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Consumption and Hours in the United States and Europe

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Abstract

We document large differences between the United States and Europe in allocations of expenditures and time for both market and home activities. Using a life-cycle model with home production and endogenous retirement, we find that the cross-country differences in consumption tax, social security system, income tax, and TFP together can account for 68-95 percent of the cross-country variations and more than half of the average differences between Europe and the United States in aggregate hours and expenditures. These factors can also account well for the cross-country differences in allocations by age and generate substantially lower market hours in Europe for the age group of sixty and above as in the data. All the factors, except income tax, are quantitatively important for determining cross-country differences in expenditure allocations. While the differences in social security system and income tax are crucial in explaining the difference in market hours around retirement ages, TFP and consumption tax are more important for the difference in market hours for prime ages.

Keywords: consumption expenditure, home production, labor supply, fiscal policy.

JEL Classifications: E21, E62, J22, O57, H31

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1 Introduction

While there is a large literature on the differences in labor supply across countries,[1] research works on cross-country differences in consumption expenditure are limited. To evaluate the effect of variations in policies on allocations, it is important to study consumption and labor-supply decisions together in a model that is consistent with data on both types of decisions. In this paper, we study cross-country differences not only on labor supply but also on consumption expenditure over the life cycle. We examine the allocations of consumption expenditure and time by age across countries not only for market activities but also for home activities because the literature has found that home production is a critical factor in propagating the effect of policies.[2]

Using time-use and consumer-expenditure surveys, we find that the allocations of time use and expenditure in the United States and Europe differ greatly.[3] First, compared to Americans, Europeans have lower market hours, higher home hours, and lower expenditures on market goods and home inputs (goods used in producing home consumption). In the aggregate, Europeans work 7-26 percent less in the market, spend 10-37 percent more time in home production, and spend 19-54 percent less expenditure on market goods and 21-47 percent less expenditure on home inputs. Second, the cross-country differences in market hours are more prolonged at old ages: European market hours for the age group of sixty and above are 34-77 percent lower than in the United States while they are only 2-17 percent lower before age sixty.

Different tax and transfer programs create different incentives for households when they allocate their time and expenditures between market and home activities over their life cycle. We observe large differences in such programs between the United States and Europe. The consumption tax rates in Europe are two to three times of that in the United States. The European social security systems feature a substantially higher tax rate accompanied by a more generous benefit scheme. The income tax in the United States is less progressive than that in most European countries and the tax rate is in between those in Europe. More impor-

[1] See, for example, Prescott (2004), Ohanian et al. (2008), Rogerson (2008), Olovsson (2009), McDaniel (2011), Ngai and Pissarides (2011), Erosa et al. (2012), Ragan (2013), Chakraborty et al. (2015), Laun and Wallenius (2016), Duernecker and Herrendorf (2018), and Bick and Fuchs-Schündeln (2018).

[2] See, for example, Benhabib et al. (1991), Rupert et al. (1995), Rogerson (2008), McDaniel (2011), Ngai and Pissarides (2011), Ragan (2013), Rogerson and Wallenius (2016), Bridgman et al. (2018), and Duernecker and Herrendorf (2018) for the effects of home production on market hours. See, for example, Dotsey et al. (2015), Boerma and Karabarbounis (2020), and Boerma and Karabarbounis (2021) for the importance of home production in assessing the welfare changes.

[3] The European countries included in our study are Austria, France, Italy, Netherlands, Norway, Spain, and the United Kingdom.

tantly, the cross-country correlations of market hours and expenditures on both market goods and home inputs with both consumption and social security taxes are all negative while the correlations of home hours with these taxes are positive. This suggests that cross-country differences in the tax and transfer policies can be important factors in accounting for the differences in allocations of expenditure and time observed in the data.

We develop a model to formally evaluate the quantitative effects of these policies on allocations. Our life-cycle model features home production, endogenous retirement decisions, and uninsurable idiosyncratic productivity shocks. In the model, households derive utility from leisure and a consumption good composited from a market good and a home good. The home good is produced using households' time and home inputs. The model incorporates key realistic features of the tax and transfer programs, including the consumption tax, the income tax, and the social security system. We calibrate the model to the United States and show that it matches well the data on US expenditure and time allocations by age. The model predictions are also consistent with the untargeted data moments on the ratio of social security expenditure to GDP, mean earnings by age, and the standard deviations of earnings, hours, and expenditures on market goods and home inputs by age.

In our cross-country study, we allow Europe to differ from the United States not only in tax and transfer programs but also in TFP for market production. In particular, most European countries have a lower TFP. Incorporating these cross-country differences, we simulate the model for each European country and evaluate the quantitative effects of them on the allocations of expenditure and hours. The simulated model can generate lower market hours, higher home hours, and lower expenditures for both market goods and home inputs in Europe than in the United States. The model can generate these results because a lower TFP and higher taxes in Europe favor production and consumption at home relative to production and consumption in the market and thus increase home hours and reduce market hours and market goods. Because home hours and home inputs are substitutes in the home production function, a lower TFP and higher taxes in Europe also favor home hours over home inputs in the production of home goods and thus reduce home inputs.

On average, across all the studied European countries, the model can account for 70 percent of the difference in aggregate market hours from the United States, 47 percent of the difference in aggregate home hours, 99 percent of the difference in aggregate expenditure for home inputs, while slightly over-predict the difference in aggregate expenditure for market goods. In addition, as measured by the coefficient of determination, the model can account for 75 percent of the cross-country variation in aggregate market hours, 68 percent in aggregate home hours, and 95 percent in aggregate expenditures on both market goods and home inputs. The model can also account well for the hours and expenditures by age. Consistent with the data, the model predicts substantially lower market hours in Europe for the age group of sixty and above and slightly lower market hours for the age group of less than sixty. On average, the model generates 73 percent of the average difference in market hours between Europe and the United States for age sixty and above and all the differences for age less than sixty.

To decompose the effects of policy and TFP, we replace European policies and TFP with the US values one by one for each of the simulated European economy. We find that the cross-country differences in TFP account for about one-third of the model-generated average differences between Europe and the United States in expenditures and hours both in the market and at home. In contrast, the cross-country differences in the combination of all three policies account for 44 percent of the model-generated average difference for expenditure on market goods, 46 percent for expenditure on home inputs, 56 percent for market hours, and 55 percent for home hours. Among the three policies, consumption tax and social security each account for one-fifth of the average differences in expenditures on both market goods and home inputs whereas income tax has much smaller effects. Moreover, while TFP and consumption tax are more important in explaining the cross-country differences in market hours for prime ages, social security and income tax are crucial in explaining the differences in market hours around retirement ages, with the former accounting for 53 percent and the latter for 40 percent of the model-generated average difference in market hours between Europe and the United States for the age group of sixty and above.

This paper is related to the literature studying life-cycle consumption profiles in the United States. Carroll (1997) and Gourinchas and Parker (2002) show that precautionary savings, generated by borrowing constraints and idiosyncratic income shocks, can explain the hump-shaped life-cycle consumption profile. Bullard and Feigenbaum (2007) find that including leisure in the utility function helps explain the decline in consumption late in life. A more recent literature studies the subcomponents of consumption over the life cycle. Fernandez-Villaverde and Krueger (2007) document hump-shaped profiles for both durable and nondurable consumption and propose to explain the hump with a model in which durables serve as collateral. Yang (2009) develops a model with illiquid housing and with collateral constraints to study the life-cycle patterns of housing and nonhousing consumption. Aguiar and Hurst (2013) show that the hump shape in market consumption is related to the substitutability of market and home-produced goods. Dotsey et al. (2014) show that a life-cycle model with home production explains well the life-cycle patterns of market and home consumption and time allocation. All these papers study life-cycle consumption profile in a single country. Our contribution to this literature is to study the consumption profile in a cross-country setting. We document the differences in expenditures on both market goods and home inputs by age between the United States and a set of European countries and show that the cross-country differences in tax policies and TFP can account for a large fraction of the cross-country differences in expenditure allocations.

There is a large literature that quantifies the effects of government policies on the differences in labor supply across countries. Prescott (2004) and Ohanian et al. (2008) use a one-sector model to study the roles of taxes in accounting for cross-country differences in labor supply. Rogerson (2008), Olovsson (2009), McDaniel (2011), and Duernecker and Herrendorf (2018) highlight the importance of home production in propagating the effect of taxes on labor supply. Ngai and Pissarides (2011) and Ragan (2013) find that subsidies for family care are important in accounting for the differences in market hours between the United States and the Nordic countries. Chakraborty et al. (2015) and Bick and Fuchs-Schündeln (2018) study the role of progressive and nonlinear labor income taxes in accounting for cross-country differences in market hours by gender. These papers all focus on the cross-country difference in aggregate labor supply between the United States and Europe. Our analysis of the data shows that the cross-country difference in market hours is mostly accounted for by the difference at old ages. Comparing to the existing literature, our contribution is to incorporate the life-cycle dimension and study the differential effects of policies on the cross-country difference in labor supply by age.

Erosa et al. (2012) and Laun and Wallenius (2016) study cross-country differences in market hours late in life. In contrast to these two papers and the referenced papers studying the cross-country difference in aggregate labor supply, we focus on labor supply over the entire adult life cycle. In addition to confirming the finding of Erosa et al. (2012) and Laun and Wallenius (2016) that differences in social security systems are crucial in explaining the difference in market hours around retirement ages, we find that TFP and consumption tax are more important in explaining the difference in market hours for prime ages. Moreover, we also find that the cross-country differences in tax policies can account for a large fraction of the allocation differences in expenditures on both market goods and home inputs while these papers only study labor supply and do not study expenditure.

The rest of the paper is organized as follows. Section 2 documents the cross-country differences in expenditure and time allocations. Section 3 first presents a static model to demonstrate the effects of taxes and wages on allocations and then presents the full-blown life-cycle model. Section 4 calibrates the model to the US economy. Section 5 applies the model to Europe and decomposes the total model-generated differences in the expenditure and time allocations between the United States and Europe into contributions from policies and TFP. Section 6 concludes.

2 Expenditure and Time Allocations

2.1 Data Construction

We use the Multinational Time Use Study (MTUS) to construct data for time allocations in the United States and Europe, the Consumer Expenditure Survey (CEX) to construct data for expenditures in the United States, and data from the European Statistical Office (Eurostat) to construct expenditures in Europe. The MTUS data by country are available in different years. We focus on countries with data available between 2005 to 2015 and use the averages if multiple surveys are available for one country. The years for the expenditure data are the available years in Eurostat that are mostly close to the available MTUS survey years.[4] The countries included in our study are Austria, France, Italy, Netherlands, Norway, Spain, the United Kingdom, and the United States. The rest of this subsection summarizes the data-construction process, and Appendix A provides more details.

It is not always trivial to distinguish between home production and leisure activities.[5] We follow Aguiar and Hurst (2007), the standard classification in the literature, and classify the time-use categories as market hours, home hours, and leisure. Market hours comprise time spent on paid work and commuting;[6] home hours comprise time spent on food preparation, cleaning, home and vehicle maintenance, obtaining goods and services, other care, and gardening and pet; the remainder of the time is classified as leisure.[7] Hours for each age are constructed as average weekly hours per adult for that age group.[8] Accordingly, the constructed hours takes into account the labor force participation at that age.

Following Dotsey et al. (2014), we classify consumption expenditures related to home production as home inputs and the rest as market goods. Home inputs include expenditures on food at home, household operations, household furnishings and equipment, utilities, housing maintenance, and housing (which consists of actual rents for renters and equivalent rents for homeowners). The CEX and

[4]Table A.1 lists the corresponding years from the MTUS and the Eurostat.

[5]For example, gardening and pet activities could be either home production or leisure.

[6]Defining market hours as only time spent on paid work does not affect the results reported in this section because communing time is small relative to time spent on paid work.

[7]Child care time is not included in home hours because we abstract from marriage and child bearing.

[8]Borella et al. (2018) show that to better match the aggregates, it is important to calibrate (or estimate) the model including both men and women in the data.

