LIFE CYCLE LABOR SUPPLY AND RETIREMENT IN A MODEL WITH ENDOGENOUS HUMAN CAPITAL ACCUMULATION

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PRELIMINARY

ABSTRACT

In this paper, I develop a general equilibrium model of life cycle labor supply and use it to assess the effects of various features of social security programs on labor supply outcomes. An endogenous workweek and retirement margin, as well as endogenous human capital accumulation are the key features of the framework. I find that if one ignores the earnings dependence of social security benefits, one will over-estimate the distortionary effects of higher labor income taxes. However, once accounting for differences in both social security taxes and other labor taxes, I find that taxes account for a large share of the difference in aggregate hours worked between the U.S. and continental Europe. In addition to the generosity of social security programs, the rules regarding eligibility and working also account for a large share of this difference.

1. INTRODUCTION

Time devoted to market work in many continental European countries, such as Belgium, France, Germany and Italy, is currently only 70% of the U.S. level. Potential explanations for the difference in hours worked include tax and transfer policies, labor and product market regulation, wage setting and preferences. Prescott (2004), Rogerson (2008) and Ohanian, Raffo and Rogerson (2008) argue that tax and transfer policies can account for a large share of this difference. These papers use a stand-in household model, which abstracts from the distinction between employment and hours worked. Furthermore, they assume that the government taxes all labor earnings at a constant proportional rate and uses the proceeds to fund a uniform lump-sum transfer to all agents, the magnitude of which is determined via a balanced budget rule. To make the argument more compelling, it is important to consider a richer description of tax and transfer policies and how they interact with age and productivity, as opposed to simply assuming a lump-sum transfer. It is also of interest to study the disaggregated patterns of hours worked. The observations that the large differences in hours worked are due to differences in both the employment to population ratios and annual hours worked per person in employment, and that the differences in employment to population ratios arise primarily from differences in this ratio for young and old workers, are of particular interest.

In this paper, I develop a general equilibrium model of life cycle labor supply and use it to assess the effects of tax and transfer policies, particularly social security, on labor supply outcomes. I study what features of social security programs are key in accounting for both the aggregate level, cross-country differences in hours worked, as well as the disaggregated patterns discussed above. Specifically, I examine the effect of changing the generosity of social security benefits, as well as of changing the rules of the program, in particular the age of eligibility and whether one can continue to work after collecting benefits. I conduct experiments where the two features are altered separately, to isolate their effect. However, since there are differences along both of the dimensions between the U.S. and continental Europe, I also conduct a cross-country comparison of social security for the U.S. and a few continental European countries.

The key features of the framework are: (1) endogenous human capital accumulation in the form of learning by doing, and (2) a non-convex mapping from hours supplied to the market to labor services. Endogenous human capital accumulation is important because if wages were simply taken exogenously from the data, no one would work when young. Human capital accumulation will also drive the variation in hours worked when working, as people will work more when wages are high. Due to the non-convexity, people will concentrate work in some fraction of their life, instead of spreading it evenly throughout. This also produces allocations in which hours worked drop discontinuously to zero, instead of gradually approaching zero at older ages. As both the intensive (hours worked when employed) and extensive (length of lifetime worked) margins of labor supply are important in accounting for the differences in aggregate hours worked observed in the data, it is important that both the length of the workweek and the length of the working life are endogenous in the model.

Social security in the U.S. is a pay-as-you-go system funded through a payroll tax. I model the retirement benefit as having a flat-rate portion and an earnings dependent portion. I find that if one ignores the earnings dependence of social security benefits (by assuming a lump-sum transfer), one will over-estimate the distortionary effects of higher labor income taxes. However, differences in social security taxes account for only roughly half of the twenty percentage point difference in labor income taxes between the U.S. and continental Europe. It turns out that the additional labor taxes are quantitatively important in accounting for the cross-country differences in aggregate hours. Once accounting for differences in both labor taxes, I find that raising taxes to the continental European level would depress aggregate hours worked in the U.S. by 14.5%. This implies that in my model the responsiveness of aggregate hours to a tax increase is roughly 70% of that with a pure lump-sum transfer (see, e.g., Rogerson and Wallenius (2009)). So, while the earnings dependence of social security benefits dampens the negative effect of labor taxes on hours worked, the tax response is still sizable. In addition to cross-country differences in the generosity of social security benefits, the rules regarding eligibility and working while collecting social security benefits also differ considerably. Specifically, in many continental European countries it is possible to start collecting social security benefits as early as age 60, but this requires that one stop working. Holding the generosity of benefits fixed, the impact of this eligibility rule is to depress aggregate hours worked by over 8%. Together, the differences in generosity and rules regarding eligibility and working account for a large share of the difference in aggregate hours worked between the U.S. and continental Europe, with the model producing allocations where aggregate hours worked in Belgium, France and Germany are between 18% and 15.5% lower than in the United States.

My model is closely related to Rogerson and Wallenius (2009). The additional features of this model are endogenous human capital accumulation and a more detailed modeling of tax and transfer programs. I also attempt a more serious parameterization of the model. Consequently, a contribution of this paper is the development and parameterization of a model that is adequate for assessing the role of tax and transfer programs in accounting for the cross-country differences in hours worked.

An outline of the paper follows. Section 2 presents the model, while section 3 outlines the parameterization of the model. Section 4 considers the effects of various features of social security on labor supply outcomes, and section 5 discusses the robustness of these results. Section 6 concludes.

2. MODEL

I consider a discrete time overlapping generations framework, in which a measure one of identical, finitely lived individuals is born every period. In the model, individuals live for 56 periods with certainty. A model period is a year. Model age zero corresponds to age 22 in the data. I assume that individuals are endowed with one unit of time each period. Letting a denote age, individuals have preferences over sequences of consumption (c) and hours supplied to the market (h) given by:

$$\sum_{a=0}^{55} \beta^a \left[\ln(c_a) - b \frac{h_a^{\frac{1}{\gamma}+1}}{\frac{1}{\gamma}+1} \right], \; b \geq 0, \gamma \geq 1,$$

where β is the discount factor. Preferences are assumed to be separable and consistent with balanced growth, thereby dictating the ln(c) term. The functional form choice for disutility from working is standard and convenient, since the preference parameter γ

determines the responsiveness of hours of work to changes in the tax rate along the intensive margin in a standard labor supply model.

I assume that human capital is accumulated via a learning by doing technology, where by working today the individual increases his/her wage tomorrow. In particular, I assume that the human capital stock of an individual evolves according to the following function:

$s_{a+1} = (1-\delta_s)s_a + \tilde{A}_a g(h_a)^{\alpha}$, where $\tilde{A}_a = \tilde{A}e^{-dt}$, $0 \le \delta_s \le 1,\ 0 \le \alpha \le 1,\ \tilde{A} \ge 0,\ d \ge 0$.

This human capital production function captures three central features of the human capital accumulation process: depreciation, learning, and the possibility that learning becomes harder with age.

I assume that if an individual with human capital stock s devotes h units of time to market work, it will yield $l = s\,g(h)$ units of labor services. The $g(h)$ function plays a key role in the analysis. The standard assumption is that labor services are linear in hours of work. Prescott, Rogerson and Wallenius (2009) assumed that g is initially convex and then concave. For simplicity, I will assume that $g(h)$ takes the specific form

$$g(h) = \max\{0, h - \bar{h}\},\ \bar{h} > 0,$$

as in Rogerson and Wallenius (2009). One justification for the non-convexity is fixed costs associated with commuting, getting setup in a job and being supervised.

The factors of production are capital and labor. The aggregate production function is assumed to be Cobb-Douglas and written as:

$$Y_t = AK_t^{\theta}L_t^{1-\theta},\ A \ge 0,\ 0 \le \theta \le 1,$$

where K_t is the aggregate capital stock at date t and L_t is the aggregate input of labor services at date t.

