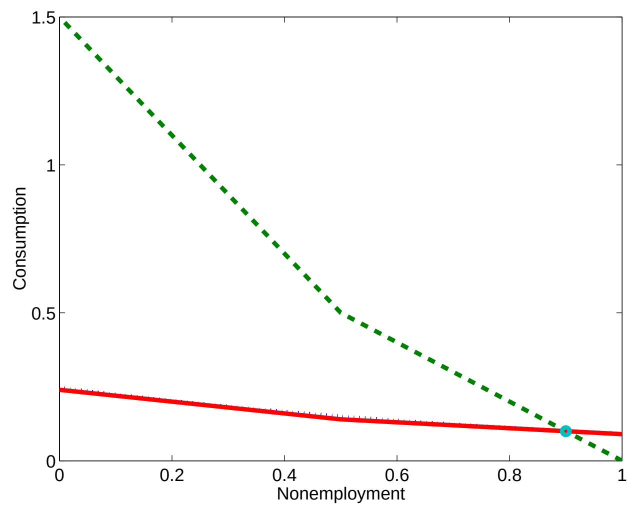
(a) $\tau = 0.10$



(b) $\tau = 0.40$



(c) $\tau = 0.60$



(d) $\tau = 0.90$

Figure 4: Equilibrium outcomes in the time averaging model with human capital for tax rates $\tau \in \{0.10, 0.40, 0.60, 0.90\}$. The solid line is the agent's budget constraint and the equilibrium allocation is marked by a circle. The dotted line depicts the indifference curve that is attained. The dashed curve is the economy's resource constraint when all agents supply the same amount of labor (which is identical to an agent's budget constraint under zero taxation). The parameter values are $B = 1$, $\check{h} = 0.5$, and $H = 2$, with normalization $w = 1$.

and satisfy the agent's first-order conditions,

$$\bar{c}_- = (1-\tau)w\,B^{-1}, \tag{45}$$
$$\bar{c}_+ = (1-\tau)H\,w\,B^{-1}. \tag{46}$$

When evaluated at those allocations, the agent's budget constraint must hold with equality,

$$\bar{c}_- = (1-\tau)w\Phi_-^{avg} + T, \tag{47}$$
$$\bar{c}_+ = (1-\tau)w\left[\Phi_+^{avg} + (H-1)(\Phi_+^{avg} - \check{h})\right] + T. \tag{48}$$

From (44) we get

$$\ln\left(\frac{\bar{c}_+}{\bar{c}_-}\right) = B(\Phi_+^{avg} - \Phi_-^{avg}); \tag{49}$$

(45) and (46) imply

$$\frac{\bar{c}_+}{\bar{c}_-} = H, \tag{50}$$
$$\bar{c}_+ - \bar{c}_- = (1-\tau)w\,B^{-1}(H-1); \tag{51}$$

while (47) and (48) yield an alternative expression for the consumption differential

$$\bar{c}_+ - \bar{c}_- = (1-\tau)w\left[\Phi_+^{avg} - \Phi_-^{avg} + (H-1)(\Phi_+^{avg} - \check{h})\right]. \tag{52}$$

From (51) and (52) we get

$$B(\Phi_+^{avg} - \Phi_-^{avg}) = (H-1)\left[1 - B(\Phi_+^{avg} - \check{h})\right]. \tag{53}$$

After substituting (50) and (53) into (49), we obtain an expression for the labor supply that does not depend on the tax rate,

$$\Phi_+^{avg} = B^{-1} + \check{h} - \frac{\ln H}{B(H-1)}, \tag{54}$$

and the value for Φ_-^{avg} can then be solved from (53),

$$\Phi_-^{avg} = \Phi_+^{avg} - B^{-1}\ln H. \tag{55}$$

4.3.3 The highest tax rates: no one chooses to become skilled

This equilibrium class looks just like the equilibrium without human capital that we studied in section 4.1.