Eurostat group all transportation expenditures together, and it is not feasible to separate the portion of expenditures for use in home production from the portion for other purposes. Following Dotsey et al. (2014), we prorate transportation expenses by travel time for market and home activities that we obtained from the MTUS.[9]

Research works from the Bureau of Economic Analysis and the Bureau of Labor Statistics find discrepancies in expenditures reported in the CEX and those in the Personal Consumption Expenditures (PCE) of the National Accounts.[10] In order for us to evaluate the aggregate implications of the policies across countries, we calibrate our model using aggregate variables constructed from the National Accounts, such the ratio of investment to GDP. Hence, it is important to make sure the aggregate consumption expenditure constructed from the household survey data matches with the PCE from the National Accounts. For this reason, we adjust the average expenditures for each age constructed from the CEX so that the aggregate consumption expenditure is consistent with the PCE. To do so, we multiply the total expenditure to total income ratio in the CEX by a factor so that the resulted ratio is the same as the PCE-to-GDP ratio. We then adjust both the market and home expenditures for each age group by the same factor. The adjustment shifts the age profiles of expenditure up and down but keeps the relative expenditures constant across age groups and between market and home expenses. The expenditures for European countries are adjusted in the same way. Appendix A provides the detailed adjustment procedures.

2.2 Data Facts

In this subsection, we first document the similarity and differences in the expenditure and time allocations across countries. These are the facts we aim to account for with our quantitative model. We then report the strong correlations between expenditure and time allocations and taxes across countries.

Aggregate Hours and Expenditures. Table 1 reports the hours and expenditures across all ages with N_m denoting market hours, N_n denoting home hours, C_m denoting expenditures of market goods, and D denoting expenditures of home inputs. The hours reported are the weekly hours per adult as a fraction of the total available time—one hundred hours per week. The expenditures reported are the real expenditures as constructed above. The expenditures reported are the real

[9]As a robustness check, we use total market hours and total home hours to prorate the transportation expenditure. The data facts are almost the same as what is reported in this section.

[10]See Passero et al. (2012) for a summary about the differences in the CEX and PCE.

expenditures normalized by the real GDP per adult in the United States.[11]

For an average adult, compared to Americans, Europeans have lower market hours and higher home hours. Relative to the United States, market hours in Europe are lower by 7-26 percent or by 1.9-7.3 hours per week; in contrast, home hours in Europe are higher by 11-37 percent or by 1.6-5.7 hours per week.[12] In addition, expenditures for both market goods and home inputs are lower in all European countries than in the United States by 19-54 percent and 21-47 percent, respectively.

Table 1: Aggregate Hours and Expenditures

	Levels				% Difference from the U.S.			
Country	N_m	N_n	C_m	D	N_m	N_n	C_m	D
Austria	0.208	0.180	0.195	0.249	-25.97	15.27	-30.87	-32.93
France	0.218	0.197	0.152	0.233	-22.30	25.75	-46.10	-37.39
Italy	0.242	0.214	0.134	0.252	-13.77	36.68	-52.51	-32.13
Netherlands	0.236	0.174	0.201	0.229	-15.80	10.93	-28.56	-38.27
Norway	0.261	0.181	0.229	0.293	-6.74	15.40	-18.64	-21.07
Spain	0.230	0.200	0.128	0.196	-17.91	28.05	-54.44	-47.25
United Kingdom	0.246	0.173	0.215	0.243	-12.38	10.48	-23.82	-34.56
Average Europe	0.234	0.188	0.179	0.242	-16.41	20.37	-36.42	-34.80
United States	0.280	0.157	0.282	0.372				

Notes: Columns 2-5 report values for hours and expenditures across all ages. N_m denotes market hours, N_h denotes home hours, C_m denotes market-goods expenditure, and D denotes home-inputs expenditure. Columns 6-9 report the percent differences in the levels from the United States.

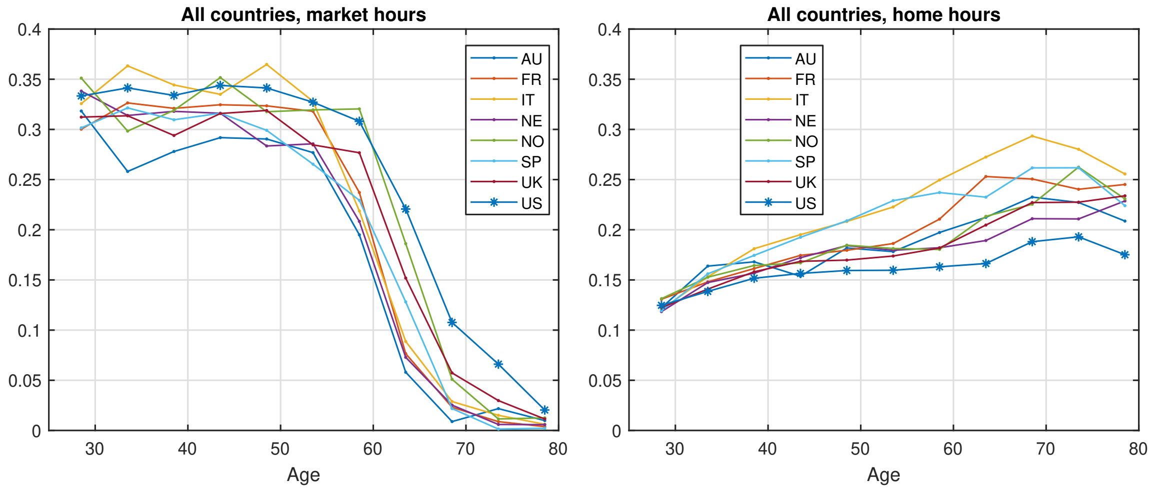
Hours and Expenditures by Age. Figure 1 displays the profiles for market and home hours by age in five-year segments. The hours profiles exhibit similar life-cycle patterns across countries. Market hours, in all countries, are flat for most of people's working lives before sharply decreasing in the late fifties. Home hours, on the other hand, increase with age and the increase is particularly large after age sixty. In most of the European countries, market hours are lower and home hours are higher than in the United States for most of the ages. More importantly, the hours are more alike at prime ages and are more divergent at old ages.

Eurostat reports expenditures by detailed consumption categories for four age groups: less than thirty, thirty to forty-four, forty-five to fifty-nine, and sixty and above. We construct expenditures for these age groups following the same procedures as for the aggregate expenditures. Table A.5 reports the expenditures by

[11]Real GDP per adult is the ratio of real GDP to population aged 25 and above.

[12]We classify gardening and pet activities to home production. Because Americans spend more time on these activities, re-classifying them to leisure will further increase the difference in home hours between European countries and the United States.

Figure 1: Age Profiles of Hours



Notes: Hours are constructed from the Multinational Time Use Study and are reported as a fraction of the total available time—one hundred hours per week. The countries are Austria (AU), France (FR), Italy (IT), Netherlands (NE), Norway (NO), Spain (SP), United Kingdom (UK), and United States (US).

age group and by country. The expenditures exhibit typical life-cycle patterns in all countries: they rise from twenties to thirties, do not vary much over the prime ages, and decline as approaching retirement ages. For each age group, expenditures on market goods and home inputs are both lower in all European countries than in the United States.

To further illustrate the differences in allocations between prime ages and old ages, Table 2 reports the percent differences of European hours and expenditures from the United States for the age groups of less than sixty and sixty and above. The table clearly shows that the percent differences from the United States in allocations between the two age groups are the largest for market hours. European market hours for the age group of sixty and above are 34-77 percent lower than in the United States while they are only 2-17 percent lower before age sixty. Hence, a large part of the cross-country differences in market hours are accounted for by the differences at old ages. The difference between the two age groups is also substantial for home hours and expenditure on market goods but at a much lesser extent than for market hours.

Correlations of Hours and Expenditures with Taxes. As discussed in the literature review of the introduction, higher tax is one critical reason for the low aggregate market hours in Europe. This motivates us to explore the relationship between taxes (consumption tax, social security tax, and income tax) and our constructed hours and expenditures across countries.

Table 3 reports the consumption and social security tax rates, where the consumption tax rates are from McDaniel (2020) and the social security tax rates are

Table 2: Hours and Expenditures by Age Group, % Difference from the U.S.

Country	Age < 60 N_m	N_n	C_m	D	Age 60+ N_m	N_n	C_m	D
Austria	-17.12	9.11	-25.52	-33.07	-76.78	20.59	-43.10	-30.02
France	-7.79	11.61	-39.63	-36.85	-72.46	35.87	-58.87	-29.10
Italy	-2.32	22.60	-43.98	-33.25	-66.27	50.55	-65.18	-25.94
Netherlands	-9.36	6.95	-22.56	-37.77	-71.95	12.71	-47.50	-36.12
Norway	-3.01	9.85	-15.86	-18.70	-34.07	25.19	-37.74	-10.98
Spain	-12.27	21.79	-48.77	-48.10	-60.76	34.88	-66.99	-42.41
United Kingdom	-8.33	5.06	-14.28	-25.86	-39.41	21.41	-47.15	-30.41
Average Europe	-8.60	12.43	-30.08	-33.37	-60.24	28.74	-52.36	-29.28

Notes: The table reports the percent differences in the levels from the United States. N_m denotes market hours, N_h denotes home hours, C_m denotes market-goods expenditures, and D denotes home-inputs expenditures.

from our reading of the policy rates including the rates on both employers and employees. As shown in Table 3, the consumption tax rates in Europe are much higher than in the United States, varying from 15 percent in Spain to 24 percent in France, compared to 7.5 percent in the United States. The social security tax rates in Europe vary from 22 percent to 33 percent, compared with the rate of 10 percent in the United States. The combined consumption and social security taxes in Europe are two to three times of their counterparts in the United States.

Table 3: Average Tax Rates (%)

Country	Consumption	Social Security
Austria	22	23
France	24	23
Italy	22	33
Netherlands	20	24
Norway	22	22
Spain	15	28
United Kingdom	16	24
United States	7.5	10

Notes: Consumption tax rates come from McDaniel (2020) and social security tax rates are from our readings of the actual policy.

Table 4 reports the cross-country correlations of hours and expenditures reported in Table 1 with the consumption taxes and social security taxes reported in Table 3. It shows that market hours N_m are negatively correlated with both types of taxes while home hours N_n are positively correlated with them. The table also shows that the expenditures on both market goods C_m and home inputs D are negatively correlated with both types of taxes.

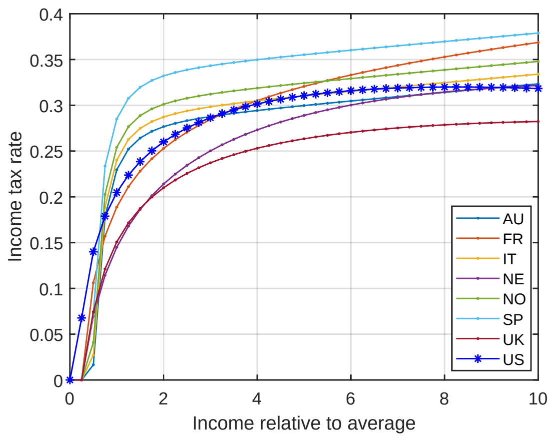
Figure 2 plots the progressive income tax functions for the studied countries,

Table 4: Correlations of Hours and Expenditures with Taxes

	Consumption	Social Security
N_m	-0.65	-0.51
N_h	0.54	0.88
C_m	-0.51	-0.89
D	-0.53	-0.80

Notes: N_m denotes market hours, N_h denotes home hours, C_m denotes market-goods expenditure, and D denotes home-inputs expenditure. Consumption tax rates come from McDaniel (2020) and social security tax rates are from our readings of the actual policy. The tax rates by country are reported in Table 3.

Figure 2: Progressive Income Tax



Notes: The countries are Austria (AU), France (FR), Italy (IT), Netherlands (NE), Norway (NO), Spain (SP), United Kingdom (UK), and United States (US).

where income is normalized by the average income in a country. The tax functions for France, the Netherlands, the United Kingdom, and the United States are from Guvenen et al. (2014) which use the OECD tax database to estimate the taxes. Guvenen et al. (2014) lump income tax and social security tax together, thus we subtract the social security tax from their estimates to derive the income tax functions.[13] Guvenen et al. (2014) do not provide estimates for Austria, Italy, Norway, and Spain. For these four countries we estimate the tax functions following the same procedures as in Guvenen et al. (2014). As shown in the figure, the income tax in the United States is less progressive than those in most European countries and the tax rates are in between those in Europe for most incomes. Because the income tax is not linear, there is no simple way to show its relationship with hours and expenditures. We therefore rely on the quantitative model for its relationship with allocations.

[13] Since social security tax is linear, we subtract the social security tax rate from the estimated constant from Guvenen et al. (2014) to derive the income tax functions.

Summary. In summary, we establish three important facts in the allocations of expenditure and hours across countries. First, compared to Americans, Europeans have lower market hours, higher home hours, and lower expenditures on market goods and home inputs both in the aggregate and by age. Second, the allocations of hours and expenditures in the market and at home have typical life-cycle patterns with most of the differences in aggregate market hours between Europe and the United States accounted for by differences in old ages. Third, the cross-country correlations with consumption and social security taxes are negative for market hours, positive for home hours, and negative for expenditures on both market goods and home inputs.