I assume that there is a government in the economy, which levies two types of taxes on labor earnings. One is a proportional payroll tax (τ_1) used to finance a pay-as-you-go (PAYG) social security program, the other is a proportional tax on income (τ_2), including the social security benefit, the proceeds of which are rebated lump-sum (T) back to the consumer period by period. I assume that starting at age 66 the individual receives social security benefits, regardless of when the individual stops working.[1] In my model, the benefit is made up of two parts: the flat rate portion and the earnings dependent portion. The benefit formula is modeled as:

$$B = b_0(b_1 + b_2 Y),\ b_1 \geq 0, b_2 \geq 0,$$

where Y is average earnings from the 35 highest years. The government balances its budget every period, and in particular, b_0 is chosen to balance the social security budget.

The two key features of this model are: (1) endogenous human capital accumulation and (2) the non-convex mapping from hours supplied to the market to labor services. If wages were simply taken exogenously from the data, no one would work when young as this corresponds to low wages. Human capital accumulation also drives the variation in hours worked when working. Specifically, people work more when wages are high. The nonlinearity of the $g(h)$ function is critical in producing labor allocations in which hours drop discontinuously to zero at older ages. Specifically, hours worked do not gradually approach zero with age[2]. Endogenous human capital accumulation and the non-convex mapping from hours worked to labor services produce allocations in which both the intensive (time devoted to work when working) and extensive (length of life spent in employment) margins of labor supply are active.

2.1. STEADY STATE

I assume that there are two assets, physical capital and one period ahead bonds. In equilibrium, one can show that if both are held, they must offer the same rate of return. Since the two assets offer the same rate of return (and there is no uncertainty to differentiate them), individuals are indifferent about how to allocate their portfolio between the two, and only care about the total. Therefore, it is simplest to formulate the

[1] While this does not precisely correspond to the social security program in the U.S., I will later argue that this is a good approximation. Specifically, I will argue that in the U.S., to a first approximation, the present value of lifetime social security benefits does not depend on the age at retirement, holding income constant.

[2] Alternatively, one could have the disutility from working increase with age. However, to get people to work into their sixties and then retire, something abrupt would need to happen with the disutility schedule at older ages. Therefore, this is not a very compelling story.

problem with only one asset[3], which can be thought of as capital, but allow individuals to hold negative amounts of capital. I assume that at each date there are markets for labor services, capital and consumption. Furthermore, I assume competitive behavior in all markets.

I will focus on the steady state equilibrium. In each period, the cross-section of the economy will be identical to the life cycle of an individual. I denote the steady state life cycle paths for consumption, hours supplied to the market, physical capital and human capital by c_a, h_a, k_a, and s_a, respectively. By construction, all prices will be constant in the steady state. I normalize the price of output to one. The rental rate (or skill price) of human capital is denoted by *w*. The rental rate on physical capital is denoted by *r*. The interest rate in the economy is the rental rate on capital less depreciation. In equilibrium, factors of production will be paid their marginal products:

$$\theta A\left(\frac{K}{L}\right)^{\theta-1} = r$$

$$(1-\theta)A\left(\frac{K}{L}\right)^{\theta} = w$$

Given the outlined structure, the utility maximization problem of a newborn agent can be written as:

$$\max_{c_a, h_a, k_a, s_a} \quad \sum_{a=0}^{55} \beta^a \left[\ln(c_a) - b\frac{h_a^{\frac{1}{\gamma}+1}}{\frac{1}{\gamma}+1} \right]$$

$$\begin{aligned}
s.t. \quad & c_a + k_{a+1} - (1+r-\delta_k)k_a = (1-\tau_1-\tau_2)ws_a g(h_a) + T, \; a = 0,...,43 \\
& c_a + k_{a+1} - (1+r-\delta_k)k_a = (1-\tau_1-\tau_2)ws_a g(h_a) + (1-\tau_2)B + T, \; a = 44,...,55 \\
& s_{a+1} = (1-\delta_s)s_a + \tilde{A}_a g(h_a)^{\alpha}, \; a = 0,...,54 \\
& B = b_0(b_1 + b_2 Y) \\
& c_a \geq 0, 0 \leq h_a \leq 1 \\
& k_0, s_0 \text{ given}
\end{aligned}$$

[3] In principle there are two equilibrium conditions, one saying that the sum over bonds is zero and one saying that the sum over capital is the capital stock. If one adds them together, the condition states that the sum over all assets equals aggregate capital. This will be consistent with market clearing in both markets.

Given that lifetimes are deterministic, individuals will not carry over any capital beyond their last period of life, $k_{56} = 0$.

In equilibrium, the aggregate inputs will be determined as:

$$K = \sum_{a=0}^{55} k_a$$

$$L = \sum_{a=0}^{55} l_a$$

and the aggregate feasibility constraint is:

$$\sum_{a=0}^{55} c_a + \delta_k K = AK^{\theta} L^{1-\theta}$$

3. PARAMETERIZATION

As noted previously, a model period is a year. Recall that the initial period for a given individual corresponds to age 22. I assume that the individual starts off with a zero asset position, $k_0 = 0$. The following parameters must be assigned a value for the quantitative analysis:

(1) preference parameters β, b and γ

(2) fixed cost $\bar{h}$

(3) human capital technology parameters α, $\tilde{A}$, d and δ_s

(4) production technology parameters A, θ and δ_k

(5) government policy parameters b_1, b_2, τ_1 and τ_2

A number of the choices for parameterizing the model are standard. In particular, I follow the procedure of requiring that the parameter values are such that the model's steady state matches the time series averages for several aggregate variables. The somewhat less standard aspects involve the special features of the model, particularly the human capital accumulation technology and the social security program. Human capital technology parameters and preference parameters are determined so as to match the life cycle profiles for hours and wages in the data. The policy parameters are chosen to match the U.S. social security program. I will start by outlining the more standard choices, and then proceed to the more special features of the parameterization.

3.1. TARGETING AGGREGATES

The discount factor, β, is chosen to target an annual interest rate of 4%. The capital share parameter, θ, is chosen to target a capital to output ratio of roughly 3, and the depreciation rate of the capital stock, δ_k, is chosen to target an investment to output ratio of roughly 20% per annum. The closest I can get to the targeted investment to output and capital to output ratios is roughly 0.28 and 2.8, respectively. This is with θ=0.33 and δ_k=0.1. These are inline with estimates in the literature, although the capital depreciation rate is a little higher than is typical of a standard life cycle model. The choice of units is made so that the skill price of human capital, w, equals one. Given the interest rate and capital share parameter, this will pin down the scale factor A.

3.2. TARETING LIFE CYCLE PROFILES

The non-policy parameters that still need to be assigned a value are $\bar{h}$,b, γ, α, $\tilde{A}$, d and δ_s. I divide the fixed cost into two components:

$$\bar{h} = \bar{h}_1 + \bar{h}_2 ,$$

where $\bar{h}_1$ corresponds to the commute cost and $\bar{h}_2$ the set-up cost. I assume that the hours object in the data includes the cost of getting set up in a job and being supervised, but not the commute cost. $\bar{h}_1$ is chosen to match a commute time of roughly 45 min per day. The parameters $\bar{h}_2$, b, γ, α, $\tilde{A}$, d, and δ_s are then chosen so as to minimize the sum of squared percent deviations of hours and wages from their data counterparts, and to target a retirement age so that the fraction of work being done after the age of 60 in the model corresponds to the fraction of work being done after the age of 60 in the United States. Unlike in the data, in the model everyone will retire at the same age. One alternative would be to target the average retirement age in the United States. However, a key policy experiment will be to compare the benchmark allocation to one where it is possible to start collecting social security benefits at age 60. Therefore, the fraction of work being done after the age of 60 seems like an appropriate statistic to target. With individuals starting work at age 22, this will correspond to targeting a retirement age of 66.

In searching for parameter vectors that minimize the distance between hours and wages in the model and the data, I found that there are many local optima. In particular, there are specifications corresponding to a range of values for α that all produce a relatively good fit to the data. In the benchmark I fix α=0.23. This roughly corresponds to the estimates of Imai and Keane (2004). Later I will discuss how the results vary, depending on the value of α.