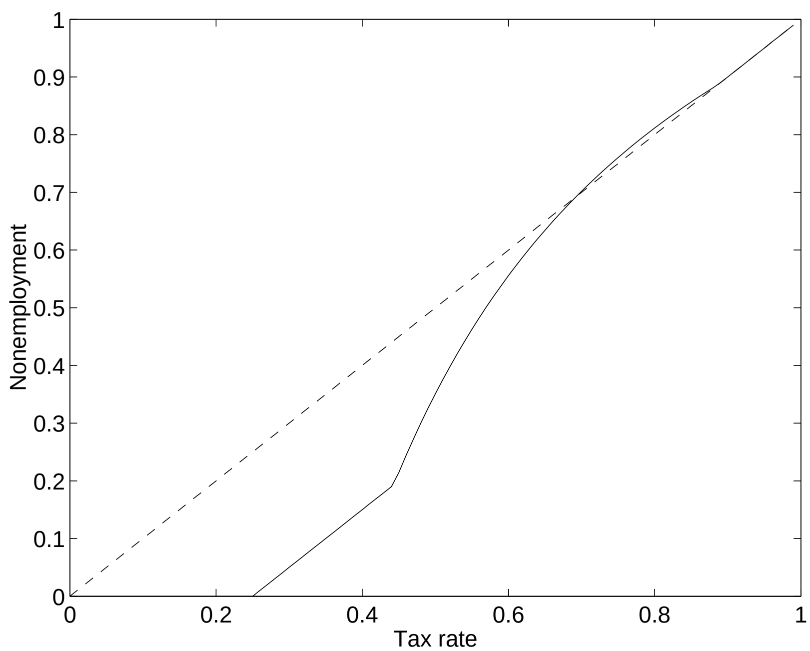


Figure 5: Nonemployment effects of taxation in models with human capital. The dashed and solid lines represent the lottery model and the time averaging model, respectively. In the time averaging model, everyone (no one) chooses to become skilled when the tax rate is lower (higher) than 0.45 (0.88); while some but not all choose to become skilled when the tax rate falls in the intermediate range $[0.45, 0.88]$. The parameter values are $B = 1$, $\check{h} = 0.5$, and $H = 2$, with normalization $w = 1$.

5 Synopsis of a general equilibrium analysis

Ljungqvist and Sargent (2006a) extend our comparison of employment lotteries and time-averaging to a closed-economy stochastic general equilibrium setting that includes physical capital, stochastic skill accumulation, and aging. Relative to our models in sections 3 and 4, those extensions enhance heterogeneity among agents and create more differences in the identities of the nonemployed workers across the lotteries and time-averaging models.[19]

The models have stochastic transitions among three age groups, young, old, and retired workers. There is a stochastic skill accumulation technology between high and low skills that allows deterioration as well as enhancement of skills. Individuals save claims on capital that enters an economy-wide production function. There is a flat rate tax on earnings from labor, which equal a wage times a skill level. An indivisiblity in labor supply is convexified either by employment lotteries or individual time-averaging.

The employment lotteries and time-averaging versions of the model share the same striking implication of the section 4 model that the quantitative responses of aggregate nonemployment to labor tax increases are quantitatively similar, thus reconfirming our findings about the insensitivity of aggregate outcomes to the 'aggregation theory'. However, there are substantial differences in the characteristics of those who work less as taxes increase in the lotteries and the time-averaging versions of the models. As taxes increase at low tax rates, the employment lotteries model assigns more and more old workers with *low* skills to specialize in leisure, while the equilibrium outcome in the time-averaging model is that more and more old workers with *high* skills stop working. At higher tax rates, as taxes increase, the employment lotteries model assigns more and more young workers with *low* skills to specialize in life-long leisure, while in the time-averaging model the outcome is that more young workers with *high* skills stop working. In the time-averaging model, a worker's age, skill, and accumulated financial assets interact with tax rates to determine when to retire. Thus, in the time-averaging model, labor tax rates work by affecting the when-to-retire margin.

We shall refer to some of these results again in subsection 6.5 when we come back to address the question 'Do taxes explain European nonemployment?'