3 The Model Economy

We first use a static model to show how taxes affect the allocations of hours and expenditures at home and in the market. We then present a full-blown life-cycle model to quantify the extent to which the tax and transfer programs and market productivity can account for the documented differences in hours and expenditures between Europe and the United States.

3.1 Static Model

There is one representative household who lives for one period. The household is endowed with one unit of time and derives utility from a composite consumption good that consists of a market good and a home-produced good. The household also values leisure and allocates her time endowment to market work, home production, and leisure. The utility function is as follows:

$$U(c,l) = \frac{[\omega_3 c^{1-\frac{1}{\zeta_3}} + (1-\omega_3) l^{1-\frac{1}{\zeta_3}}]^{\frac{1-\gamma}{1-\frac{1}{\zeta_3}}} - 1}{1-\gamma}, \tag{1}$$

where l is leisure, c is the composite consumption good, $\zeta_3 > 0$ is the elasticity of substitution between l and c, and γ is the relative risk-aversion parameter. The composite consumption good is produced by aggregating the market good c_m and home-produced good c_h through a CES aggregator:

$$c = [\omega_2 c_m^{1-\frac{1}{\zeta_2}} + (1-\omega_2) c_h^{1-\frac{1}{\zeta_2}}]^{\frac{1}{1-\frac{1}{\zeta_2}}}, \tag{2}$$

where $\zeta_2 > 0$ is the elasticity of substitution between the market good and the home good. The home good is produced according to the production function:

$$c_h = [\omega_1 d^{1-\frac{1}{\zeta_1}} + (1-\omega_1) n_h^{1-\frac{1}{\zeta_1}}]^{\frac{1}{1-\frac{1}{\zeta_1}}}, \tag{3}$$

where n_h is the labor input and d is the market good used in home production and is called home input.[14] $\zeta_1 > 0$ is the elasticity of substitution between home input d and home time n_h.

Let τ_c be a proportional consumption tax and τ_i be a proportional tax on labor income. The tax revenues are discarded. Normalizing the price of market goods to one, the household's budget constraint is as follows:

$$(1+\tau_c)(c_m + d) = (1-\tau_i) w n_m, \tag{4}$$

where w is the wage rate and $n_m = 1 - l - n_h$ is market hours. The derivation of the solution to the household's maximization problem is provided in Appendix B. It yields the following two results that characterize the effects of taxes and wages (market productivity) on allocations.[15]

The first result is that $\frac{n_h}{d}$ is decreasing in w and is increasing in τ_i and τ_c. The intuition for this result is as follows. The ratio of the two inputs in home production, $\frac{n_h}{d}$, is decreasing in the price of home hours relative to home inputs. The price of home hours is the after-tax market wage. An increase in wage rate w, or a decrease in tax rate τ_i or τ_c, increases the price of home hours relative to home inputs and leads to a lower $\frac{n_h}{d}$. The magnitude of these effects depends on the size of the elasticity of substitution between home inputs and home time (ζ_1). A larger ζ_1 generates larger responses of $\frac{n_h}{d}$ to changes in wages and taxes.

The second result is that $\frac{c_m}{d}$ is decreasing in τ_c and τ_i and is increasing in w if $\zeta_2 > \zeta_1$. The change in the ratio $\frac{c_m}{d}$ depends on the substitution between home goods and market goods (ζ_2) and the substitution between home hours and home inputs (ζ_1). Specifically, a decrease in the tax rate τ_c or τ_i or an increase in wage w favors consumption in the market over consumption at home and leads to substitution from home to market goods. As shown in the first result, these changes in policies and wages also lead to substitution from home hours to home inputs. When $\zeta_2 > \zeta_1$, the substitution from home goods to market goods is stronger than that from home hours to home inputs, generating a rise in $\frac{c_m}{d}$.

[14] We follow Greenwood and Hercowitz (1991) and McGrattan et al. (1997), among others, and assume that home production takes time and home capital as inputs. In those papers, home capital consists of residential housing and consumer durables. Our definition of home inputs includes residential housing, consumer durables, and some nondurables, such as food at home. See section 2.1 for details.

[15] Boerma and Karabarbounis (2020) find similar results for wages.

Table 5: Model Validation – Data Correlations with Taxes and Productivity

	Taxes		Productivity	
	Consumption	Social Security	GDP per Adult	GDP per Hour
$\frac{N_h}{D}$	0.42	0.85	-0.93	-0.72
$\frac{C_m}{D}$	-0.17	-0.49	0.47	0.50

Notes: GDP per adult is the ratio of real GDP to population aged 25 and above and GDP per hour is the ratio between GDP per adult and market hours per adult. N_h denotes home hours, C_m denotes market-goods expenditure, and D denotes home-inputs expenditure. Consumption tax rates come from McDaniel (2020) and social security tax rates are from our readings of the actual policy. The tax rates by country are reported in table 3.

To validate the intuition from the two results, we compute the cross-country correlations of $\frac{N_h}{D}$ and $\frac{C_m}{D}$ with taxes and measures of productivity. The productivity measures are GDP per adult and GDP per hour. Both are strongly related to wages. Table 4 shows that the correlations of $\frac{N_h}{D}$ with consumption and social security taxes are both positive and with the two productivity measures are both negative, implying that countries with higher taxes or lower productivity tend to use more home hours and less home inputs to produce home goods. In contrast, the correlations of $\frac{C_m}{D}$ with both taxes are negative and with both productivity measures are positive, implying that countries with higher taxes or lower productivity tend to produce more home goods since they allocate more expenditures to home inputs. The two model results are thus consistent with the data correlations.

In summary, the static model illustrates the effects of the consumption tax, the linear tax on labor income, and the wage rate on the allocations of time and expenditure. It also shows the importance of the elasticity of substitution between market goods and home goods (ζ_2) and that between home time and home inputs (ζ_1) in generating these effects. However, it is silent on how allocations vary over the life cycle and how they are affected by the social security benefits. Next, we introduce a richer life-cycle model to quantify the effects of policies and market productivity on the allocations.

3.2 Life-Cycle Model

The model builds on Dotsey et al. (2015) by enriching the role of government. It is an overlapping generations model with an infinitely lived government. The government collects taxes on consumption and labor income to provide social security benefits to retirees and to fund government spending. There is no aggregate risk, and households face death shocks and uninsurable idiosyncratic shocks to their market labor productivity. We focus on a stationary equilibrium with constant interest rate and constant wage rate per efficiency unit of labor.

3.2.1 Market Production

A representative firm produces a final good according to the following production function:

$$Y = ZF^m(K, L_m) = ZK^\alpha L_m^{1-\alpha}, \tag{5}$$

where Z is the total factor productivity (TFP), K is the aggregate capital stock, and L_m is the aggregate labor input measured in efficiency units.

The final good can be used in four different ways. It can be consumed directly, used as an input in the production of the home good, invested in capital stock, or purchased by the government. The capital stock depreciates at rate δ^k. The representative firm pays a social security tax on its total wage bill at rate τ_f. Normalizing the price of the final good to one and denoting the interest rate by r and the wage rate per efficiency unit by w, the firm's maximization problem gives:

$$r = ZF_1^m(K, L_m) - \delta^k, \tag{6}$$

$$w = ZF_2^m(K, L_m)/(1 + \tau_f), \tag{7}$$

where $ZF_1^m(K, L_m)$ and $ZF_2^m(K, L_m)$ are the marginal product of capital and the marginal product of labor, respectively.

3.2.2 Households

Households have the same home-production function as those given in the static model. In the life-cycle model, they also derive utility from government spending. Let g be the exogenous government spending on a household and Q(g) be the utility from g. The household's utility is given by:

$$U(c, l, g) = \frac{[\omega_3 c^{1-\frac{1}{\zeta_3}} + (1-\omega_3) l^{1-\frac{1}{\zeta_3}}]^{\frac{1-\gamma}{1-\frac{1}{\zeta_3}}} - 1}{1-\gamma} + Q(g).$$

We assume that the utility from government spending is separable from a household' consumption and leisure time. This implies that the household's allocations of time and expenditures are not affected by g.

Demographics. There are T overlapping generations of households in each period. Each generation is indexed by their age $t = 1, 2, ..., T$. Hence T denotes the maximum possible age. The life span is uncertain, and the exogenous survival probability is denoted by λ_t for households of age t. We assume a constant population growth rate ϕ. Since the evolution of the population is stable, the distribution of households by age is constant at any point in time.

Labor Productivity. A worker's labor productivity in the market comprises a deterministic component and a stochastic component. The deterministic component is age dependent and is denoted by e_t. The stochastic component, denoted by ε_t^i for worker i at age t, follows a Markov process:

$$\ln \varepsilon_t^i = \rho_\varepsilon \ln \varepsilon_{t-1}^i + v_t^i, \ v_t^i \sim N(0, \sigma_\varepsilon^2). \tag{8}$$

The total productivity of worker i at age t is $e_t \varepsilon_t^i$, the product of the worker's age-t deterministic efficiency unit and age-t productivity shock. This parsimonious productivity process follows the literature and captures well the wage dynamics observed in the data.

Borrowing Constraints. Households are borrowing constrained with a debt limit equal to twice their lowest possible labor income next period, assuming that they spend half of their time working in the market. That is, at any given time a household's financial wealth next period, denoted by a', must satisfy the following condition:

$$a' \geq -e' \underline{\varepsilon}' w, \tag{9}$$

where e' is the next period's age-efficiency unit and $\underline{\varepsilon}'$ is the next period's lowest possible labor-efficiency shock.

3.2.3 Tax and Social Security System

The government maintains a pay-as-you-go social security program. In addition to taxing firms, the government imposes a social security tax on households' labor earnings to finance social security payments. Households' labor earnings are subject to a constant tax rate of τ_s up to a maximum income of $y_{\max}$. Households endogenously choose whether to retire (i.e. claim social security) each period. We allow the retired households to work. The social security claiming status is described by f' with $f' = 1$ indicating claiming and $f' = 0$ indicating non-claiming.

After claiming social security, retirees receive benefits each period. The amount of the benefit $pen(t_r, y_s)$ is determined by a household's average social security earnings y_s and is adjusted by the claiming age t_r. We allow the pension benefits to vary by the claiming age to capture the actual social security policies for early and late retirement which are prevalent in the set of countries we study. Hence the claiming age t_r is a state variable with $t_r = 0$ indicating nonretirement and $t_r = t$ indicating retired at age t. Following the actual policy, the social security benefits are calculated based on the best t_m years of earnings before retirement. The evolution of average social security earnings, described in equation (10), mimics this feature. Specifically, for a household who has not claimed social security benefits, average social security earnings y_s accumulate in the first t_m years, and from t_m years onward, y_s only accumulates when the current-period earnings y exceed the average social security earnings y_s. For a household who has claimed social security benefits, average social security earnings do not update.

$$y_s' = \begin{cases} \left[(t-1)y_s + \min(y_{max}, y)\right]/t, & t_r = 0, t \leq t_m \\ \left[(t_m-1)y_s + \min(y_{max}, y)\right]/t_m, & t_r = 0, t > t_m, y_s < \min(y_{max}, y) \\ y_s, & t_r = 0, t > t_m, y_s \geq \min(y_{max}, y) \\ y_s, & t_r > 0. \end{cases} \tag{10}$$

The government imposes taxes on consumption and labor earnings. The consumption tax is proportional, with a rate of τ_c levied on both market consumption c_m and home input d. We assume that half of the social security payment is subject to the income tax, which is progressive and the average tax rate on labor income y is $\tau(y)$. We further assume that the government uses the total tax revenues from the consumption tax, income tax, and social security tax, net of social security payments, to finance exogenous government spending G and thus balances its budget each period.