3.2.1. CONSTRUCTING LIFE CYCLE PROFILES FOR HOURS AND WAGES

I now outline how the targeted life cycle profiles for hours and wages are constructed from the data. Wallenius (2007) stresses the importance of using data for as many years as possible, when inferring parameter values, particularly the value of the intertemporal elasticity of substitution parameter. Consequently, I wish to target long life cycle profiles for hours worked and wages. I use CPS data[4] to construct average life cycle profiles. The appropriate CPS data for hours and wages is available for the years 1976-2006.

Because I am abstracting from educational decisions, I want people to have completed their schooling by the time they enter my sample. I use age 22 as the starting age, as a person starting college at the age of 17 or 18 will have completed a four-year degree by age 22. Note that 84% of 22 year-olds in the dataset work. Although people work until age 65 in the model, I target data up to age 62. The reason for this is that I wish to mitigate the bias resulting from selection. Close to 60% of 62 year-olds in the dataset work, whereas only 40% of 65 year-olds in the dataset work. I have chosen to target data up to age 62 although there is clearly some selection already at that age, as I want the model to capture the fact that people who remain employed into their 60's, do not considerably reduce their hours. As is standard in the literature, I restrict my sample to employed males.

I impute hours supplied to the market as a fraction of the total time endowment, which was assumed to equal one. Following the literature, I assume that the maximum

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[4] Data from: Miriam King, Steven Ruggles, Trent Alexander, Donna Leicach, and Matthew Sobek. *Integrated Public Use Microdata Series, Current Population Survey: Version 2.0*, Minneapolis, MN: Minnesota Population Center, 2004.

time allotted to work is 14 hours a day, 7 days a week. The measure of hours worked for a particular individual for a given year is then given by:

$$\textit{fraction of time spent working} = \frac{\textit{total annual hours worked}}{365 \times 14}.$$

The hourly wage rate for an individual is calculated as:

$$\frac{\textit{annual wage and salary income}}{\textit{annual hours worked}}.$$

Note that the hours object in the model that is being matched to the data is $h_a - \bar{h}_1$. Correspondingly, the wage object in the model that is being matched to the data is $\frac{s_a(h_a - \bar{h}_1 - \bar{h}_2)}{h_a - \bar{h}_1}$.

I construct the average life cycle profiles in the following manner: I compute average hours and average hourly wages for 22 year olds in 1976, 1977,…,2006, for my sample and the same for 23 year olds in 1976, 1977,…,2006 and so forth, concluding with 62 year olds in 1976, 1977,…,2006. I then compute the percentage increase in hours worked and hourly wages between ages 22-23, 23-24,…,61-62 in all sample years and average over them. I then use this to construct average life cycle profiles for hours and wages.

Incomes are made comparable across time by adjusting for increases in the price level using the Consumer Price Index. Since the initial wage in the model is equal to an endowment, only relative wages are of interest. Therefore, the initial human capital stock for an individual is normalized to one, $s_0 = 1$.

Figures 1 and 2 plot the average fraction of time spent working and average wages, respectively, for ages 22-62 for the sample. Hours worked rise throughout the twenties and early-thirties, after which they level off. Starting in the fifties, hours decline slightly. Wages rise steeply early on, and level off in the forties.

Figure 1

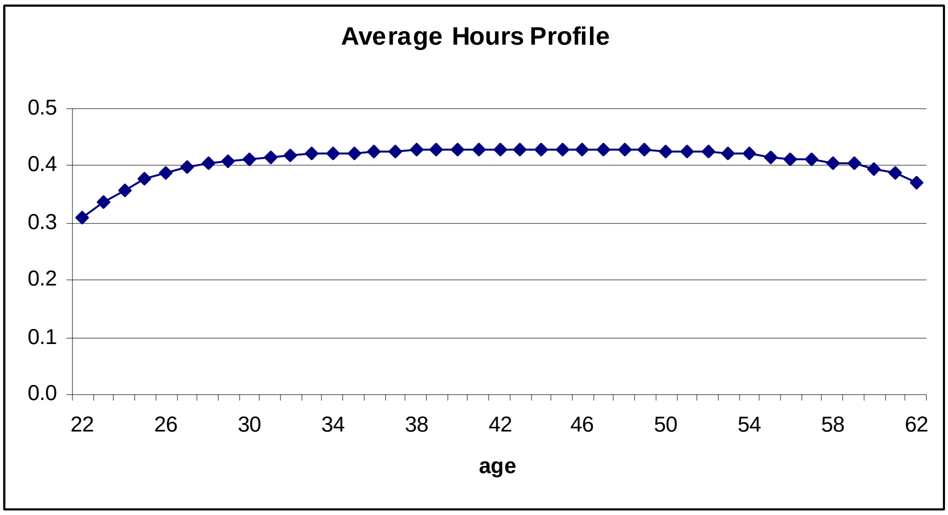
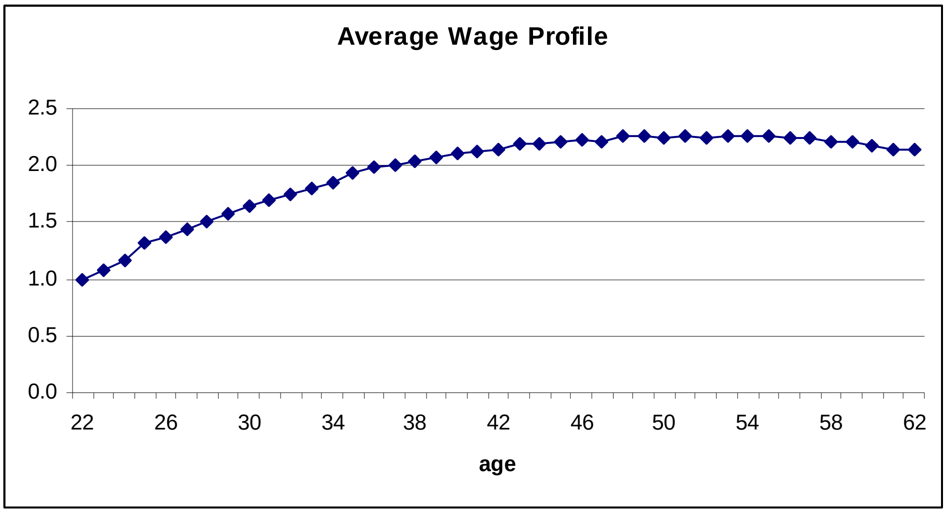


Figure 2



3.3 POLICY PARAMETERS

The policy parameters are chosen to roughly match the U.S. social security program. The payroll tax reflects the joint contributions of the employer and employee: τ_1=0.153. The additional tax on labor income is chosen so as to match the average effective tax on labor income in the U.S. in recent years, which is roughly equal to 0.3. This gives τ_2=0.15. In the U.S., a worker's retirement benefit is a piece-wise linear function of the average income of the highest 35 years. The retirement benefit is 90% of average income up to the first kink, and 32% of the excess of income over the first kink but not in excess of the second kink, plus 15% of income in excess of the second kink. In 2008, the first kink occurs at $711 and the second kink at $4,288. I choose the flat rate portion of the retirement benefit in my model, b_1, to match 90% of the first $711 the individual earns each month. The earnings dependent portion, b_2, reflects the accrual of benefits after the first kink. I abstract from the second kink as the average person in my sample does not have income in excess of the second kink. b_0 is chosen to balance the budget of the social security program.

As noted previously, in the model I assume that individuals begin receiving social security benefits at age 66, regardless of when they stop working. In actuality, people in the U.S. are eligible for social security starting at age 62. However, benefits are adjusted downward by 5/9 of 1 percent per month for each month in which benefits are received in the three years immediately prior to the full-retirement age. The reduction of benefits is 5/12 of 1 percent for every month before that.[5] Workers claiming benefits after the full-retirement age earn a delayed retirement credit, which is 2/3 of 1 percent for each month up to age 70. The adjustments for early claiming and delayed claiming are considered roughly actuarially fair. The rules state that people do not have to stop working to collect benefits. If a person is below the full-retirement age and continues working after collecting social security benefits, he/she is subject to an earnings test. In other words, benefits are reduced if earnings exceed a certain threshold. However, these individuals are compensated after reaching the full-retirement age in the form of higher benefits. While the adjustments are not precisely actuarially fair, assuming that the present value of lifetime social security benefits is independent of the age at which the individual begins collecting social security, holding income constant, is a good first approximation. Furthermore, given that everyone in the model will retire at the same age (since there is no heterogeneity in the model), early retirement is not of particular interest. The social security program in the model is designed to capture three central features of U.S. social security: (1) benefits are linked to earnings, but (2) the response is less than one-for-one, and (3) one does not have to retire to collect benefits.