6 Practical implications of the models

To summarize what to make of our theoretical findings, this section (1) describes how it is impossible to include social insurance with the high benefit levels observed in Europe while maintaining the high disutility of labor favored by Prescott; (2) summarizes what delivers that high labor supply elasticity in the lotteries and the time-averaging model; (3) compares calibration strategies for that disutility in the lotteries and time-averaging models without benefits; (4) criticizes some of the evidence Prescott used to justify setting a

[19] For another time averaging version of a stochastic general equilibrium model that focuses on the extensive margin of labor supply, see Chang and Kim (2006). In their model, agents are infinitely lived and, hence, the life-cycle dimension of careers is absent, but Chang and Kim enrich their analysis by studying two-person households.

high disutility parameter; and (5) answers 'no' to the question 'Do taxes explain European nonemployment?'

6.1 Social insurance is problematic

Prescott (2002, p. 9) summarized his findings by saying: "I find it remarkable that virtually all of the large difference in labor supply between France and the United States is due to differences in tax systems. I expected institutional constraints on the operation of labor markets and the nature of the nonemployment benefit system to be more important." Because generous social insurance is indeed a pervasive phenomenon in Europe, accounting for cross-country employment differences with any model that ignores it is naturally subject to the suspicion that one has miscast other parameters in order to fit the employment observations. Figure 1 confirms that suspicion about the stand-in household model with complete markets and employment lotteries.[20]

Rogerson (2006a) adds social insurance to a stand-in household model and interprets it as a subsidy to leisure: "unemployment insurance programs, social security programs and traditional welfare programs all involve a transfer of resources that is conditional upon not engaging in market work and hence implicitly involve marginal subsidies to leisure." We like Rogerson's description especially as it pertains to Europe, but we question the way that he implicitly sets replacement rates for European social insurance programs. Referring to Prescott (2004), Rogerson calibrates the preference parameter α in the stand-in household's utility function (1) so that $h = 1/3$ at the U.S. tax level, then assumes that $\bar{h} = 1$ in budget constraint (2). The replacement rate ρ is implicitly determined by his assumptions about government taxes and tax revenues. In a key calibration that provides an explanation for why hours of work in Continental Europe are only 2/3 of those in the U.S., Rogerson assumed that both economies hand back lump sum the tax revenues raised by the U.S. level of taxes, while the 20 percentage points incremental taxation in Continental Europe are used to finance the subsidy to leisure. A back-of-the-envelope calculation then yields a replacement rate of 15%.[21] The low replacement rate that he calibrates is much lower than the replacement rates estimated by Martin (1996), which are more than 50%. Figure 1 tells why Rogerson wants a low replacement rate.

When it comes to understanding cross-country differences in employment and nonemployment, social insurance seems to be the Achilles' heel of models that have a high labor supply elasticity. Nevertheless, let's temporarily set aside the troublesome issue of social insurance and explore what our analysis in sections 3 and 4 has taught us about the forces behind Prescott's high aggregate labor supply elasticity.

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[20] Also see Ljungqvist and Sargent (2006b).

[21] Hours of work in Continental Europe should be $h = 2/9$, since those hours are only 2/3 of the U.S. value $h = 1/3$. After multiplying the hours worked by the incremental tax rate of 0.2 that pays for the subsidy to leisure, and then dividing by the number of hours eligible for the subsidy $(1 - h = 7/9)$, we arrive at a replacement rate on gross earnings of $\rho(1 - \tau_h) = 0.057$. Hence, given the calibrated Continental European tax rate $\tau_h = 0.6$, the replacement rate on net-of-tax earnings is $\rho = 0.1425$.

6.2 Time averaging versus lotteries

As reviewed in section 2.4, Prescott (2006) assigns great importance to Rogerson's model of employment lotteries as a theory of aggregation. But taking our que from Mulligan (2001), we have shown that this aggregation theory is not necessary for Prescott's results.[22] In a model without human capital and no uncertainty, households can attain the same allocations by alternating between spells of employment and nonemployment and relying on private savings to smooth consumption. This is good news for Prescott's tax analysis because his assumption of complete markets with employment lotteries has been questioned and occasionally deemed incredible.