3.2.4 Equilibrium

Households' Problem. A household's state variables are $x = (t, a, \varepsilon, y_s, t_r)$, where t denotes the household's current age, a denotes financial assets carried over from last period, ε denotes the labor-productivity shock in the current period, y_s denotes average social security earnings up until the previous period, and t_r denotes retirement age. Let β be the discount factor. The household's problem is given by:

$$\begin{aligned} V(t, a, \varepsilon, y_s, t_r) = \max_{\{c_m, d, a', n_m, n_h, f'\}} \Big\{ & U(c, 1 - n_m - n_h) + \\ & \beta \lambda_t E_t V(t+1, a', \varepsilon', y_s', t_r') \Big\} \end{aligned} \tag{11}$$

subject to (2), (3), (9), (10) and

$$y = e_t \varepsilon w n_m \tag{12}$$

$$a' \leq b_t + (1+r)a + y + pen(t_r, y_s) - \tau_{ss} \min(y_{max}, y) \tag{13}$$
$$- \tau(y + 0.5pen(t_r, y_s))(y + 0.5pen(t_r, y_s)) - (1+\tau_c)(c_m + d)$$

$$t_r' = \begin{cases} 0, & f' = 0, \\ t+1, & f' = 1, \end{cases} \tag{14}$$

$$c_m \geq 0,\ d \geq 0,\ 0 \leq n_m, n_h \leq 1. \tag{15}$$

In any period, a household's resources consists of her asset holdings a, labor earnings y, received bequests b_t, and the social security benefit $pen(t_r, y_s)$.

Initial distribution of assets and bequest. At birth, a household draws her initial assets from a distribution constant for each generation. The uncertainty of life span may lead to a positive amount of assets at death, which are first used to finance the initial assets of the next generations and then equally distributed to households younger than age fifty as bequest b_t. Let $v(x)$ be the invariant distribution of people over the state space. The following equation states that the total amount of bequests equals the total amount of assets left at death less the total amount of initial assets at birth for the next generation:

$$\int b_t v(dx) = \int (1-\lambda_t)[(1+r)a']v(dx) - \int_{t=0} [a(1+r)]\, v(dx). \tag{16}$$

Definition of the Stationary Equilibrium. Let C_m be the aggregate consumption of the market good, D be the aggregate home input, I be the aggregate investment on capital, N_m be the aggregate market hours, N_h be the aggregate home hours, $G = \int gv(dx)$ be the aggregate government expenditure, and $S = \int pen(t_r, y_s)v(dx)$ be the total pension payments. The stationary equilibrium is defined as follows.

Definition 1. A stationary equilibrium is given by value function $V(x)$; policy functions $c_m(x)$, $d(x)$, $a'(x)$, $n_m(x)$, $n_h(x)$, $f'(x)$; bequest b_t; government policies τ_c, $\tau(\cdot)$, τ_f, τ_s, $pen(t_r, y_s)$, and G; interest rate r and wage rate w; and the invariant distribution $v(x)$, such that the following conditions hold:

(i) Given the interest rate, the wage, the government policies, and the bequest, the value functions and policy functions solve the household's maximization problem.

(ii) $v(x)$ is the invariant distribution of households over the state space.

(iii) Bequest b_t is determined by equation (16).

(iv) The interest rate r and wage per efficient unit w are characterized by equations (6) and (7), respectively.

(v) The government budget is balanced each period:

$$\int [\tau_c(c_m + d) + \tau(y + 0.5pen(t_r, y_s))(y + 0.5pen(t_r, y_s)) + \tau_s \min(y_{max}, y)]\, v(dx) + \tau_f w L_m = G + S$$

(vi) All markets clear.

4 Calibration to the US Economy

We calibrate the model economy to the salient features of the US economy.[16] We set the parameters of our model in two steps. In the first step, we choose parameters that can be cleanly identified outside our model. The values for these parameters are reported in Table 6. In the second step, we estimate jointly the remaining parameters by minimizing the difference between the model and data moments for households' allocations of expenditure and time. The calibrated parameters in the second step are reported in Table 7.

4.1 First-Stage Calibration

A period in the model is two years. For the purpose of exposition, the reported parameter values are converted to annual frequency, unless stated otherwise. The annual population growth rate ϕ is 1%. Each person enters the model at age twenty-four. The maximum age T is set to be ninety-eight. The conditional biannual survival probabilities λ_t, shown in the left panel of Figure 3, are taken from the Social Security Administration Life Tables in 2000 with both genders included. We set the risk-aversion parameter γ to 1.5, following Gourinchas and Parker (2002). We set the capital share α to 0.3565, following Dotsey et al. (2015), who calibrate this parameter using National Income and Product Accounts (NIPA) and Fixed Assets Tables from the Bureau of Economic Analysis. We normalize the TFP in the United States to be one.

The deterministic life-cycle profile of labor productivity for the United States, e_t, is shown in the right panel of Figure 3.[17] Appendix D describes how we use the March supplement of the Current Population Survey (CPS) to construct the

[16] See Appendix C for details of the computation algorithm.

[17] Policies could affect allocations indirectly through their effects on productivity by age. For example, higher taxes reduce market hours and thus reduce the accumulation of human capital. This will in turn generate even lower market hours. Hence the quantitative effects we find are the lower bound of the policy effects.

Table 6: First-Stage Calibrated Model Parameters

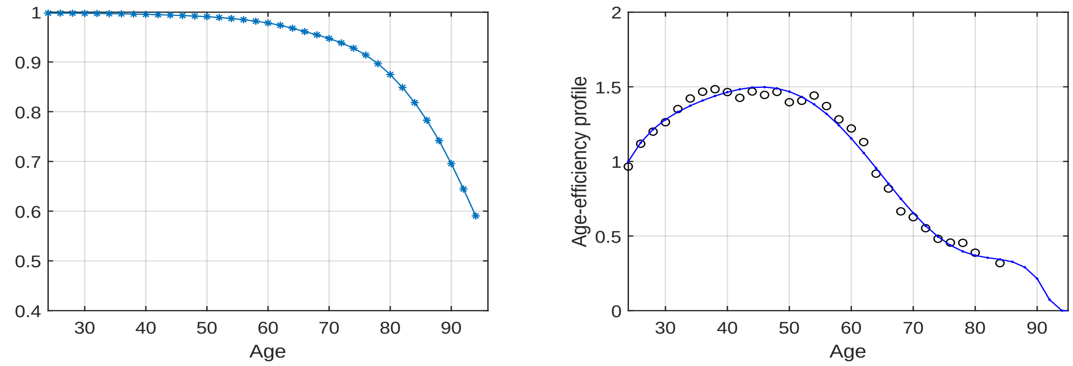
Parameters		Value	Source
Demographics			
ϕ	annual population growth	1%	
T	maximum life span	98	
λ_t	survival probability	fig. 2	SSA Life Tables
Preference			
γ	risk-aversion coefficient	1.500	Gourinchas and Parker (2002)
Technology			
α	capital share in NIPA	0.3565	Dotsey et al. (2015)
Z	TFP	1	normalization
Labor Productivity			
e_t	age-efficiency profile	fig. 2	authors' calculation
ρ_ε	AR(1) coef. of income process	0.96	Huggett (1996)
σ_ε^2	innovation of income process	0.045	Huggett (1996)
σ_1^2	var. of income process at age 24	0.38	Huggett (1996)
Government policy			
t_m	years counted in soc. sec.	36	authors' calculation
t_r	soc. sec. retirement-age range	62–70	authors' calculation
$y_{\max}$	soc. sec. tax cap	2.47	Huggett and Ventura (2000)
$pen(t_r, y_s)$	soc. sec. benefit	see text	Huggett and Ventura (2000)
τ_s	soc. sec. tax rate on employee	5.2%	authors' calculation
τ_f	soc. sec. tax rate on employer	5.2%	authors' calculation
$\tau(\cdot)$	income tax function	see text	Guvenen et al. (2014)
τ_c	consumption tax rate	7.5%	McDaniel (2020)

age-efficiency profile. The profile is consistent with that in French (2005). It is hump-shaped with a peak around age fifty. Because there are not many people older than 85 in the data, we fit the age-efficiency profile with a polynomial to obtain efficiency values after age 85. In Figure 3, circles represent data and the solid line is the fit from a polynomial.

We take the idiosyncratic productivity shock from Huggett (1996). In particular, the variance of the initial productivity shock at age twenty-four is set to 0.38, the variance of the stochastic productivity process σ_ε^2 is set to 0.045, and the AR(1) coefficient ρ_ε is set to 0.96. The joint distribution of wealth and initial labor productivity of households is taken from Dotsey et al. (2015), who calculate it using heads of household aged twenty-three to twenty-six in the Survey of Consumer Finances (2001, 2004, and 2007).

The social security system mimics the Old Age Insurance component of social security in the United States. The number of highest-earning years used to calculate the social security benefits, t_m, is thirty-six. The earliest age to claim social security benefit is sixty-two, and the age to receive the full retirement benefit is

Figure 3: US Survival Rate and Efficiency Unit



(a) Survival Rate (b) Efficiency Unit

sixty-six. The retirement benefit at age sixty-six is borrowed from Huggett and Ventura (2000):

$$pen(t_r = 66, y_s) = \left\{ \begin{array}{ll} 0.9y_s, & y_s \leq 0.2; \\ 0.18 + 0.32(y_s - 0.2), & 0.2 \leq y_s < 1.24; \\ 0.5128 + 0.15(y_s - 1.24), & 1.24 \leq y_s < y_{max}; \\ 0.6973, & y_s \geq y_{max}. \end{array} \right\}$$

The bend points and the social security earnings cap y_{max} are expressed as fractions of average earnings. The retirement benefit is adjusted by the claiming age as follows. A household retiring at age sixty-two receives 75 percent of the full pension. A household retiring at age sixty-four receives 87 percent of the full pension. A household retiring after age sixty-six receives 8 percent more pension benefits per year up to age seventy. The social security tax rates for employee τ_s and employer τ_f are both set to 5.2 percent, which are the average since the 1970s.

As discussed in section 2.2, the income tax function, shown in Figure 2, is from Guvenen et al. (2014), and the consumption tax rate is set to 7.5 percent, which comes from McDaniel (2020).

4.2 Second-Stage Calibration

There are eight parameters left for the second-stage calibration: δ^k, β, ζ_1, ζ_2, ζ_3, ω_1, ω_2, and ω_3. We jointly estimate them to match the capital-output ratio, K/Y, of 3.1, the investment-to-output ratio, I/Y, of 0.17, and the US age profiles of hours and expenditure to economy-wide income ratios at home and in the market. The calibrated parameters are reported in Table 7. The resulting depreciation rate δ^k is 0.045, a value within the range of those used in the literature. The implied interest rate on capital (net of depreciation), r, is 0.07.[18] In our model, r is the average return on capital. A 7% average annual return on capital is a value within the range of those used in the literature.

The estimation results in a value larger than one for each of the three elasticity of substitution: $\zeta_1 > 1$, $\zeta_2 > 1$, and $\zeta_3 > 1$. This implies that home time and home inputs, home goods and market goods, and consumption and leisure are all substitutes. More importantly, the estimation gives a larger value for ζ_2 than for ζ_1, implying that the substitution between home goods and market goods is stronger than that between home hours and home inputs.

Table 7: Second-Stage Calibrated Model Parameters

Parameters (8)		Value
δ^k	annual depreciation rate	0.0450
β	discount factor	0.9475
ζ_1	sub. betw. home input and n_h	1.3627
ω_1	weight on home input	0.6241
ζ_2	sub. betw. market and home goods	2.7984
ω_2	weight on market goods	0.3259
ζ_3	sub. betw. consumption and leisure	1.3257
ω_3	weight on consumption	0.5946

Although the model is quite complex and the parameters and moments do not map one to one, some parameters affect certain moments more than others do. For example, β is largely determined by K/Y and δ^k is mostly related to I/Y. The elasticity and share parameters in the utility and home-production functions play crucial roles in determining the changes in the allocations of hours and expenditures over the life cycle. The age variations in home-production time and home-input expenditure help to identify ζ_1 and ω_1. The age variations in expenditures of the market good and the home input help to pin down ζ_2 and ω_2. The age variation in the sum of market hours and home hours is useful in identifying ζ_3 and ω_3 since those two types of hours help determine leisure hours.