[5] The full-retirement age is gradually being raised from 65 to 67.

3.4. BENCHMARK PARAMETERIZATION

Table 1 presents the benchmark parameter values for the model. I would now like to draw the reader's attention to a few of the relevant parameters that have yet not been discussed in detail.

Table 1: Model Parameters

PARAMETER	VALUE
Preferences	
β	0.977
b	5.248
γ	1.41
Production Technology	
$\bar{h}_1$	0.08
$\bar{h}_2$	0.08
A	0.985
θ	0.33
δ_k	0.1
Human Capital Technology	
α	0.23
$\tilde{A}$	0.145
d	0.029
δ_s	0.01
Government	
b_1	0.081
b_2	0.3
τ_1	0.153
τ_2	0.15

Rogerson and Wallenius (2009) showed that while γ does not have a large impact on the responsiveness of aggregate hours to a change in the tax rate, it matters for how the aggregate response is broken down into changes along the intensive and extensive margin. Particularly, the larger the value of γ, the more action there is along the intensive margin. Furthermore, Wallenius (2007) illustrates that larger values of γ are often linked to larger values of α. Later, I will show how the results vary as α, and consequently γ, are varied. A value of γ=1.4 is rather large compared with standard micro estimates. Imai and Keane (2004) showed that once allowing for human capital accumulation, the estimates of the preference parameter can be significantly larger. While Wallenius (2007) cautions that Imai and Keane (2004) may over-estimate the effect of learning by doing, estimates in the neighborhood of 1.2-1.4 are plausible once allowing for human capital accumulation. The small but positive value for d implies that learning becomes somewhat harder with age, whereas the small value for δ_s indicates that the human capital stock depreciates only slightly from one period to the next. The fixed cost time cost $\bar{h}_2$ is equal to 0.08. This implies that roughly 20% of hours supplied to the market (non-inclusive of commute time) are spent getting set-up in a job and being supervised[6].

Figures 3 and 4 plot hours worked and hourly wages relative to the data. The model provides a good fit to the wage data. However, there is a small disparity in the hours profiles, with hours rising slightly more steeply in the 30s and 40s and declining more rapidly at older ages in the model than in the data. The steeper rise in hours is in part driven by the learning effect and in part by the fact that retirement benefits are based on average earnings from the 35 highest years, and not average lifetime earnings. The steeper decline in hours, on the other hand, is due to the high capital share parameter.[7] Recall that in the benchmark model individuals work ages 22-65, i.e., retire at age 66. In equilibrium, the social security benefit is scaled up by 30.27% to balance the budget. The scaling of the benefit does not affect the relative importance of the flat-rate and earnings dependent portions of the benefit.

[6] The addition of home production to the model would reduce the size of the non-convexity needed to induce retirement. The intuition for this is that in a model with home production, leisure time does not change as abruptly when people retire.

[7]As the capital share parameter, θ, increases, the discount factor, β, adjusts in order to continue to target the interest rate. The change in β causes the slope of the hours profile to change.

Figure 3

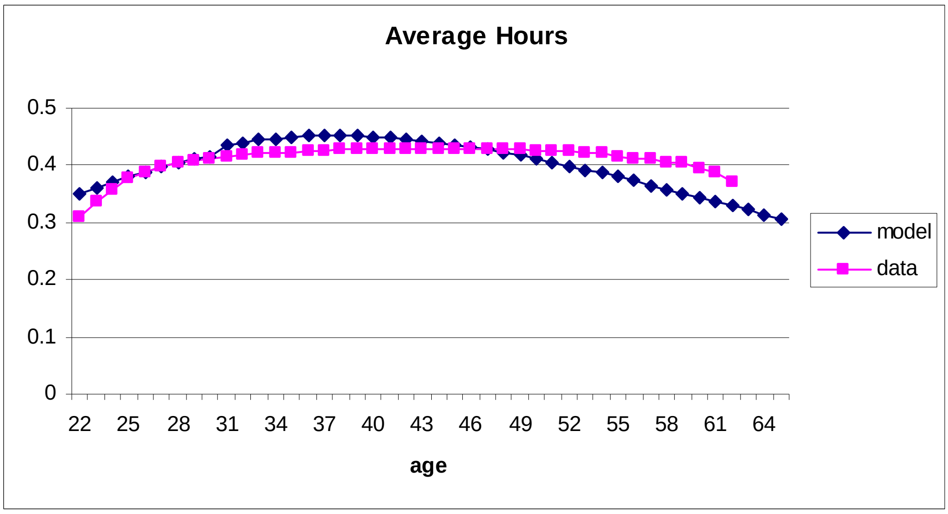
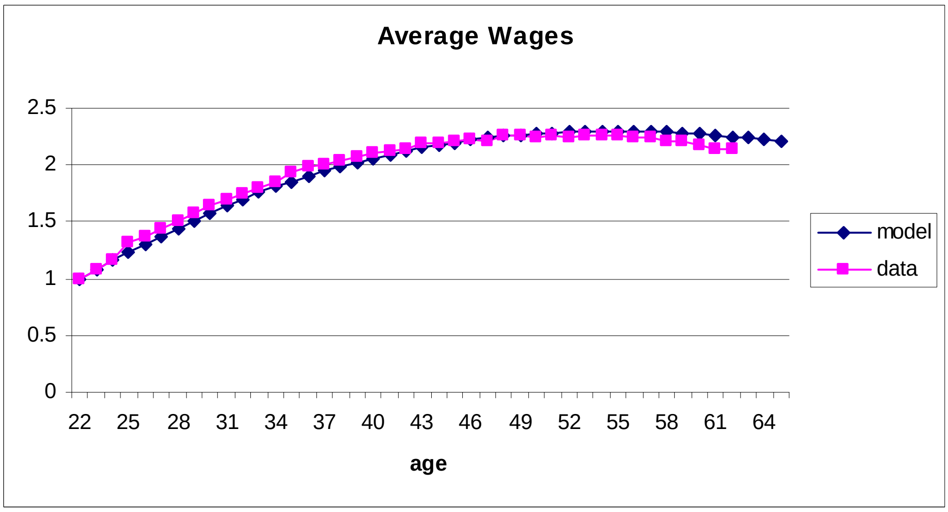


Figure 4



4. POLICY ANALYSIS

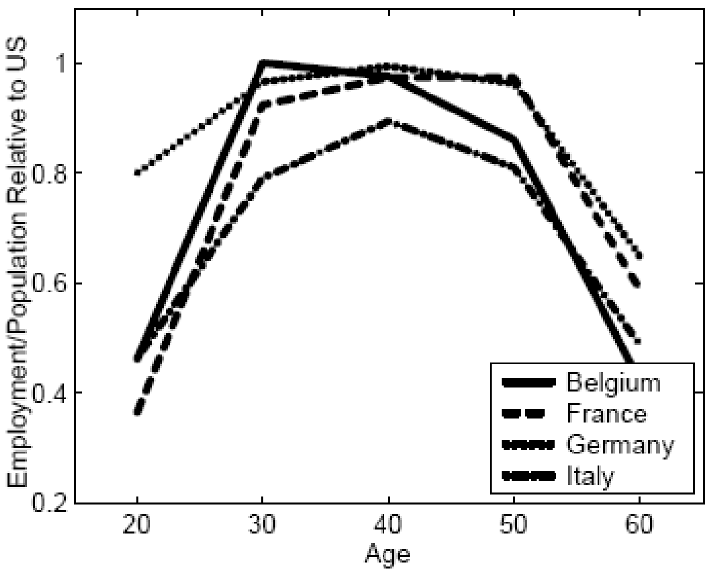
It is well known that hours of market work per person of working age are much lower in continental Europe than in the United States. Specifically, market work in Belgium, France and Germany is currently about 70% of the U.S. level. Rogerson and Wallenius (2009) establish two further properties. First, the large difference in total hours is due to differences in both the employment to population ratio and annual hours worked per person in employment. Second, the differences in employment to population ratios arise primarily from differences in this ratio for young and old workers. The first observation is illustrated in Table 2, where total annual hours of work is decomposed into two components: the number of people employed, and annual hours worked per person in employment. In making cross-country comparisons it is necessary to normalize employment relative to some measure of population. In what follows I use the size of the population aged 15-64. Table 2 reports values for aggregate hours per person aged 15-64, the employment to working age population ratio, and annual hours of work per person in employment for Belgium, France and Germany relative to the US.