But the pertinence of the employment lotteries model for Prescott's tax results reemerges when we add a human capital acquisition technology. Like the choice of either working full time or not at all in Rogerson's (1988) static model, career choices in a dynamic model with human capital accumulation introduce a kind of indivisibility. The individual who accumulates human capital reaps the returns on that investment by working. By way of contrast, in an economy with employment lotteries and complete markets, the efficient allocation is one where some individuals pursue labor careers while others specialize in providing leisure to the stand-in household. This is accomplished through a grand lottery for newborn workers that grants the same ex ante utility to everyone but dooms the losers of the lottery to life-long labor careers.[23]

In the absence of employment lotteries, individuals are on one side or the other of the expected consumption-leisure tradeoff in the lottery economy. The individual consumes less if returns on human capital are too low to compensate him for bearing the disutility of supplying the labor needed to acquire human capital all by himself. The random assignment of labor in the lottery allocation implies a more favorable expected tradeoff that could very well justify human capital investments by the community. In contrast, an isolated individual works and consumes more only if returns on human capital are high enough to spur careers with human capital acquisition, because then his optimality condition will favor a longer working life as compared to the average labor supply in the lottery allocation that smooths the indivisibility of labor careers.

The different allocations supported by time averaging versus lotteries have implications for the employment effects of taxation. For example, if the equilibria without taxation are characterized by a corner solution with full employment, successive increases in taxation will first reduce employment in the economy with employment lotteries while the labor supply

[22] The published version of Prescott's (2006) Nobel lecture contains an added section on "The Life Cycle and Labor Indivisibility" that shares features of our analysis in section 3.3. This analytical perspective raises new issues to be addressed and suggests new empirical facts to be explained. Hence, it is potentially an important addition to the original lecture, http://nobelprize.org/economics/laureates/2004/prescott-lecture.pdf.

[23] We thank Richard Rogerson for alerting us to Grilli and Rogerson (1988) who also analyze human capital accumulation in a model with employment lotteries. The authors cite the story "The Lottery in Babylon" by the surrealist Jorge Luis Borges, in which an all-encompassing lottery dictates all activities in a fictional society. The Borges story either arouses skepticism about the real-world relevance of the analysis or exemplifies that reality sometimes surpasses fiction.

in the economy with time averaging is more robust. The reason is that individuals who have accumulated human capital in the time-averaging economy view the investment as a sunk cost and are unwilling to surrender the returns on those sunk investments by shortening their careers. The lottery economy does not exhibit this feature because the lotteries have convexified labor careers so that the losers pursue life-long careers and any substitution toward leisure shows up in the number of winners who specialize in leisure. However, if we suppose that individuals in the time-averaging economy do choose to shorten their careers in response to taxation, then the marginal employment effects of taxes are identical to those of the lottery economy (and even surpass those when taxes become so high that they compel some individuals to give up on human capital accumulation altogether). Hence, how the disutility of working is calibrated is crucial for understanding how taxes affect those career choices.

6.3 Calibration of the disutility of working

In the first business cycle model with Rogerson's (1988) aggregation theory, Hansen (1985) took the calibration of a model with divisible labor as a starting point for calibrating the disutility of working. Specifically, the model with divisible labor was calibrated to match "the observation that individuals spend 1/3 of their time engaged in market activities and 2/3 of their time in non-market activities." After imposing the same steady-state hours of work across the models, Hansen arrived at a calibration for the disutility of working in the model with indivisible labor.

An alternative to matching the fraction of households' total hours devoted to work is taken by Hopenhayn and Rogerson (1993), who calibrate the disutility of working to "produce an employment to population ratio equal to .6." For an economy with indivisible labor and employment lotteries, it would seem that the latter calibration target is the proper one. In any case, the two approaches share the important outcome that target observations imply calibrations to interior solutions for the stand-in household's labor supply. We understand that those interior solutions define what Prescott (2006, p. 221) refers to as "the empirically interesting cases."

The model with employment lotteries prompts us to try to match snapshots of averages in the population. The time-averaging model tells us instead to focus on matching household outcomes over time. The labor services performed by individuals determine their disposable incomes and consumption rates in the time-averaging model, while they don't in the stand-in household model because of the extensive state-contingent consumption insurance. Hence, it is important from the perspective of the time-averaging model to study the distribution of labor supply across individuals while, in the stand-in household model, we can just sum up the labor supplied by all individuals and focus on aggregates.[24] In our time-averaging

[24] The theory of the stand-in household tells us to expect private transfers across individuals: some of them specialize in generating leisure and others in providing for consumption goods. Shiller's (2003) vision for a new financial order in the 21st century with privately provided livelihood insurance and inequality insurance prevails in the stand-in household model.

model, taxes impact labor supply by shortening individuals' labor careers. Besides the effects of differences in the subjective rate of discount and the market interest rate, the simple model has little to say about the timing of nonemployment spells – front loading ("youth nonemployment"), back loading ("early retirement") or intermittent shorter spells of nonemployment. However, as summarized in section 5, our numerical analysis of a related stochastic general equilibrium model with human capital accumulation in Ljungqvist and Sargent (2006a) suggests that taxes cause early retirement.