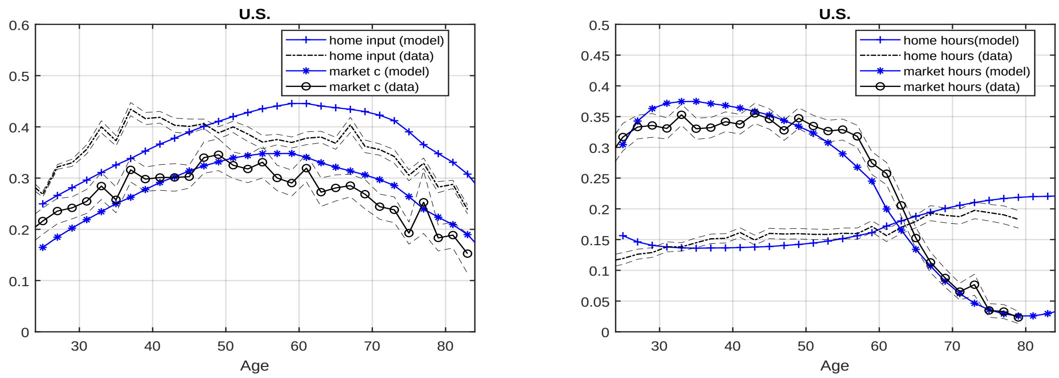
4.3 Model Fit for the US Economy

This subsection compares the predictions of the calibrated model with the actual US economy. Figure 4 compares the model-implied age profiles for hours and ex-

[18] In the stationary equilibrium, the following two conditions hold: $\frac{I}{Y} = (\delta^k + \phi)\frac{K}{Y}$ and $\frac{\alpha Y}{K} = r + \delta^k$. The first condition means that investment equals to depreciation of capital plus increase in capital due to population growth. The second condition means that the return to capital equals to interest rate plus depreciation rate. Given population growth ϕ, capital share α, $\frac{K}{Y}$, and $\frac{I}{Y}$, the above two conditions uniquely determines r and δ^k.

penditure to economy-wide income ratios with the targeted profiles, along with the 95 percent confidence interval of the data. The figure shows that the model generally matches the actual allocations of time and expenditure ratios by age both in the market and at home. The hours profiles are mostly sensitive to the age-efficiency profile, with social security also playing an important role in old ages. The borrowing constraint and precautionary-saving motive suppress the consumption of young households. As households age, these forces are alleviated and consumption expenditures increase until old ages, when the increase of mortality risk leads to a decline in the consumption path.

Figure 4: Age Profiles in the United States – Model versus Data



(a) Expenditure (b) Hours

Notes: The dashed lines are the 95 percent confidence intervals of the data.

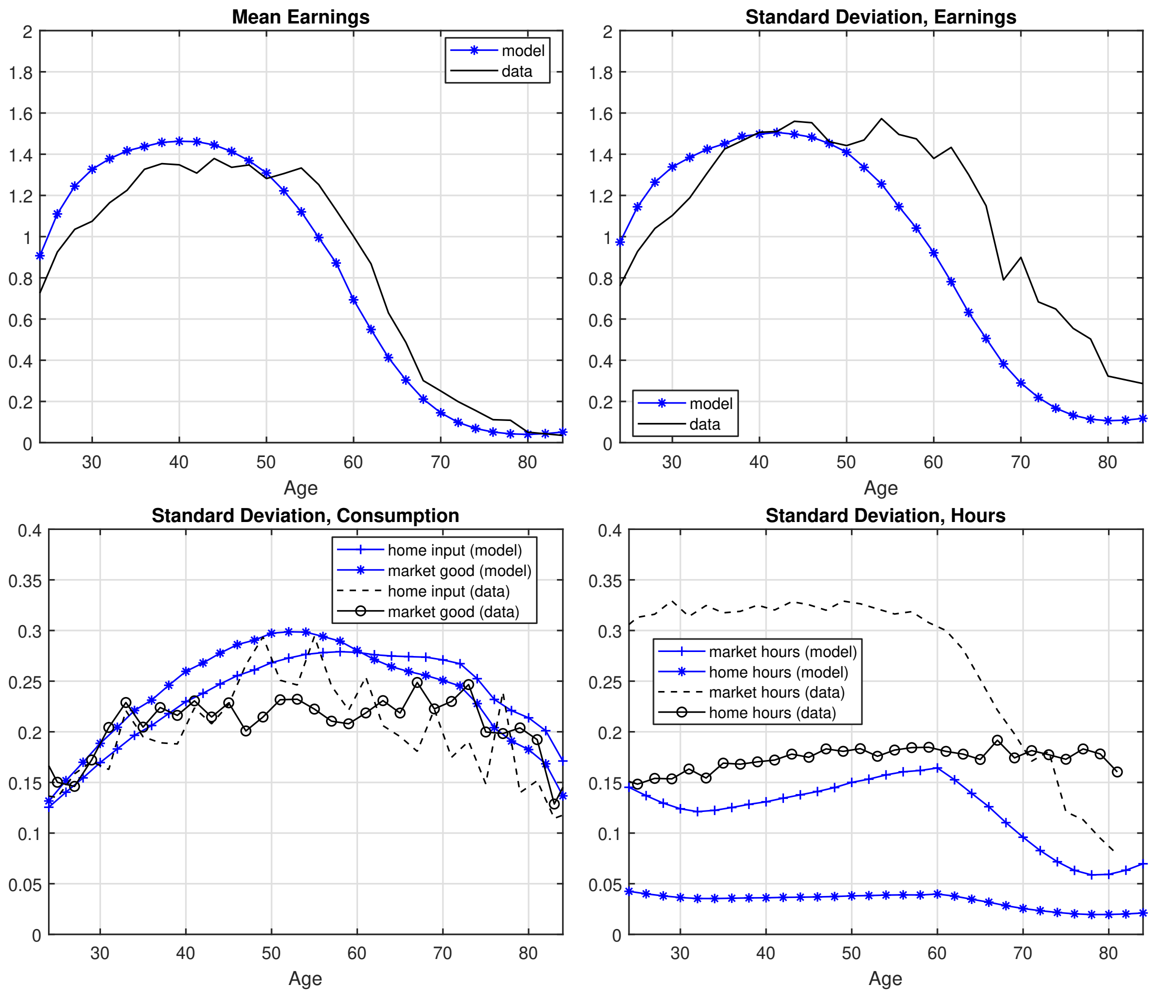
The model also matches the aggregate variables in the data. Table 8 compares the model predictions to the data with GDP per adult normalized to one in both the model and the data. In the table, the investment-to-GDP ratio is the only targeted moment, and it is matched exactly. The model-implied aggregate hours and expenditures for both market and home allocations match the data closely. As a result, government-spending-to-GDP ratio also matches data. Moreover, the model-implied ratio of social security expenditure to GDP of 5.8 percent, an untargeted moment, matches the data.

Table 8: Model and Data Comparison in the Aggregate

	N_m	N_h	C_m	D	$\frac{I}{Y}$	$\frac{G}{Y}$	$\frac{S}{Y}$
US model	0.2803	0.1565	0.2811	0.3709	0.1697	0.1929	0.0579
US data	0.2795	0.1567	0.2817	0.3716	0.1697	0.1920	0.0580

Notes: N_m denotes market-hours, N_h denotes home-hours, C_m denotes market-goods expenditure, and D denotes home-inputs expenditure. I/Y and G/Y are investment-to-GDP ratio and government-spending-to-GDP-ratio, respectively. The data values for I/Y and G/Y are the averages between 2005-2015, computed from the NIPA tables. S/Y is the social-security-expenditure-to-GDP ratio. The data value for S/Y, from the OECD Social Expenditure Database, is the average ratio of public expenditure on old-age pension benefits to GDP between 2005-2015.

Figure 5: Untargeted Moments – Model vs Data



Notes: Hours are constructed from the Multinational Time Use Study and are reported as a fraction of the total available time—one hundred hours per week. Expenditure to economy-wide income ratios are constructed from the CEX. Earnings are normalized by the mean earnings both in the model and the data.

We further validate the model calibration by comparing the model implications on the untargeted mean earnings and the standard deviations of earnings, hours, and expenditure to economy-wide income ratios by age in Figure 5. The model predictions on mean earnings and the standard deviation of earnings match the data closely. The model generates hump-shaped volatility of expenditure ratios by age, as is observed in the data (bottom left of Figure 5). In the data, the standard deviations of both expenditure ratios are about 0.15 at the beginning of the life cycle, increase to 0.25 around age fifties, and decrease to their initial values of 0.15 at age eighties. The model matches these patterns closely. The model predictions on the standard deviations of hours are consistent with the life-cycle patterns in the data while the implied dispersion is lower than in the data. Factors that are not included in our model, such as part-time work, differences in work arrangements by industry and occupation, and differences in family situations, could also contribute to the dispersion in hours.

5 Cross-country Study

In this section, we simulate the model economy for Europe. In the simulation, we assume that preferences are the same in Europe and the United States but policies and productivity differ. In particular, countries differ in TFP and the tax and benefit systems, including consumption tax, income tax, and social security. We first discuss parameters in each European country that differ from those in the United States. We then simulate the calibrated model for each European country and compare the predicted hours and expenditures with those in the data and in the United States. Lastly, we decompose the model-predicted differences between the United States and Europe into contributions from policies and TFP.

5.1 Parameters Across Countries

Exogenous Differences in Policies. This subsection describes the parameters that have different values from those in the United States. The consumption tax rates in Europe, reported in Table 3, come from McDaniel (2020). The tax rates in Europe are much higher than in the United States, varying from 15 percent in Spain to 24 percent in France, compared to 7.5 percent in the United States. The income tax functions are presented in Figure 2 in section 2.2. As shown in the figure, the income tax in the United States is less progressive than those in most European countries and the tax rates are in between those in Europe.

The social security system differs dramatically across countries. We model the systems as close to the real-world policies as possible for each country. In particular, the social security program differs by country in the following dimensions: the tax rate on workers τ_s and firms τ_f, the earnings cap that the tax is subject to $y_{\max}$, the number of working years used in calculating the social security benefits t_m, and the policies to calibrate the benefits $pen(t_r, y_s)$ including the normal retirement age, the reduction (increase) in pension benefits if claimed earlier (later) than the normal retirement age, and the benefit-replacement rate at the normal retirement age. Table E.6 in Appendix E provides the detailed parameter values by country. Overall, the social security tax rate is much higher in Europe than in the United States with the sum of the rates on workers and firms varying between 22 percent and 33 percent, compared with the rate of 10 percent in the United States. The number of working years used in calculating the social security benefits is generally lower in Europe than in the United States. The policies for early and late retirement vary a lot and there is no systematic patterns across countries.

Endogenous differences in Parameters. In the simulation, we assume that each European country is a small open economy and thus has the same interest rate as the United States. We assume that the pension benefit is a linear function of the average social security earnings y_s with a benefit-replacement rate of *pen* for the normal retirement age. Besides parameters for the policies discussed above, there are three other parameters that also differ across countries and are calibrated jointly: social security benefit-replacement rate at the normal retirement age *pen*, TFP Z, and the depreciation rate δ^k. The parameter *pen* is largely determined by the ratio of aggregate social security spending to GDP. TFP Z is pinned down by GDP per adult relative to the United States for each European country. The investment-to-GDP ratio varies from 14 percent in the United Kingdom to 21 percent in Norway. We adjust the depreciation rate to generate differences in this ratio.[19] The resulted parameter values along with the data targets and model implications on the same moments are reported in Table 9. The model matches the targeted moments exactly. The model implied TFP is lower in Europe than in the United States except in Norway. The implied depreciation rate is between 3-9 percent and is within the values used in the literature. The implied replacement rate for social security is between 13-51 percent.

5.2 Results

In this subsection, we discuss the simulation results and compare the model predictions with the data on hours and expenditures in the aggregate and by age. We use three statistics to evaluate the model performance. The first one is the ratio of the average European percentage difference from the United states between model and data. This statistic measures the average fraction of the European differences

[19]Combining the two conditions in footnote 18 gives the equation: $\frac{I}{Y} = (\delta^k + \phi)\frac{\alpha}{r+\delta^k}$. Given the interest rate r, capital share α, population growth ϕ, the depreciation rate δ^k is determined by the investment-to-GDP ratio $\frac{I}{Y}$.