Table 2: Market Work in Europe Relative to the U.S. in 2003

	Belgium	*France*	*Germany*
Hours/Pop	.71	.68	.73
Emp/Pop	.83	.88	.91
Hours/Emp	.86	.77	.8

The second observation is illustrated in Figure 5, which shows the employment rate by age relative to the U.S. for Belgium, France and Germany.

Figure 5



In this section, I study the role of tax and transfer programs in explaining both the aggregate level differences as well as the disaggregated patterns documented above. In particular, having developed and parameterized the model, I now use it to assess the effects of social security on labor supply outcomes. I will study what features of social security programs are key in accounting for the cross-country differences in hours worked, particularly in observed retirement behavior. I examine the effect of changing the generosity of social security benefits, as well as of changing the rules of the program, in particular the age of eligibility and whether one can continue to work after collecting benefits. I also study the impact of the relative importance of the flat-rate portion of the benefit versus the importance of the earnings dependent portion on labor allocations. I will conduct experiments where each feature is altered separately, to isolate their effect. However, since there are differences along all of the aforementioned dimensions between the U.S. and continental Europe, I conclude this section with a cross-country comparison of social security for the U.S. and a few continental European countries.

In the policy analysis to follow, all parameters other than policy parameters are held fixed at the values determined in the previous section. A new interest rate and skill price corresponding to the new equilibrium are computed. Government budget balance will continue to be imposed.

4.1. ALTERING GENEROSITY OF TAX AND TRANSFER PROGRAMS

Benefit payments from the Old-Age and Survivors Insurance Fund in the U.S. currently constitutes 4.23% of GDP. Social security expenditure is considerably larger in continental Europe, with countries such as Belgium, France and Germany spending between 7.3% and 10.9% of GDP on old-age retirement benefits. This is in part explained by demographics. The aged dependency ratio, defined as the number of people aged 65 and over relative to the number of people aged 15-64, is roughly 18% for the U.S., whereas it is between 21% and 26% for the aforementioned countries. The remainder of the large differences in expenditure shares between the U.S. and continental Europe is due to more generous social security programs in continental Europe. As the programs are primarily financed through payroll taxes, this translates into higher social security taxes in continental Europe. Here, I ignore differences in demographics and instead focus on differences in the generosity of programs. I find that the payroll tax needed to fund the more generous social security programs in continental Europe is roughly ten percentage points higher than in the United States.[8]

I examine the effect of increasing the payroll tax to 0.24 on the benchmark allocation corresponding to the current U.S. system. For this experiment the relative importance of the flat-rate and earnings dependent portions of the social security benefit are left unchanged. In other words, b_1 and b_2 are held fixed at the benchmark values, but the benefit is scaled up to balance the budget. Also, τ_2=0.15 as in the benchmark.

The second column of Table 3 reports the results for the higher payroll tax. The second row reports the drop in aggregate hours resulting from the higher tax, the third row reports the drop in hours worked when working, and the fourth row reports the drop in employment (synonymous with length of working life). The bottom part of the table reports the new equilibrium values for the scale factor, interest rate and skill price. With the higher payroll tax, people find it optimal to reduce the working life by two years. Individuals now work ages 22-63, i.e., retire at age 64. This corresponds to a 4.55% drop in employment. The drop in aggregate hours is 5.28%. During ages 22-63, hours worked are 1.83% lower than in the benchmark.

The average effective tax on labor income is roughly twenty percentage-points higher in continental Europe than in the United States. Approximately half of this difference can be attributed to differences in social security taxes. Consider the joint impact of raising both the payroll tax and the additional labor income tax, set τ_1=0.24 and τ_2=0.25. The pertinent results are reported in the third column of Table 3. Under this scenario people find it optimal to work ages 22-62, i.e., retire at age 63. This corresponds to a 6.82% drop in employment. The drop in aggregate hours is 14.53 %. During ages 22-62, hours worked are 9.7 % lower than in the benchmark.

I now compare these results to others in the literature. To consistently do so, I define the following measure of the responsiveness of aggregate hours to changes in the tax rate:

$$\frac{\text{percentage change in aggregate hours}}{\text{percentage change in tax rate}}$$

[8] This calculation is based on the assumption of budget balance for the social security program.

Using this measure to compare my results to those of Prescott (2004) and Rogerson and Wallenius (2009), one notes that they find larger drops in aggregate hours in response to an increase in the tax on labor earnings. Specifically, Rogerson and Wallenius (2009) find that when the labor tax rate is raised from 30% to 50%, aggregate hours drop by roughly 22%. The percentage change in aggregate hours relative to the percentage change in the tax rate is then roughly 0.33. When τ_1 is raised from 0.153 to 0.24 and τ_2 is raised from 0.15 to 0.25 in my model, the corresponding measure is roughly 0.235. The responsiveness of aggregate hours to a change in the labor income tax rate is thus roughly 70% of that in Rogerson and Wallenius (2009). Note that both Prescott (2004) and Rogerson and Wallenius (2009) assume that the government taxes all labor earnings at a constant proportional rate and uses the proceeds to fund a uniform lump-sum transfer to all agents, the magnitude of which is determined via a balanced budget rule. In their models the benefit is not earnings dependent, i.e., b_2=0. When b_2>0, b_2 acts as a form of forced saving. Forced saving is less distortionary than a pure tax and lump-sum transfer program. While the combined higher taxes produce a sizable reduction in aggregate hours in my model, the drop is significantly smaller than when no part of the transfer is earnings dependent. So, if one ignores the earnings dependence of social security benefits, one will over-estimate the distortionary effects of higher labor income taxes. This is one reason why it is of interest to consider a richer description of tax and transfer programs, as opposed to simply assuming a uniform lump-sum transfer.

To illustrate the importance of the higher additional labor taxes, I do the same calculation for the case where only the social security tax is altered. When τ_1 is raised from 0.153 to 0.24 in my model, the percentage change in aggregate hours relative to the percentage change in the tax rate is 0.093. Thus, when only examining the differences in social security taxes, one finds that the responsiveness of aggregate hours to a tax change is much lower, less than a third of that in Rogerson and Wallenius (2009). So, on the one hand, if one ignores the earnings dependence of transfers, one overestimates the responsiveness of aggregate hours to taxes. But on the other hand, if one only looks at the differences in social security taxes, and not other labor taxes, one significantly downplays the role of tax and transfer programs in accounting for cross-country differences in hours worked.

One can also ask what would happen to the length of the working life and hours worked when working, if social security was abolished. Setting τ_1=0 is akin to having voluntary saving. In the absence of social security, people would find it optimal to continue to work much longer. Specifically, individuals would work ages 22-70, i.e., retire at age 71. Aggregate hours would increase by 10.26%, and hours worked during ages 22-65 would increase by 1.59% relative to the benchmark. Conversely, employment increases by 11.36%. The last column of Table 3 presents the results for this case.