The model without employment lotteries raises the question: what should be the calibration target for the length of labor careers? Some might argue that the large number of people working until the legislated retirement age suggests a corner solution and the disutility of working should be calibrated accordingly. Needless to say, such a calibration would mute the employment effects of taxation.[25] Others might suggest that the employment effects of taxation manifest themselves largely as having one of two spouses in a household curtail his/her labor career. Hence, the disutility of working should be calibrated to reflect household composition in the economy.

Much remain to be learned from explicit models of the family, such as the collective labor supply model of Chiappori (1992). However, one immediate implication of changing the perspective from models with a stand-in household to models of nuclear families without employment lotteries is the additional empirical evidence that needs to be addressed before one can declare any theoretical success in explaining cross-country differences in employment. The evidence that we present below does not look particularly promising for the tax explanation of European nonemployment.

6.4 Prescott's Evidence for a high labor supply elasticity

Prescott (2006) emphasizes that a high labor supply elasticity is necessary to reproduce business cycles of the magnitude and nature observed. He says that compelling corroborating evidence for a high aggregate elasticity can be found in observations on employment and tax rates across countries and across time, as studied and modelled by Prescott (2004), who is particularly successful reproducing the observed differences between France and Germany, on the one hand, and the United States, on the other. Given that French and German tax rates in Table 1 increased by 10 and 7 percentage points, respectively, the aggregate labor supply elasticity must indeed be very high if tax changes are to explain the plummeting employment in these countries.[26] In addition to being an example of a successful application

[25] Carneiro and Heckman (2003, p. 196) argue that "[i]n a modern society, in which human capital is a larger component of wealth than is land, a proportional tax on human capital is like a nondistorting Henry George tax as long as labor supply responses are negligible. Estimated intertemporal labor supply elasticities are small, and welfare effects from labor supply adjustment are negligible. . . . Taxes on human capital should be *increased*, whereas taxes on capital should be decreased, to promote wage growth and efficiency."

[26] Prescott (2006, p. 225) offers a misleading summary of his earlier study (Prescott 2004) when he states that France and Germany "increased their marginal effective tax rate from 40 percent in the early 1970s to 60 percent today." Below we reiterate the fact that the actual tax increases were only half of that size and hence, half of the tax differential versus the United States was already in place in the early 1970s.

of the growth model with a stand-in household, Prescott interprets the theory's ability to rationalize those outcomes as evidence for a high labor supply elasticity. The high labor supply elasticity is the key ingredient that makes real business cycle theory work and that also explains the dramatic fall in European employment.

Prescott suggests that one reason that earlier microeconomic studies failed to find a high labor supply elasticity is that they ignored human capital investments. He refers to a study of Imai and Keane (2004) for substantiation. Imai and Keane analyze how a human capital acquisition technology can reconcile a rather flat life-cycle labor supply path with a high labor supply elasticity, which they estimate to be 3.8. Prescott takes comfort in this high elasticity. But there is another implication that emerges with human capital accumulation and that is more troublesome for real business cycle theory. Specifically, the presence of human capital weakens the link between the curvature parameter on the disutility of working and the optimal response of workers with these preferences to fluctuations in the wage rate. Imai and Keane (2004, figure 8) forcefully illustrate this with a computational experiment that imposes a temporary wage increase of 2% and finds that at age 20 a person with that 3.8 elasticity parameter would respond by increasing hours by only 0.6%. As Imai and Keane explain, the presence of human capital adds a term representing the continuation value to what had been an *intratemporal* marginal condition for moment t labor supply in models without human capital; the presence of this term means that the wage understates a worker's value of time, especially a young worker's. The response of hours to a temporary wage jump increases with age, especially towards the end of a career. Hence, the inclusion of human capital investments in real business cycle models might increase the aggregate labor supply elasticity but it would be at odds with the business-cycle fact that most variations in hours are borne by young rather than old workers.[27] Once again, this highlights the new set of interesting issues that arise when we abandon Prescott's aggregation theory and his stand-in household.