Table 9: Calibrated Parameters and Targeted Moments in Europe

Parameter	Targeted Moments
Z	GDP per Adult Relative to U.S., $\frac{Y}{Y_{US}}$
δ^k	Investment to GDP Ratio, $\frac{I}{Y}$
Pen	Social Security Spending to GDP Ratio, $\frac{S}{Y}$

Parameter Values, Targeted Moments, and Predictions from the Model

Country	Parameter			Targets, Data			Targets, Model		
	Z	δ^k	Pen	$\frac{Y}{Y_{US}}$	$\frac{I}{Y}$	$\frac{S}{Y}$	$\frac{Y}{Y_{US}}$	$\frac{I}{Y}$	$\frac{S}{Y}$
Austria	0.99	0.08	0.40	0.78	0.21	0.11	0.78	0.21	0.11
France	0.89	0.06	0.40	0.72	0.19	0.11	0.72	0.19	0.11
Italy	0.83	0.04	0.36	0.64	0.17	0.12	0.64	0.17	0.12
Netherlands	0.88	0.04	0.51	0.79	0.17	0.09	0.79	0.17	0.09
Norway	1.17	0.09	0.13	0.98	0.22	0.05	0.98	0.22	0.05
Spain	0.84	0.07	0.33	0.57	0.20	0.07	0.57	0.20	0.07
United Kingdom	0.81	0.03	0.28	0.73	0.14	0.09	0.73	0.14	0.09

Notes: Social security spending to GDP ratio is the ratio of public expenditure on old-age pension benefits to GDP from the OECD Social Expenditure Database. The data values for GDP per adult relative to the United States are calculated from the ratio between real GDP from the Penn World Tables 10.0. and the size of population aged 25 and above from the OECD. The data values for investment to GDP ratio are calculated from tables for National Accounts from Eurostat.

from the United States in the data explained by the model. The second statistic is the correlation coefficient between model and data. The last one is the coefficient of determination as used in Chakraborty et al. (2015) which measures the variations in the data captured by the model.[20]

Aggregate Hours and Expenditures. Table 10 reports the model implied percentage differences on hours and expenditures between each European country and the United States against the data. The model can generate lower market hours, higher home hours, and lower expenditures for both market goods and home inputs in Europe than in the United States. On average, across all the studied European countries, the model can account for 70 percent (-11.41/-16.41) of the difference in market hours from the United States, 47 percent (9.51/20.37) of the difference in home hours, 99 percent (-34.43/-34.80) of the difference in expenditures for home inputs, while slightly over-predict the difference in expenditures for market goods.[21] The correlation coefficients and the coefficients of determination between model and data are all positive and sizable. In particular, as measured by the coefficient of determination, the model can account for 75 percent of the cross-country variation in market hours, 68 percent in home hours, and 95 percent

[20]For any given variable y, the coefficient of determination equals $R^2 = 1 - SS_e/SS_T$ where $SS_e = \sum_i (y_{i,model} - y_{i,data})^2$ and $SS_T = \sum_i (y_{i,data} - y_{US})^2$, where $y_{i,model}$ is the value predicted by the model for country i, $y_{i,data}$ is the value taken by variable y in such country, and y_{US} is the value taken by variable y in the data for the United States. It compares the "loss" associated with the model prediction relative to the "loss" associated with the U.S. data.

[21]The model implied government spending to GDP ratios are also reasonable close to the data. Please see Table F.7 in Appendix F.

in expenditures on both market goods and home inputs.

Table 10: Aggregate Hours and Expenditures – Model *vs* Data

Country	Model (% Diff. from the U.S.) N_m	N_n	C_m	D	Data (% Diff. from the U.S.) N_m	N_n	C_m	D
Austria	-13.06	9.46	-38.50	-29.48	-25.97	15.27	-30.87	-32.93
France	-8.46	8.75	-50.14	-39.27	-22.30	25.75	-46.10	-37.39
Italy	-17.30	14.19	-58.44	-46.59	-13.77	36.68	-52.51	-32.13
Netherlands	-5.35	5.24	-31.44	-23.90	-15.80	10.93	-28.56	-38.27
Norway	-9.42	6.58	-29.61	-22.03	-6.74	15.40	-18.64	-21.07
Spain	-19.73	15.72	-62.36	-49.82	-17.91	28.05	-54.44	-47.25
United Kingdom	-6.56	6.65	-38.70	-29.95	-12.38	10.48	-23.82	-34.56
Average Europe	-11.41	9.51	-44.17	-34.43	-16.41	20.37	-36.42	-34.80
% Explained	69.53	46.71	121.28	98.95				
Correlation	0.18	0.85	0.96	0.61				
Coeff. Determ	0.75	0.68	0.95	0.95				

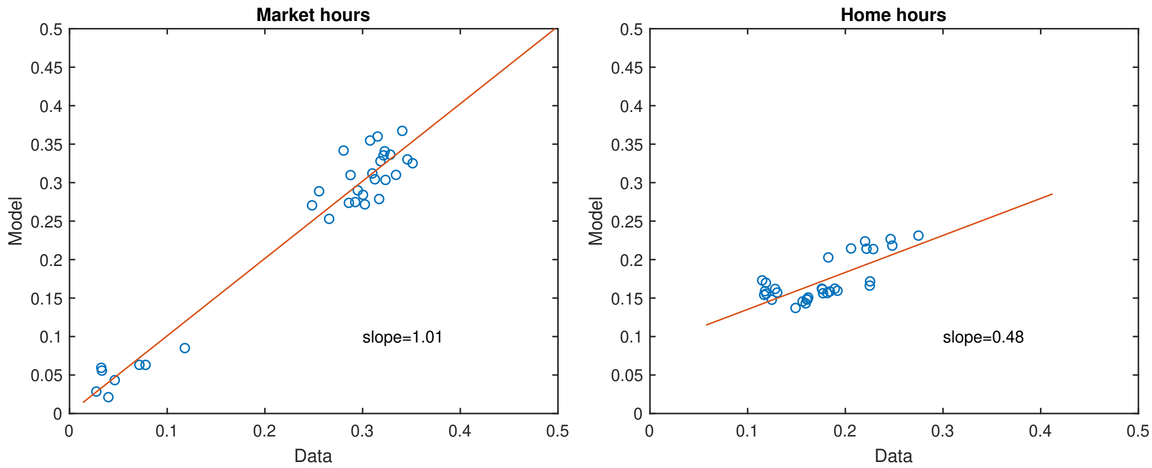
Notes: "% diff. from the U.S." is calculated as (Europe/US-1)*100. "% explained" is the ratio of the average European percentage difference from the United states in the model to that in the data "Coeff. Determ" refers to the coefficient of determination.

In subsection 5.3, we quantify the contribution of each country-specific feature in generating those results, while we summarize the key mechanisms for the results here. In the model, lower TFP and higher taxes in Europe favor home production over market production and thus increase home goods and home hours and reduce market goods and market hours. As implied by the positive relationship of $\frac{N_h}{D}$ with taxes and the negative relationship with productivity in the static model, lower TFP and higher taxes in Europe also favor home hours over home inputs in the production of home goods and thus increase home hours and reduce home inputs. The estimation implies that the substitutability between home goods and market goods is bigger than that between home time and home inputs ($\zeta_2 > \zeta_1$). Thus the negative relationship of $\frac{C_m}{D}$ with taxes and the positive relationship with productivity from the static model imply that higher taxes and lower TFP in European countries generate a larger decline in expenditures on market goods than on home inputs. These intuitions imply that Europe's TFP and tax system favor production and consumption at home relative to production and consumption in the market.

Hours and Expenditures by Age. Next we compare the model predictions on the allocations of time and expenditures for market and home by age with the data. Figure 6 plots the model predictions on hours against the data. It pools hours for the four age groups (<30, 30-44, 45-59, 60+) and for all countries together and each circle is hours for a specific age group in a specific country. Figure 7 plots the model predictions on expenditures against the data in the same way as Figure 6.

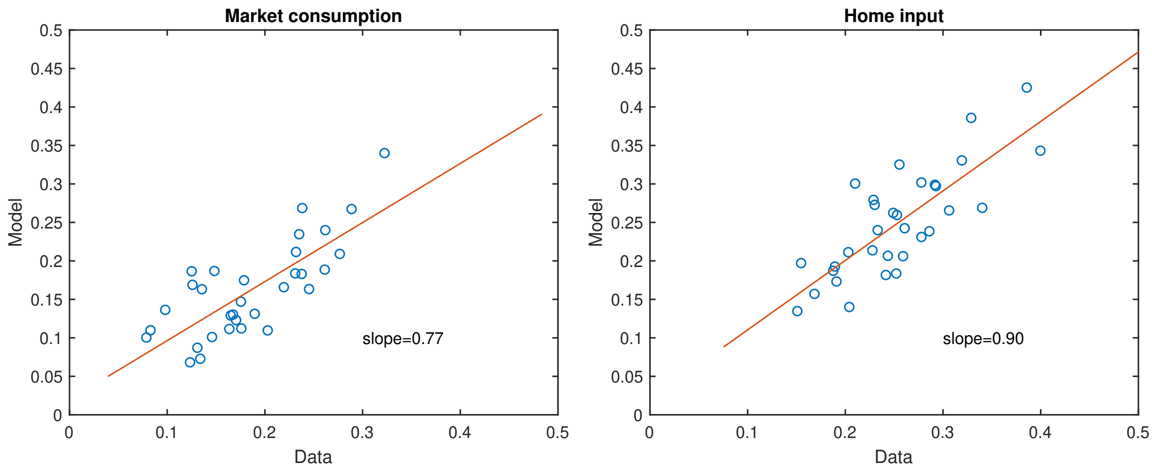
As the figures show, the model predictions on hours and expenditures line up with the data extremely well. The linear regression coefficients of model against data are all positive and significant at 1 percent level with values of 1.01, 0.48, 0.77, and 0.90 for market hours, home hours, market goods expenditure, and home inputs expenditure, respectively. The size of these coefficients implies that the model performs well in predicting the cross-country differences in allocations because if the model accounts perfectly for the data, all circles will be on the 45 degree line and thus the model fits the data better if the slope is closer to one.

Figure 6: Hours by Age Group – Model *vs* Data



Notes: Model and data comparison by age. Each circle is the average at each of the four age groups of < 30, 30-44, 45-59, and 60+ for a specific country. The red lines are the fitted linear regression lines.

Figure 7: Expenditures by Age Group – Model *vs* Data



Notes: Model and data comparison by age. Each data is the average at each of the four age groups of < 30, 30-44, 45-59, and 60+ for a specific country. The red lines are the fitted linear regression lines.

To evaluate the model performance by age, Table 11 reports the same statistics used in Table 10, calculated using the scattered data in Figures 6 and 7. The percent explained for all four allocations are close to the aggregate percent explained reported in Table 10. The correlation coefficients and the coefficients of determination are all sizable.

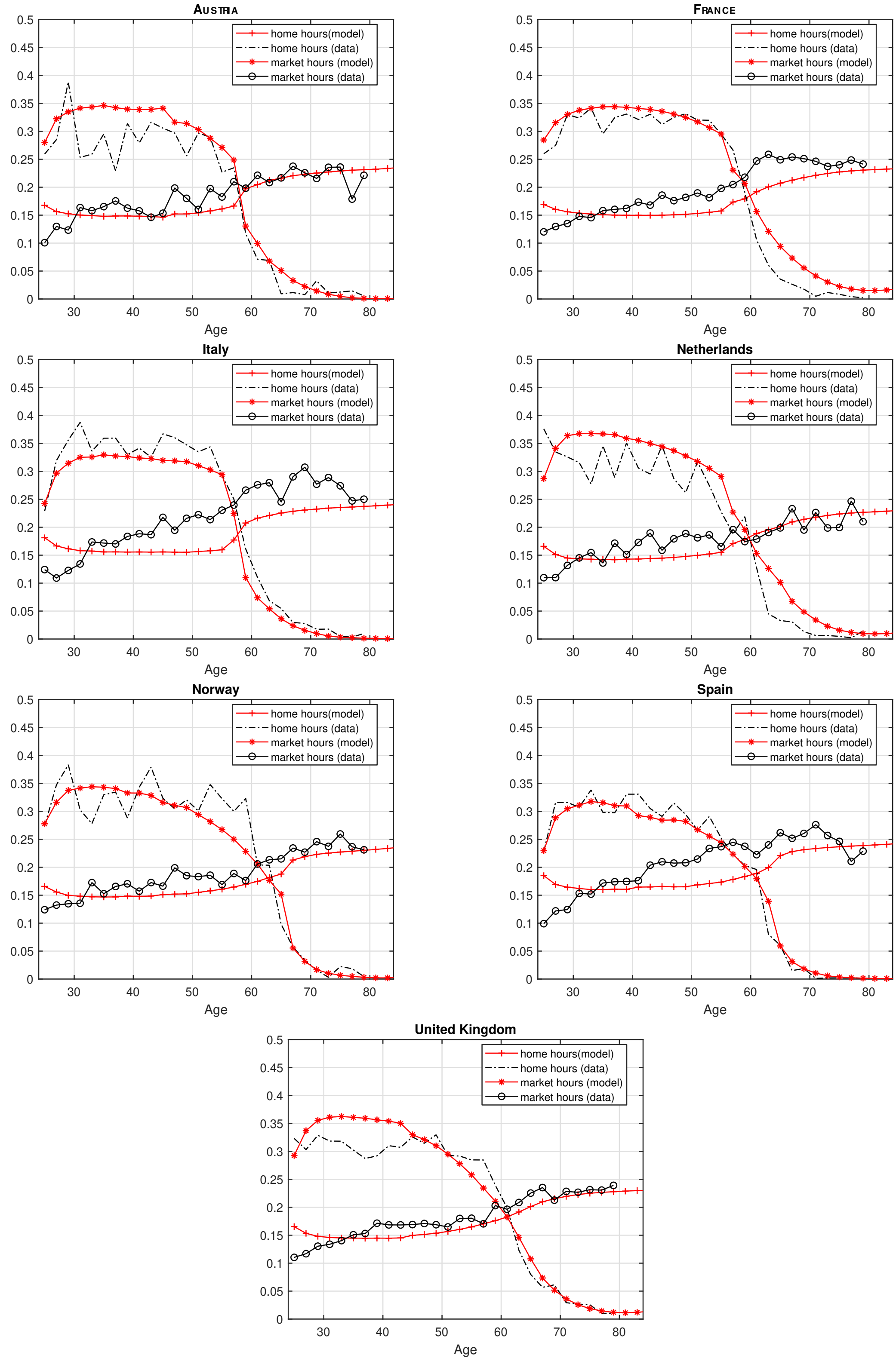
Table 11: Model Evaluation across All Ages

	N_m	N_h	C_m	D
% Explained	82.06	63.41	122.78	104.00
Correlation	0.98	0.74	0.77	0.79
Coeff. Determ	0.73	0.26	0.77	0.89

Notes: % explained is the ratio of the average European percent difference from the United states between model and data. Percent difference from the United States is calculated as (Europe/US-1)*100. "Coeff. Determ" refers to the coefficient of determination.