Table 3: Altering Generosity of Tax and Transfer Program

	τ_1=0.24	τ_1=0.24, τ_2=0.25	τ_1=0
working life	22-63	22-63	22-70
agg. hours	-5.28%	-14.53 %	+10.26%
hours	-1.83%	-9.7%	+1.59%
employment	-4.55%	-6.82%	+11.36%
b_0	1.96	1.87	-
i	0.0433	0.0423	0.0358
w	0.9887	0.992	1.0149

4.2. FLAT-RATE VERSUS EARNINGS DEPENDENT BENEFIT

As noted previously, not only the generosity of the social security program, but the relative importance of the flat-rate portion of social security benefits and the earnings dependent portion matters. Consider the experiment of setting b_2=0, holding the tax rate and other parameters fixed at the benchmark level. The generosity of the benefits is effectively the same as in the benchmark, but the transfer is now independent of earnings. In response, aggregate hours worked decrease by 3.2%. All of the action is on the intensive margin, as the working life is unchanged from the benchmark, with people working ages 22-65. The results are summarized in the second column of Table 4.

Now consider the experiment of setting b_1=0, holding the tax rate and other parameters fixed at the benchmark level. Since there is now no flat-rate portion of the transfer, this is in essence forced saving. In response, aggregate hours worked increase by 0.96% relative to the benchmark. Again, all of the action is on the intensive margin, with people working ages 22-65. Having people voluntarily save for retirement and forcing people to save for retirement via a tax and transfer program produce very different results. Aggregate hours are roughly 11% higher under the voluntary saving program than under the forced saving program, with the bulk of the difference arising from the differences in the length of the working life. The third column of Table 4 summarizes the results for the forced saving experiment, while the last column restates the results for the voluntary saving experiment.

Table 4: Flat-rate vs. Earnings Dependent Benefit

	b_2=0	b_1=0	τ_1=0
working life	22-65	22-65	22-70
agg. hours	-3.2%	+0.96%	+10.26%
hours	-3.2%	+0.96%	+1.59%
employment	0%	0%	+11.36%
i	0.0387	0.0404	0.0358
w	1.0048	0.9987	1.0149

4.3. ALTERING ELIGIBILITY OF SOCIAL SECURITY

In addition to sizable cross-country differences in the generosity and composition of social security benefits, the rules regarding eligibility and working while collecting social security benefits also differ considerably. In many continental European countries it is possible to start collecting social security at a considerably younger age than the U.S. full-retirement age, but this often requires that one stop working. To study this feature of social security, consider the following experiment: alter the benchmark U.S. system in such a manner that one can start collecting social security as early as age 60, but to do so one must stop working. There are two alternative ways of implementing such a policy change. One alternative is to keep the payroll tax rate fixed at the benchmark value, τ_1=0.153, and to scale the benefits downward in order to balance the budget. The other alternative is to keep benefits fixed at the benchmark level and to raise the payroll tax rate to balance the budget. As people will choose to work fewer years under the new program, it is not possible to keep the benefits at the benchmark level and balance the budget with the original tax rate. I consider both alternatives in turn. In both scenarios b_1 and b_2 are set equal to their benchmark values.

First consider the case where the payroll tax rate is fixed at the benchmark value of 0.153. The pertinent results are summarized in the second column of Table 5. Not surprisingly, under the new rules people find it optimal to retire at age 60, i.e., work ages 22-59. This corresponds to a 13.64% drop in employment. Aggregate hours fall by 8.15% relative to the benchmark. During ages 22-59, hours worked are actually 3.28% *higher* than in the benchmark. The intuition for this is that the fact that people cannot continue to work while collecting social security benefits acts like a constraint on years worked. The two margins of labor supply act as substitutes, so when years spent in employment are in essence constrained below the optimal value, people increase hours worked when working. Because fewer years are spent in employment and more in retirement, benefits are scaled down by 21.5%. This results in a benefit that is roughly 39% lower than in the benchmark.

Table 5: Must Stop Working to Collect Social Security Benefits

	τ_1=0.153	τ_1=0.27
working life	22-59	22-59
agg. hours	-8.15%	-12.78%
hours	+3.28%	-1.93%
employment	-13.64%	-13.64%
i	0.0342	0.0406
w	1.021	0.9981

Now consider the case where the retirement benefit is fixed at the benchmark level. The results for this case are presented in the third column of Table 5. The payroll tax that balances the budget is 26.95%. Again, people find it optimal to work during ages 22-59, so the drop in employment is again 13.64%. Aggregate hours fall by 12.78% relative to the benchmark. During ages 22-59, hours worked are 1.93% lower than in the benchmark. While it is still true that the fact that people are unable to work while collecting social security mimics a constraint on the fraction of lifetime spent in employment, the higher payroll tax drives down hours worked when working relative to the benchmark. Despite the differences in the generosity of benefits, both scenarios produce strong incentives for people to retire at age 60. As one would expect, the reduction in aggregate hours is more pronounced in the higher tax scenario. Both cases, however, illustrate that the rules regarding eligibility and working while collecting social security greatly impact the labor supply choice of individuals, particularly their retirement decisions.

4.4. COMPARISON WITH CONTINENTAL EUROPE

The previous analysis reveals that both the generosity of social security benefits and the rules regarding eligibility and work are of importance, when studying the impact of social security on life cycle hours profiles and retirement behavior. Heretofore, the two features have been studied separately. As alluded to before, however, when comparing the social security program in the U.S. with those in continental Europe, one notes that there are significant differences along both dimensions. Several continental European countries have social security programs that are more generous than the U.S. social security program. Correspondingly, the European countries have higher payroll taxes. Also, in many of these countries it is possible to start collecting social security benefits at a rather young age, but this requires that the person stop working. In order to study the joint impact of differences in generosity and the rules regarding eligibility and working, I will conduct a comparison of the U.S. social security program with the programs in Belgium, France and Germany. Before describing the results for these countries, I will briefly outline the social security program in each of them.

In addition to differences in full-retirement ages as well as the generosity of and the rules regarding early retirement, it is considerably easier to claim disability pensions in many European countries than in the United States. Also, in many of these countries it is possible to transition from unemployment to retirement. In my model I abstract from disability and unemployment as segues into retirement.

BELGIUM

In Belgium people are eligible for social security benefits starting at age 60. One must stop working to begin receiving benefits. There is no flat rate portion of retirement benefits, b_1=0. Rather, benefits are completely tied to lifetime earnings. Age at retirement influences benefits through the following formula:

$$Benefit = 0.6 \times \frac{n}{45} \times average\ lifetime\ earnings\ ,$$

where n equals years of social security contributions. So, if one starts working at age 22 and retires at age 60, b_2=0. 506667, whereas if one defers retirement to age 61 b_2=0.52. Social security in Belgium is a PAYG system financed through a payroll tax. The joint contributions of the employer and employee are reported as 16.36%. However, the social security program requires an annual government subsidy. In the model, I set the payroll tax so as to balance the social security budget every period. In the policy experiment I then keep all non-policy parameters fixed at the benchmark level, but alter the benefit formula and the rules regarding social security to reflect the Belgian system. As noted previously, the difference in average effective tax rates on labor income between the U.S. and several economies in continental Europe is approximately twenty percentage points, with roughly half of this difference attributed to differences in social security contribution rates. To account for the remainder, I set τ_2=0.25.

The results are presented in Table 6. Under the policy modeled after Belgium, people find it optimal to work ages 22-59, i.e., retire at age 60. Aggregate hours fall by 18.48% relative to the benchmark. During ages 22-59, hours worked are 8.34% lower than in the benchmark. Employment falls by 13.64%. The social security tax that balances the budget is 0.24 and in equilibrium the benefit is equal to 0.3609. Note that although payroll taxes are higher in this economy than in the benchmark economy, the annual retirement benefit is lower. This is because people in this economy spend a smaller fraction of their lifetime working and a larger one in retirement, relative to the benchmark.

Table 6: Altering U.S. Social Security to Resemble Belgium

	τ_2=0.25	τ_2=0.15
working life	22-59	22-59
agg. hours	-18.48%	-10.7%
hours	-8.34%	+0.42%
employment	-13.64%	-13.64%
i	0.0389	0.0391
w	1.0041	1.0031

Recall that when only the generosity of both tax and transfer programs was increased (τ_1=0.24, τ_2=0.25), aggregate hours fell by 14.53% relative to the benchmark. The drop in aggregate hours is close to 30% larger when the differences in rules regarding eligibility and working are also taken into account. Consequently, if one were to ignore these differences in rules regarding eligibility and working, one would significantly underestimate the role of social security programs in accounting for cross-country differences in aggregate hours worked.