Although Imai and Keane (2004) offer no simulations of the employment effects of taxation, their estimated model could conceivably support Prescott's assertion of potent employment effects of taxes. Relevant for our analysis of the extensive margin in labor supply, the estimated age-hours path by Imai and Keane (2004, figure 3) predicts a sharp acceleration of retirement already at the age of 50. While we have yet to observe the actual retirement of the cohort in their study, this prediction is clearly at odds with past data from the U.S. where retirement peaks have been recorded at the ages of 62 and 65. See e.g. the study of Rust and Phelan (1997), who attribute the observed past retirement behavior to the U.S. Social Security and Medicare insurance systems – institutions that are not modelled by Imai and Keane (2004). Despite our skepticism of their forecast of an imminent early retirement boom in the U.S., we fully agree with Imai and Keane's emphasis on the importance of modelling human capital accumulation when attempting to understand individuals' labor supply.

[27] See e.g. Gomme et al. (2004).

	Empirical estimates of tax rates		Benefit dependency rates in the working-age population	
	1970-74	1993-96	1980	1999
U.S.	0.40	0.40	0.168	0.137
France	0.49	0.59	0.139	0.242
Germany	0.52	0.59	0.152	0.224

Table 1: Empirical estimates of tax rates (Prescott 2004, table 2) and benefit dependency rates in the population aged 15 to 64 (OECD 2003, table 4.1).

6.5 Do taxes explain European nonemployment?

Prescott's (2002) explanation of today's 30-percent difference in labor input per working-age person in France relative to the U.S. posits a tax differential of 20 percentage points. From a time series perspective, Prescott (2004) finds that his theory is especially successful in explaining changes over time for the two large Continental European countries – France and Germany – that have increased their taxes by 10 and 7 percentage points, respectively, between the early 1970s and the mid-1990s when the U.S. tax rate remained constant. (See Table 1.) But this means that half of today's tax differential between France and Germany versus the U.S. was already in place in the early 1970s when hours worked were similar across these countries. As described in section 2.3, to explain why those already large early tax differentials did not lower European employment relative to the U.S. Prescott estimated a French-German consumption-output ratio that was significantly depressed relative to that of the U.S. Hence, variation in consumption-output ratios over time and across countries, not explained by the theory, contributes substantially to the success of Prescott's account. We have nothing to say about this exogenous factor and instead turn to discuss how we might go about seeking further evidence about the particular individuals that the theory predicts to be nonemployed.

In section 5, the lotteries and time averaging versions of the stochastic general equilibrium model with human capital accumulation have some deceptively appealing implications about nonemployment. In the lotteries model, the efficient allocation prescribes making older workers who have had disadvantageous labor careers the first to be furloughed into nonemployment as labor taxes rise. This implication seems to conform to some evidence about employment problems among displaced European workers.[28] However, the next wave of individuals that the lottery allocation furloughs into nonemployment as taxes rise higher is less convincing – new labor market entrants who are assigned to specialize in leisure for the rest of their lives. As explained in sections 3 and 4 with a nonstochastic human capital accumulation technology, the acquisition of human capital gives rise to an endogenous indivisibility in labor careers that the stand-in household convexifies by allocating individuals either to life-long work or to life-long leisure. However, this counterfactual outcome

[28]See e.g. Burda and Mertens (2001).