Figure 8 plots the model implied life-cycle profiles for market hours and home hours against the data for each country. Overall, the model matches the data well. It generates the flat market hours at prime ages and the decline around age fifties in each country as well as the large rise in home hours after age sixty. Table 2 shows that the cross-country differences in market hours are much larger for the age group of sixty and above. To evaluate the model's performance along this dimension, columns 2-5 of Table 12 compare the percent differences in market hours from the United States between model and data for the age groups of less than sixty and sixty and above. The table shows that the model indeed predicts substantially lower market hours in Europe for the age group of sixty and above. On average, the model generated European market hours are 43.78 percent lower for the group of sixty and above and thus account for 73 percent (-43.78/-60.24) of the difference in market hours between average Europe and the United States for this age group. In contrast, the model generated European market hours are 8.60 percent lower for the group of less than sixty and thus account for 100 percent (-8.60/-8.61) of the differences in market hours between average Europe and the United States for this younger group. As evaluated by the coefficient of determination, the model can account for 53 percent of the cross-country variation in market hours for the group of less than sixty and 95 percent for the group of sixty and above.

Figure 8: Age Profiles of Hours – Model *vs* Data



Notes: This figure plots hours in the data and in the Model. Hours in the data are constructed from the Multinational Time Use Study and are reported as a fraction of the total available time—one hundred hours per week.

Table 12: Market Hours by Age – Model *vs* Data, % Difference from the U.S.

Country	Benchmark				Exogenous Retirement			
	Age < 60		Age 60+		Age < 60		Age 60+	
	Model	Data	Model	Data	Model	Data	Model	Data
Austria	-8.20	-17.12	-66.46	-76.76	-6.37	-17.12	-40.12	-76.76
France	-6.52	-7.81	-30.17	-72.47	-6.26	-7.81	-27.75	-72.47
Italy	-11.96	-2.31	-75.06	-66.31	-11.41	-2.31	-43.70	-66.31
Netherlands	-2.82	-9.37	-34.42	-71.93	-2.20	-9.37	-32.98	-71.93
Norway	-8.35	-3.00	-25.71	-34.07	-7.45	-3.00	-31.54	-34.07
Spain	-17.28	-12.28	-49.00	-60.77	-16.03	-12.28	-42.58	-60.77
United Kingdom	-5.06	-8.35	-25.64	-39.40	-3.50	-8.35	-28.94	-39.40
Average Europe	-8.60	-8.61	-43.78	-60.24	-7.60	-8.61	-35.38	-60.24
% Explained	99.90		72.67		88.34		58.72	
Correlation	0.34		0.77		0.26		0.82	
Coeff. Determ	0.53		0.95		0.43		0.93	

Notes: % difference from the United States is calculated as (Europe/US-1)*100. "Coeff. Determ" refers to the coefficient of determination.

Exogenous Retirement. In the benchmark simulation, we allow households to endogenously choose the retirement age and we also incorporate the cross-country differences in the normal retirement age and the social security rules for early and late retirement. Hence the pension benefits vary by the retirement age in a given country. To explore the importance of endogenous retirement and the associated policy details, as a sensitivity analysis, we eliminate the endogenous choice for retirement and the early and late retirement policies, and set the retirement age to be age 66 and the years of earnings used to calculate social security benefits to be 36 years as in the United States. For each country, we re-estimate the parameters in Table 9 as in the benchmark simulation. Columns 6-9 of Table 12 show that while this version of the model generates similar correlation coefficients and coefficients of determination, it generates much smaller differences in market hours from the United States than the benchmark simulation.[22] Specifically, the model accounted average difference in market hours between the studied European countries and the United States reduces to 59 percent for the older group and to 88 percent for the younger group. This result highlights the importance of modeling endogenous retirement and the associated policy details in accounting for the cross-country differences in market hours.

[22]Figure F.1 plots the model implied market hours and home hours against the data for each country with exogenous retirement.

5.3 Decomposition

This subsection evaluates the quantitative effect of each country-specific feature in accounting for the differences in allocations of expenditure and time between the United States and Europe. We proceed by comparing the changes in the allocations after replacing one of the features in each of the simulated benchmark European economy with that in the United States. Table 13 reports the percent changes in the allocations of hours and expenditures in the aggregate from each country's benchmark economy after changing each factor. As a comparison, the model-implied differences between each country's benchmark economy and the calibrated US economy are reported in panel (f). Table 14 reports the same percent changes in the allocations by age group averaged across European countries.

Consumption Tax. Panel (a) of Table 13 reports the aggregate effect of replacing the consumption tax in each country with the US consumption tax. Unsurprisingly, when we apply the lower US rate to Europe, market consumption becomes cheaper and households choose to consume more of it. Because home inputs and home time are substitutes ($\zeta_1 > 1$), a reduction in the home input price leads households to substitute home hours with home inputs. Hence they reduce home hours and increase home inputs. As a result, the reduction in consumption tax raises the consumption of both market goods and home inputs. Because consumption and leisure are substitutes ($\zeta_3 > 1$), the substitution effect is larger than the income effect and therefore the increase in consumption leads to a decrease in leisure time. The decrease in leisure explains why market hours increase more than the decline in home hours.

More interestingly, the increase in expenditure is larger for market goods than for home inputs. This is because the elasticity of substitution between market goods and home goods is larger than that between home inputs and home time ($\zeta_2 > \zeta_1$) and therefore, as demonstrated in the static model, a lower consumption tax rate induces a stronger substitution from home goods to market goods than from home time to home inputs and thereby generates a larger increase in market goods than in home inputs.

As for the magnitude, the consumption tax alone can account for 24 percent (3.15/13.26) of the average cross-country difference in market hours generated by the model, 26 percent (-2.23/-8.58) of the average difference in home hours, 20 percent (17.83/88.65) of the average difference in market-goods expenditure, and 22 percent (12.34/56.48) of the average difference in home-inputs expenditure,

Panel (a) of Table 14 reports similar percent changes as those in Table 13 but by age group and averaged across countries. Because the consumption tax rate

Table 13: Decomposition – Percent Change in Aggregate Allocations

	(a). Consumption Tax				(b). Social Security			
	N_m	N_h	C_m	D	N_m	N_h	C_m	D
Austria	3.54	-2.52	20.70	14.35	3.58	-1.96	9.12	6.54
France	4.11	-2.92	23.22	15.90	-1.71	-0.41	14.98	11.07
Italy	3.29	-2.24	20.35	13.95	4.70	-3.31	29.94	20.75
Netherlands	3.23	-2.39	17.87	12.48	0.82	-0.73	1.94	1.98
Norway	3.47	-2.60	20.37	14.20	3.42	-2.58	22.05	15.07
Spain	2.10	-1.27	10.18	7.05	3.58	-2.37	22.98	15.41
United Kingdom	2.29	-1.67	12.10	8.48	-0.06	-0.96	12.57	9.48
Average Europe	3.15	-2.23	17.83	12.34	2.05	-1.76	16.23	11.47
% Rel. US Benchmark	23.73	25.98	20.11	21.85	15.44	20.51	18.30	20.31

	(c). Income Tax				(d). All Policy			
	N_m	N_h	C_m	D	N_m	N_h	C_m	D
Austria	5.51	-2.06	1.25	0.87	10.82	-5.80	33.41	22.93
France	0.40	-0.02	0.48	-0.16	2.35	-3.17	42.05	28.47
Italy	8.38	-3.02	5.22	3.35	12.18	-7.02	61.34	40.57
Netherlands	-1.99	1.49	-7.01	-5.53	2.04	-1.68	11.55	8.27
Norway	6.97	-2.96	7.32	4.74	12.66	-7.66	56.79	37.61
Spain	7.90	-3.18	14.64	9.53	12.39	-6.41	54.91	35.38
United Kingdom	-2.28	1.62	-9.71	-7.06	-0.04	-1.04	14.08	10.46
Average Europe	3.56	-1.16	1.74	0.82	7.49	-4.68	39.16	26.24
% Rel. US Benchmark	26.81	13.53	1.96	1.45	56.45	54.56	44.17	46.46

	(e). TFP				(f). US Benchmark			
	N_m	N_h	C_m	D	N_m	N_h	C_m	D
Austria	0.25	-0.18	1.30	0.92	15.02	-8.64	62.58	41.78
France	5.20	-3.70	30.26	20.59	9.24	-8.05	100.50	64.62
Italy	7.75	-5.18	52.12	34.54	20.92	-12.42	140.67	87.23
Netherlands	5.58	-4.21	33.43	22.92	5.65	-4.98	45.87	31.43
Norway	-6.17	4.84	-30.38	-22.67	10.40	-6.18	42.11	28.25
Spain	8.28	-5.23	52.15	34.44	24.58	-13.58	165.69	99.30
United Kingdom	9.47	-6.95	61.92	41.26	7.03	-6.23	63.15	42.76
Average Europe	4.34	-2.94	28.69	18.86	13.26	-8.58	88.65	56.48
% Rel. US Benchmark	32.70	34.30	32.36	33.39	100.00	100.00	100.00	100.00

Notes: This table shows the percent changes in each aggregate variable from each country's benchmark in the decomposition. "% Rel. US" is the ratio between "Average Europe" in each decomposition and "Average Europe" in case (f).

Table 14: Decomposition – Percent Change in Allocations by Age

(a). Consumption Tax

Age	N_m	N_h	C_m	D
< 30	2.81	-2.41	18.99	12.94
30-44	2.67	-2.61	18.19	12.59
45-59	3.00	-2.40	17.83	12.40
60+	5.70	-1.33	17.72	12.24

(b). Social Security

Age	N_m	N_h	C_m	D
< 30	-0.25	-1.08	18.63	13.50
30-44	-1.06	-0.50	16.54	12.10
45-59	1.27	-1.53	14.58	10.40
60+	57.60	-2.79	15.45	9.72

(c). Income Tax

Age	N_m	N_h	C_m	D
< 30	2.81	-0.81	0.03	-1.22
30-44	3.21	-1.49	1.04	0.04
45-59	0.02	0.03	1.61	1.03
60+	43.73	-1.76	3.58	2.46

(d). All Policy

Age	N_m	N_h	C_m	D
< 30	4.55	-3.95	41.09	26.77
30-44	4.19	-4.28	39.01	26.31
45-59	4.85	-4.10	37.30	25.46
60+	90.10	-5.23	39.37	25.25

(e). TFP

Age	N_m	N_h	C_m	D
< 30	4.62	-3.49	30.15	19.27
30-44	3.99	-3.59	28.73	18.76
45-59	4.37	-3.23	28.38	18.73
60+	6.39	-1.76	28.72	19.09

(f). US Benchmark

Age	N_m	N_h	C_m	D
< 30	10.08	-8.32	93.49	57.75
30-44	9.12	-8.82	88.70	56.71
45-59	10.45	-8.33	85.59	55.38
60+	108.55	-7.86	88.69	55.08

Notes: This table shows the percent changes in each aggregate variable from the benchmark for each country in the decomposition.

is the same for every age group, the percent increases in expenditures are similar across age groups for both market goods and home inputs. The percent increases in market hours are slightly larger for the age group of sixty and above.