Recall also that when only the rules regarding eligibility and working were altered (and not the generosity of benefits), so that one could start collecting social security benefits at age 60 but had to stop working to do so, aggregate hours fell by 8.15% relative to the benchmark. The drop in aggregate hours is roughly 127% larger when the differences in tax rates are also taken into account.[9] Consequently, one can conclude that the differences in labor tax rates are also very important in accounting for the observed cross-country differences in aggregate hours worked.

When the effect of increasing both tax rates and the effect of changing the rules regarding eligibility and working are added up, the implied total effect on aggregate hours is 22.68%. This is somewhat larger than the drop in aggregate hours of 18.48% for the case of Belgium. The reasons for this are two-fold. First, there is no flat-rate portion of benefits in Belgium. As noted earlier, the distortionary effects of taxes are lower when transfers are earnings dependent. Second, the effect of higher taxes is further dampened by the fact that the rule stating that one must stop working to collect benefits acts as a constraint on the length of the working life. When there is more action on the extensive margin of labor supply, there is less on the intensive margin, as the two act as substitutes.

The increase in the additional tax on labor income, and the corresponding lump-sum transfer to consumers, has no impact on labor supply decisions along the extensive margin, but has a large impact along the intensive margin. If τ_2 was kept at 0.15 instead of raised to 0.25, people would work the same number of years, from age 22 to age 59. However, hours worked when working would be 0.42% *higher* than in the benchmark, relative to 7.77% *lower* in the presence of the additional tax. Consequently, the aggregate

[9] Note that b_1 and b_2 are also changing, so this isn't a perfectly clean comparison, rather a suggestive one. This is also true of the previous comparison.

drop in hours relative to the benchmark would be 10.7%, instead of 18.48%. This experiment illustrates that the labor income taxes levied on individuals in addition to the payroll tax are important in accounting for the cross-country differences in aggregate hours worked.

The case of Belgium illustrates that once both the differences in generosity of benefits and the rules regarding eligibility and working are taken into consideration, the differences in social security programs can account for a large share of the cross-country differences in aggregate hours documented in Table 2. In particular, higher payroll taxes and the fact that one must stop working to receive benefits compel people to retire early in continental Europe. The higher additional tax on labor earnings, on the other hand, drives down hours worked when working. Note that since the model starts at age 22 (not age 15), and assumes that all schooling has been completed by that age, the model only addresses differences in aggregate hours arising from later in life. Therefore, it does not even attempt to account for the whole difference in aggregate hours.

FRANCE

The French social security system is very similar to the Belgian one. Also in France people are eligible for social security benefits starting at age 60, but one must stop working to begin receiving benefits. Again, there is no flat rate portion of retirement benefits, b_1=0. In France, benefits are tied to earnings from the highest 25 years[10]. The maximum replacement rate is 50%, and requires a minimum of 160 contribution quarters. The replacement rate is reduced by 0.00621% per quarter that contributions fall below 160 quarters. So, if one starts working at age 22 and retires at age 60, b_2=0.4275, whereas if one defers retirement to age 61 b_2=0.4631. It is a PAYG system financed through a payroll tax. The joint contributions of the employer and employee are reported as 16.45%. It is again the case, however, that the social security program requires an annual government subsidy. As with Belgium, in my model I set the payroll tax so as to balance the social security budget every period. I now keep all non-policy parameters fixed at the

[10] The system is currently in transition. Benefits used to only be tied to the earnings from the 10 highest years.

benchmark level, but alter the benefit formula and the rules regarding social security to reflect the French system. I again set τ_2=0.25.

As one would expect, the results are very similar to those from the Belgian economy. They are summarized in Table 7. People again find it optimal to work from age 22 to age 59. That is, it is optimal to retire at age 60. Aggregate hours fall by 17.82% relative to the benchmark. Hours worked are 7.6% lower along the intensive margin relative to the benchmark. Again, employment is reduced by 13.64%. The social security tax that balances the budget is 0.2357 and in equilibrium the benefit is equal to 0.3611.

Table 7: Altering U.S. Social Security to Resemble France

	τ_2=0.25	τ_2=0.15
working life	22-59	22-59
agg. hours	-17.82%	-10.09%
hours	-7.6%	+1.1%
employment	-13.64%	-13.64%
i	0.0397	0.0398
w	1.001	1.0007

As was the case with Belgium, both the generosity of benefits and the rules regarding eligibility and working are key in accounting for the drop in aggregate hours relative to the United States. The drop in aggregate hours is roughly 23% larger when the differences in rules regarding eligibility and working, as well as tax rates, are taken into account, relative to the case where only the differences in tax rates are considered. Similarly, the drop in aggregate hours is roughly 119% larger when the differences in tax rates, as well as the rules regarding eligibility and working, are taken into account, relative to the case where only the differences in rules regarding eligibility and working are considered. Again the fact that there is no flat-rate portion of social security benefits in France dampens the distortionary effects of taxes. As was the case with the Belgian economy, the higher additional tax on labor income has no impact on years worked, but a significant impact on hours worked when employed. Without the increase in the additional labor income tax, people would again work from age 22 to age 59. Hours worked when working, however, would be 1.1% *higher* than in the benchmark, relative to 7.6% *lower* in the presence of the higher additional tax. As a result, the drop in aggregate hours relative to the benchmark would be 10.09%, compared with 17.82%.

GERMANY

In Germany, the so called social security program covers only private sector employees. There is a separate program for government employees. In what follows I will focus solely on the private sector. The full-retirement age in Germany is 65. However, it is possible to start collecting social security benefits at age 62 (if the worker has at least 35 years of contributions), but benefits are reduced by 0.3% per month for every month that social security is colleted prior to reaching the full-retirement age. This yields a maximum reduction of 10.8%. Prior to the social security reform in 1992, there was no reduction in benefits from early retirement. One is allowed to only earn a very small amount while on social security, 325 euros per month. For simplicity, I assume that one must stop working to begin receiving benefits. There is no flat rate portion of retirement benefits, b_1=0. Benefits are tied to lifetime earnings[11]. The replacement rate is dependent on the number of years of social security contributions. If one starts working at age 22 and retires at age 62, b_2=0.552 (prior to the reform b_2=0.6), whereas if one defers retirement to age 63, b_2=0.579 (prior to the reform b_2=0.615). The German system is a PAYG system financed through a payroll tax. The joint contributions of the employer and employee are reported as 19.3%. It is again the case, however, that the social security program requires an annual government subsidy. So, in my model I again set the payroll tax so as to balance the social security budget every period. In the policy experiment I now keep all non-policy parameters fixed at the benchmark level, but alter the benefit formula and the rules regarding social security to reflect the German system. I will report results both for the pre-reform benefit formula and the post-reform one. Again, I set τ_2=0.25.

I begin with the pre-reform case, where there is no reduction in benefits from early retirement. With this policy, people find it optimal to work from age 22 to age 61, i.e., retire at age 62. Aggregate hours fall by 15.8% relative to the benchmark. During

[11] Benefits are also dependent on the relative earnings position. The replacement rates used in the model are for the average worker.

ages 22-61, hours worked are 9.26% lower than in the benchmark. Conversely, employment falls by 9.09%. The somewhat smaller drop in aggregate hours relative to Belgium and France is explained by the fact that people are eligible for social security benefits starting at age 62, instead of age 60. Consequently, there is slightly more action along the intensive margin in the German economy than in the Belgian or French economies. The drop in aggregate hours is roughly 9% larger when the differences in rules regarding eligibility and working, as well as tax rates, are taken into account, relative to the case where only the differences in tax rates are considered. Consequently, while both the generosity of benefits and the rules regarding eligibility and working are important in accounting for the drop in aggregate hours relative to the United States, the eligibility rules account for a smaller share of the aggregate response than in Belgium and France. The social security tax that balances the budget is 0.24 and in equilibrium the benefit is equal to 0.4191.