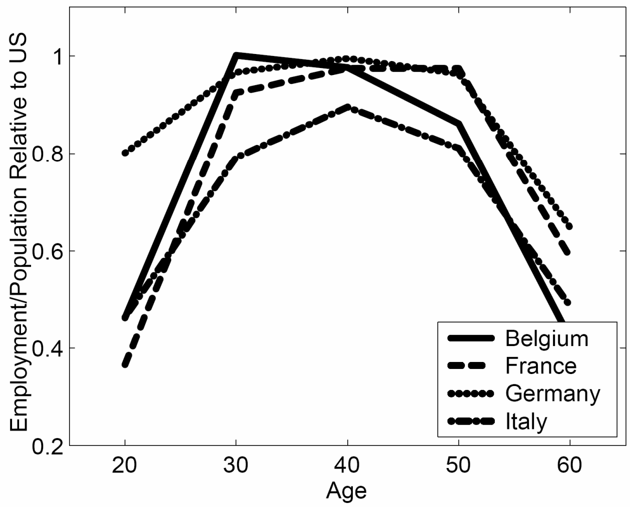

Figure 6: Employment relative to the U.S. by age in 2000 (Rogerson 2006b, figure 37).

disappears when we replace lotteries with time averaging. The time averaging model has the robust implication that individuals respond to higher taxes by shortening their labor careers. Furthermore, in our stochastic general equilibrium model, the increase in leisure takes place at the end of workers' labor careers. Figure 6 depicts substantial empirical support for that account. The employment-population rates are remarkably similar between Europe and the U.S. for ages 30-50 years. The young and the old account for the deficiencies in European employment.

But isn't the observed incidence of nonemployment among the old exactly what is predicted by our time averaging version of Prescott's tax model? Yes, but unfortunately there is a serious mismatch between the arrangement that the theory uses to pay for those 'early retirements' and what actually prevails in Europe. The theory states erroneously that the workers finance their nonemployment with either private insurance (in the lotteries model) or private savings (in the time averaging model). But as is well known, the nonemployed in the welfare states of Europe are to a large extent financed with government supplied benefits. Table 1 depicts how the benefit dependency rate in the working-age population has changed between 1980 and 1999. The largest benefit programs in 1999 were disability, unemployment, and early retirement. The European welfare states have created dual economies that divide households into those who are gainfully employed and those who are inactive and living on government supplied benefits. The OECD (2005, figure SS3.1) reports that in 2000 the number of persons living in households with a working-age head where no one works accounted for 11.1% and 16.1% of the total population in France and Germany, respectively, versus only 4.9% in the U.S.

While there are no government supplied inactivity benefits in Prescott's (2002, 2004) model, it is important to recognize that the employment effects of taxes hinge critically on the government's returning the tax revenues as lump sum transfers to the households. Those transfers are vast. Their sheer magnitude makes the cost of the progressive proposals made by some interest groups, especially in Europe, who want the government to guarantee modest levels of a citizen's income, or "basic income," to pale by comparison.[29]

[29]As defined by Guy Standing (2004) at the International Labor Office in Geneva, "a basic income is an income unconditionally granted to everybody on an individual basis ... regardless of gender, age, work status, marital status, household status or any other perceived distinguishing feature of individuals." The

7 Concluding Remarks

We answer 'no' to the question 'Do taxes explain European nonemployment?' When we modify Prescott's model to incorporate the generous social insurance that European governments offer their citizens to protect them from periods of nonemployment, the fit of the model deteriorates. We conclude by sketching an alternative view of European nonemployment and by emphasizing three basic messages of our analysis.

7.1 Our alternative vision

To explain cross-country differences in employment rates, we advocate using a model that includes the following features that are missing or different from the model in Prescott (2002): (1) a much lower disutility of labor than chosen by Prescott; (2) other activities like unemployment, disability, and old-age retirement in addition to the two activities, labor and leisure, that are included in Prescott's model; (3) government-supplied inactivity benefits; and (4) tax revenues that are not handed back lump-sum but rather are used to finance public goods and inactivity benefits.

Feature (1) will obviously help make the alternative framework compatible with feature (3), i.e., the fact that Europe has generous social insurance. Feature (4) will also help by reactivating the negative income effect of taxation that Prescott disarmed when he assumed that all tax revenues are handed back lump sum to households. Under our alternative assumption, tax revenues are used to finance public good that are imperfect substitutes for private consumption and to pay for inactivity benefits that, in an equilibrium, are conferred on 'marginalized' groups of the population. In such an equilibrium, the high taxes of Europe provide little of private value to those who actually pay them because tax revenues either finance public goods or accrue to people who are marginalized and not working. Hence, the negative income effect of taxation would help to keep most people at work and stop them from planning to arrange employment lotteries with high odds of leisure (in the lottery model) or to accumulate private wealth with the thought of taking early retirement (in the time averaging model).