As one would expect, it is again the case that the higher additional tax on labor income significantly impacts hours worked when employed, but leaves years worked unchanged. Without the increase in the additional labor income tax, people would work ages 22-61. Hours worked when working would be only 0.69 % lower than in the benchmark, instead of 9.26% lower, as was the case when τ_2=0.25. It follows that the drop in aggregate hours relative to the benchmark would be 7.85%, compared with 15.8% in the scenario with the higher additional labor income tax.

Now consider the post-reform case, where benefits are reduced by 0.3% per month for every month that social security is colleted prior to reaching the full-retirement age. This reduction in benefits has no impact on optimal retirement behavior. That is, with this policy people still find it optimal to work from age 22 to age 61. Consequently, employment falls by 9.09%. Aggregate hours fall by 14.95% relative to the benchmark. During ages 22-61, hours worked are 8.35% lower than in the benchmark. While the reduction in retirement benefits has no impact on the retirement age, people work slightly more when employed under the less generous social security program. The social security tax needed to balance the budget is lower following the reform, as the generosity of benefits has been reduced. Specifically, the social security tax that balances the budget is now 0.2208 and in equilibrium the retirement benefit is equal to 0.3914. The role of the higher additional labor income tax in this economy is the same as in all the other exercises. All the results for the economy modeled after Germany are presented in Table 8.

Table 8: Altering U.S. Social Security to Resemble Germany

	Pre-reform		Post-reform	
	τ_2=0.25	τ_2=0.15	τ_2=0.25	τ_2=0.15
working life	22-61	22-61	22-61	22-61
Agg. hours	-15.8%	-7.85%	-14.95%	-7.14%
hours	-9.26%	-0.69%	-8.35%	+0.07%
employment	-9.09%	-9.09%	-9.09%	-9.09%
i	0.0408	0.0411	0.0398	0.04
w	0.9971	0.9962	1.0008	1

This exercise illustrates that moderately reducing the generosity of social security benefits does not create powerful incentives for people to remain employed longer or even to increase hours worked when working by much. If, given the aging populations in many countries, this is indeed the goal of the government, changing the rules regarding eligibility and working while collecting social security benefits would create much bigger incentives for the continued employment of older workers.

5. DISCUSSION

In this section I discuss the robustness of the results to changes in the parameter vector. I also comment on how capital accumulation and productivity varies across the policy experiments, as heretofore I have only examined the effects of policy changes on labor supply outcomes.

5.1. SENSITIVITY ANALYSIS

As noted earlier, there are many specifications corresponding to a range of values for α that all produce a relatively good fit to the data. In the benchmark I set α=0.23, which is roughly the estimate of Imai and Keane (2004). The primary differences in specifications, as α is varied, are for the values of γ and $\bar{h}_2$. The other parameters are rather similar across specifications. As documented by Wallenius (2007), smaller values of α typically correspond to smaller values of γ, and vice versa. To gain intuition for this, start with the benchmark parameterization and lower α, holding γ fixed. In the benchmark allocation, where learning is rather important, the intertemporal elasticity of substitution of labor supply is rather high. In the absence of learning, a relatively flat hours profile and a relatively steep wage profile can only be reconciled with a small elasticity. As learning becomes less important, but the elasticity is fixed at a high value, hours become steeper. So, to get a good fit to the data with a smaller value of α, γ too must be smaller. Smaller values of γ in turn correspond to larger values of $\overline{h}_2$. This is intuitive: a small γ implies that people prefer smooth hours, and since retirement is a large, abrupt change in hours, a large fixed cost is required to induce retirement.

The value of α=0.23, and the corresponding value of γ=1.41, is close to the upper end of values for α and γ that produce a decent fit to the data. However, there are specifications where both are somewhat lower, that also produce a decent fit to the data. I will now discuss how the results vary across specifications. When γ is smaller, there is slightly less action along the intensive margin of labor supply. For example, when α=0.042 and γ=1.21, hours worked when working are 6.8%, 6.42% and 7 % lower in Belgium, France and post-reform Germany, respectively, relative to the U.S., compared with 8.34%, 7.6% and 8.35% lower with the benchmark parameterization. The slightly smaller action on the intensive margin is not compensated by an increase in action on the extensive margin, as the length of the working life is primarily determined by rules governing eligibility for retirement benefits. Also, the fact that the model period is a year causes an indivisibility in the length of the working life. Given this, the small changes along the intensive margin are not sufficient to induce action along the extensive margin. This translates into a slightly smaller response in aggregate hours. Specifically, aggregate hours worked are 17.89%, 17.55% and 14.21% lower in Belgium, France and post-reform Germany, respectively, relative to the U.S., compared with 18.48%, 17.82% and 14.95% lower with the benchmark parameterization. Since there is not much difference in the results for the different parameterizations, I will not report results in any further detail. Suffice it to say that the relative importance of labor income taxes and rules regarding eligibility and working in accounting for the cross-country differences in hours worked is roughly the same across specifications.

5.2. DIFFERENES IN CAPITAL ACCUMULATION AND PRODUCTIVITY

So far I have only discussed the effects of various changes to social security on labor allocations. In now briefly outline the effects of some of the key policy experiments on physical capital accumulation and productivity.

Social security is a form of forced saving. Since the social security programs are more generous in continental Europe relative to the U.S., individual savings are lower. In my model this results in capital to output ratios that are on average roughly 4% lower in Belgium, France and post-reform Germany compared with the United States.

When discussing the effects of the various social security policies on productivity, I use the measure output per hour. Raising the social security tax to from 0.153 to 0.24 depresses productivity by 2.48%, whereas raising both the social security tax and the additional labor income tax decreases productivity by 4.56%, relative to the benchmark. Higher taxes shift the hours profile downward, lowering the ratio of labor services to hours and thereby reducing productivity. Conversely, the elimination of the flat-rate portion of social security benefits, i.e., moving to a pure forced saving system, increases productivity by 0.35%. This effect is due to the small increase in hours worked along the intensive margin. Reducing the eligibility age for social security benefits to 60, but requiring that people stop working to collect benefits reduces productivity by 1.68% relative to the benchmark. Combining these effects, the model implies that output per hour in Belgium, France and Germany is roughly between 7% and 8% lower than in the United States.

6. CONCLUSIONS

Total time devoted to market work in continental Europe is currently only about 70% of the U.S. level. It has been argued that tax and transfer policies can account for a large share of this difference. The argument has been made in the context of a stand-in household model with a proportional tax and lump-sum transfer program. To make the argument more compelling, it is important to consider a richer description of tax and transfer policies and how they interact with age and productivity, as opposed to simply assuming a lump-sum transfer. It is also of interest to study the disaggregated patterns of hours worked. To do this, we need an adequate model to assess the effects of various features of social security programs on labor supply outcomes. The key ingredients of such a model are an endogenous workweek and retirement margin, as well as endogenous human capital accumulation. In this paper, I develop and parameterize such a model.

I find that if one ignores the earnings dependence of social security benefits, one overestimates the distortive effects of higher labor taxes. However, social security taxes only account for half of the twenty percentage point difference in labor income taxes between the U.S. and continental Europe. If all labor taxes were raised to continental European levels, aggregate hours worked in the U.S. would be depressed by 14.5%. This illustrates that despite the dampening effect of the earnings dependence of benefits, taxes account for a large share of the cross-country difference in aggregate hours. In addition to the differences in the generosity of social security programs, the differences in rules governing eligibility and working account for a large share of the difference in aggregate hours worked between the U.S. and continental Europe. If one were eligible for social security benefits at age 60, but had to stop working to receive benefits, as is the case in many continental European countries, aggregate hours of work would decline by roughly 8%. In the model, higher payroll taxes and the fact that one must stop working to collect social security benefits compel people to retire early in continental Europe. The higher additional labor taxes in turn drive down hours worked when working. When accounting for both the differences in generosity and the rules regarding eligibility and working, as well as the composition of the benefits, the model produces allocations where aggregate hours worked in Belgium, France and Germany are between 18% and 15.5% lower than in the United States. This illustrates that differences in social security programs are important in accounting for the differences in aggregate hours worked across countries.

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