We have already used some of these proposed features in our research on the European employment experience. Because we are also interested in explaining observations pertaining to stocks and flows of workers searching for jobs, we have incorporated an additional feature: (5) a search or matching friction that impedes moving between labor and leisure. Ljungqvist and Sargent (2005) construct a McCall search model and Ljungqvist and Sargent (2006c) construct several matching models and a search-island model that are able to match many

idea is partially to protect citizens from the vagaries of the market economy by providing a basic income that can be supplemented with market activities, if so desired. Some proponents argue that such a reform can be financed largely by reallocating spending from other government programs and expenditures. In the world of Prescott's (2002) analysis of European employment, there is no reason either to advocate or to oppose such a reform: it would have no impact on the equilibrium, since one kind of government lump-sum transfer would just replace another in the stand-in household's budget constraint.

aspects of U.S. and European employment outcomes over the last half century.[30] These models put the spot light on cross-country differences in the generosity of government inactivity benefits, rather than on the tax rates emphasized by Prescott (2002).

7.2 Three basic messages

Since our paper contains a number of nuances and qualifications, it seems appropriate that we summarize the main lessons in three basic messages.

1. *Employment lotteries are not necessary for Prescott's (2002) conclusion about large employment effects of taxation.* The aggregate employment effects of taxation are quite similar in the lotteries and time averaging models, even though the identities of the nonemployed differ. A high disutility of labor and returning tax revenues via lump sum transfers to households are the critical ingredients for obtaining Prescott's large employment effects of taxation.

2. *A model with a high disutility of labor is a non-starter for explaining employment outcomes in Europe with its generous social insurance.* A forceful illustration of that is our incorporation of government-supplied benefits in Prescott's model in section 2 where employment literally implodes. Hence, it is also important to avoid a common mistake of not differentiating between private and social insurance when discussing possible real-world examples of employment-lottery equilibria.[31]

3. *The tax explanation for European nonemployment has counterfactual implications about the identities of the nonemployed and how they are financed.* Empirical observations support neither the lottery model when it allocates people to specialize either in labor or in leisure, nor the time averaging model when it asserts that the nonemployed in Europe are successful people who have amassed enough savings to afford early retirement. The notion that nonemployed Europeans are financed with private consumption insurance or personal savings is utterly wrong.

[30]However, Ljungqvist and Sargent (2006b) show that it is difficult to get an employment-lotteries model with a high disutility attached to labor to match the observations. One failure of that framework is especially informative. Even though the assumed preference specification (8) is consistent with a constant labor supply when wages increase along a balanced growth path, our modelling of a human capital accumulation technology disrupts that cancellation of the income and substitution effects. We find that the labor supply responds strongly when there is rapid obsolescence of human capital following instances of involuntary job dissolutions. In the laissez-faire economy, the employment-population ratio converges rapidly to its maximum because of a negative income effect, while even with a modest replacement rate in its social insurance system, the welfare state experiences a sharply falling employment-population ratio because of a substitution effect. The high labor supply elasticity in that framework is evidently at work.

[31]For a recent example, see Mulligan (2001) who slips by including social insurance in his list of real-world counterparts to the consumption insurance arrangements in the employment-lottery model: "the sharing of resources by husbands and wives, sick pay, disability insurance, and intergenerational transfers (both public and private)." As we have shown, it is a mistake to think that government-supplied nonemployment insurance helps to implement an optimal allocation either by completing markets or by substituting for private insurance in the employment lottery framework.

We are not able to run large-scale policy experiment with real-world economies, but our models do invite us to entertain thought experiments. The following question comes to mind. Faced with its predicament of high nonemployment in the last 30 years, suppose that Europe had to choose either a reform that cuts labor tax rates to the levels of the U.S. or a reform that replaces its social insurance programs with U.S. style income support. Which reform would increase European employment the most? Using the stand-in household model, Prescott (2002) is on the record as suggesting that the solution to European nonemployment is to cut labor tax rates. We lean the other way and suggest that reforming social insurance would go much farther in providing incentives for people to choose to work.

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