Social Security System. As the combined social security tax rate for employers and employees falls from 22-33 percent to 10 percent in this decomposition experiment, households have more income to spend. As a result, they increase expenditures on both market goods and home inputs. As reported in Table 13, differences in the social security system contribute to 18 percent of the model generated cross-country difference in expenditure on market goods and 20 percent of the difference in expenditure on home inputs. The magnitude of the effect is substantial but slightly smaller than that of the consumption tax.

The impacts of social security system on hours and expenditures vary substantially by age. As shown in Panel (b) of Table 14, when social security taxes are reduced and social security benefits become less generous, market hours decrease at younger ages and increase around retirement age. This is driven by two important changes in the social security system. First, the reduction in the tax rate and pension benefit leads households to smooth working hours over their lives and therefore they reduce market hours at younger ages and increase market hours at older ages. This is mostly responsible for the reduction in market hours before age fifties. Second, the number of years used in calculating social security benefits is lower in Europe and thus increases in this decomposition experiment. Hence, to maximize social security benefits, households choose to retire later and work more years. Correspondingly they increase their market hours and decrease their home hours at older ages. Compared to the total model generated differences between the United States and Europe, reported in panel (f) of Table 14, social security is the most important factor for the low market hours and high home hours for age sixty and above in Europe. For this age group, it accounts for 53 percent (57.60/108.55) of the average model generated difference in market hours between Europe and the United States and 36 percent (-2.79/-7.86) for home hours. In addition, because of the reduction in pension benefits, the percent increases in expenditures are smaller at older ages.

Income Tax. As shown in Figure 2, the income tax in the United States is in between those in Europe and generally is less progressive than in Europe. Overall the tax rates are lower in the Netherlands and the United Kingdom and higher in other European countries than in the United Sates. Hence applying the US taxes generates lower market hours, higher home hours, and lower expenditures for both market goods and home inputs in the Netherlands and the United Kingdom and generates the opposite changes in allocations in other countries. The magnitude of the effects on market and home hours is comparable to those of the consumption tax and social security but is much smaller for expenditures. More importantly, as reported in Table 14, the effect on market hours is much larger for age sixty and above and for this age group it can account for 40 percent (43.73/108.55) of the model generated average difference in Europe from the United States. This is consistent with the empirical and theoretical finding that labor supply is more elastic at old ages than young ages (see, for example, French (2000) and Borella et al. (2022)).

All Policies. In the decomposition exercises discussed so far, we changed only one specific policy to the US level and left all remaining policies at the country-specific level. To separate the effects of policies from the effects of TFP, we now conduct a decomposition exercise in which we use all US policy variables. Panel (d) of Table 13 reports the results for this decomposition. On average all policies combined can account for 44 percent of the model difference in the expenditure on market goods and 46 percent on home inputs between Europe and the United States. Among the policies, the consumption tax and social security system are more important than the income tax in determining expenditure allocations. As for hours, all policies combined can account for 56 percent of the model difference on market hours and 55 percent on home hours.

TFP. As expected, panel (e) of Table 13 shows that applying the higher US TFP to Europe generates higher market hours, lower home hours, and higher expenditures. As reported in Table 9, TFP is lower in all European countries except for Norway. Thus the qualitative changes of allocations in Norway are opposite to other countries. As shown in the static model, $\frac{C_m}{D}$ is increasing with wages and therefore higher TFP generates a larger percent change in market goods than in home inputs. On average, the difference in TFP alone can account for 33 percent of the model difference in aggregate market hours and 34 percent for home hours between Europe and the United States, compared to a contribution of 56 percent for market hours and 55 percent for home hours from all policies combined. In addition, the difference in TFP can account for one-third of the model difference in expenditures on both market goods and home inputs, compared to a contribution of 44 percent for market goods and 46 percent for home inputs from all policies combined. Hence the decomposition shows that policies are more important than TFP in accounting for the differences in allocations between the United States and Europe.

Panel (e) of Table 14 reports the changes in the expenditures and hours by age when applying the US TFP to Europe. Because TFP changes productivity in the same proportion across ages, the quantitative effects for expenditures are similar across age groups. The percent changes for market hours are larger for age sixty and above because their labor supply is more elastic. Changes in home hours are the reverse of the changes in market hours over the life cycle, but the changes are mitigated because leisure hours change in the same direction as home hours.

Summary To summarize, the decomposition shows that the cross-country differences in TFP account for about one-third of the model generated average differences between Europe and the United States in aggregate expenditures and hours both in the market and at home, and the cross-country differences in policies account for 44-56 percent of the differences. Among the three policies, consumption tax and social security each account for one-fifth of the average differences in expenditures on both market goods and home inputs whereas income tax has much smaller effects. Moreover, while TFP and consumption tax are more important in explaining the cross-country differences in market hours for prime-ages, social security and income tax are crucial in explaining the differences in market hours around retirement ages, with the former accounting for 53 percent and the latter for 40 percent of the differences in market hours between average Europe and the United States for the age group of sixty and above.

6 Conclusions

In this paper, we study cross-country differences on both labor supply and consumption expenditure over the entire adult life cycle. Using time-use and consumer-expenditure data, we documented large differences between the United States and Europe in the allocations of consumption expenditures and time use. More specifically, we found that Europeans work less in the market but spend more time in home production than Americans and the differences are more prolonged for the age group of sixty and above. In addition, Europeans also have lower expenditures on market goods and home inputs. More importantly, the cross-country correlations of market hours and expenditures on both market goods and home inputs with consumption and social security taxes are negative while the same correlations of taxes with home hours are positive.

We used a life-cycle model with home production to account for the impact of the tax and transfer programs on the cross-country differences in expenditures and hours. The model features a borrowing constraint, idiosyncratic income shock, endogenous labor-leisure decision, and endogenous retirement decision. Countries differ in their consumption taxes, progressive income taxes, social security systems, and market production TFP. Incorporating these cross-country differences, we simulate the model for European countries and evaluate the quantitative effects of them on the allocations of expenditure and hours.

The simulated model can generate lower market hours, higher home hours, and lower expenditures for both market goods and home inputs in Europe than in the United States. The cross-country differences in consumption tax, social security system, income tax, and TFP together can account for 68-95 percent of the cross-country variations and more than half of the average differences between Europe and the United States in aggregate hours and expenditures. The model can also account well for the hours and expenditures in the aggregate and by age as measured by the differences in allocations from the United States, the correlation coefficients, and the coefficients of determination between model predictions and the corresponding data. Consistent with the data, the model also predicts substantially lower market hours in Europe for the age group of sixty and above. All the factors, except income tax, are quantitatively important for determining cross-country differences in expenditure allocations. While the differences in social security system and income tax are crucial in explaining the difference in market hours around retirement ages, TFP and consumption tax are more important for the difference in market hours for prime ages. The model can generate these results because lower TFP and higher taxes in Europe favor production and consumption at home relative to production and consumption in the market.

In building a rich model that quantifies the key allocation differences in the United States and Europe, we assumed that productivity at home, preferences and culture are the same across countries. Boerma and Karabarbounis (2021) highlight the importance of incorporating heterogeneity in productivity and in preferences for home production in studying welfare inequality. Differences in these factors could also contribute to cross-country differences in allocations of hours and expenditure. For example, higher home productivity or a preference towards home-produced goods will shift more resources from market production to home production. A culture against women working in the market will necessarily reduce market hours and increase home hours in the aggregate. We leave these topics for future analysis.

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Appendix

A Data

We use the Multinational Time Use Study (MTUS) to construct data for time allocations in the United States and Europe, the Consumer Expenditure Survey (CEX) to construct data for expenditures in the United States, and data from the European Statistical Office (Eurostat) to construct expenditures in Europe. The MTUS data by country are available in different years. We select countries with data available between 2005 to 2015. The countries included in our study are Austria, France, Italy, Netherlands, Norway, Spain, the United Kingdom, and the United States. The expenditure data are the available years that are mostly close to the available MTUS surveys. Table A.1 lists the survey years by country

Table A.1: Data Years for Eurostat and MTUS

Country	Eurostat	MTUS
Austria	2010	2008, 2009
France	2010	2010
Italy	2010	2008, 2009
Netherlands	2005	2005
Norway	2005	2000, 2001
Spain	2005, 2010	2009, 2010
United Kingdom	2005, 2010, 2015	2005, 2014, 2015
United States	2009-2012	2009-2012

A.1 Time Use

We use the MTUS to construct market hours and home hours.[23] Time-use data record time diaries from survey respondents. The survey groups time spent on daily activities into twenty-five types of activity, and we further group the twenty-five activities into market hours, home hours, and leisure. The division of the activities follows Aguiar and Hurst (2007). Market and home activities are summarized in Table A.2. The remainder is leisure activities.

The MTUS survey records time diaries for different days of the week and shows that weekdays and weekends have very different time allocations. It is therefore important to weight observations by day of the week. The MTUS provides such weights that incorporate the weights for the days of a week (5/7 for weekdays and 2/7 for weekends) and the population weights. Hence we weight the observations as suggested by the MTUS. The age profiles of market and home hours are

[23] The data can be obtained from http://www.timeuse.org/mtus/.

Table A.2: MTUS Activities and Categories

MTUS Variable	Category
Paid work	Market work
Commuting to work	Market work
Food preparation	Nonmarket work
Cleaning	Nonmarket work
Home & vehicle maintenance	Nonmarket work
Obtaining goods and services	Nonmarket work
Other care	Nonmarke work
Gardening & pet	Nonmarket work
Remainder	Leisure

constructed as the average weekly hours per adult by two-year age segments.

A.2 Consumption Expenditure

Consumption Expenditure for the United States. We use the CEX to construct consumption expenditures in the United States.[24] We classify the detailed expenditure categories in the CEX into market and home expenditures following Dotsey et al. (2014). Table A.3 reports the division of expenditures between market goods and home inputs. The CEX groups all transportation expenditures together, and it is not feasible to separate the part dedicated to home production from the other parts, so we prorate transportation expenses by travel time for market and home activities that we obtained from the MTUS. We use the actual rent for renters and the imputed rent for homeowners for spending on housing. We weight the consumption expenditures using the sample-suggested population weights and construct the age profiles of expenditures on market goods and home inputs as the cross-sectional averages for every two-year age group, where the age is that of the head of household.

Consumption Expenditure for Europe. There are three years of Eurostat consumption expenditure data available in the 2000s: 2005, 2010, and 2015. We use data for the years that are most close to the survey years in the MTUS. Table A.1 lists the years used for MTUS and Eurostat and we use the averages across years if data for multiple years are available. We use two types of data from Eurostat to construct the expenditures in Europe by age group: structure of consumption expenditure by age of the reference person and by consumption purpose and mean consumption expenditure by age of the reference person. The first file provides the average expenditure shares among total expenditure for each Classification of

[24]Data can be obtained from http://www.bls.gov/cex/.

Table A.3: US Market- and Home-Expenditure Categories

Market-Expenditure Categories
Food away from home
Alcoholic beverages
Apparel and services
Tobacco and smoking supplies
Reading
Personal care
Other lodging
Fees and admissions
Televisions, radios, and sound equipment
Other equipment and services
Medical services, prescription drugs, and medical supplies
Education
Insurance
Transport, weighted by market-time share
Home-Expenditure Categories
Food at home
Maintenance, repairs, and other expenses
Gardening and pet care
Household operations
House furnishings and equipment
Utilities, fuels, and public services
Housing
Transport, weighted by home-time share

Individual Consumption by Purpose (COICOP) by age group. The second file contains the mean expenditures by age group. The data are available for four age groups: less than 30, 30-44, 45-59, and 60+. The product of the average expenditure share and the mean expenditure level gives the expenditure for each consumption category.

The consumption categories are slightly different from those in the CEX. We divide these categories into market goods and home inputs so that they are comparable to those in the United States. Table A.4 reports the division of expenditures between market goods and home inputs. Similar to the CEX, the transportation expenditures are grouped together and thus we pro-rate for each country the expenses by travel time for market and home activities that we obtained from the MTUS.

NIPA Adjustment. Let c_{mt} and d_t be the average expenditure levels for age t in the data, $\bar{c}_m$ the average market expenditure, and $\bar{d}$ the average home expenditure. The adjustment procedure is as follows. First, we derive PCE as a share of

Table A.4: Eurostat Market- and Home-Expenditure Categories

Market-Expenditure Categories
Alcohol and tobacco
Clothing and footwear
Health consumption
Recreation and culture
Education
Restaurants and hotels
Personal care
Personal goods and services
Insurance
Transport, weighted by market-time share
Home-Expenditure Categories
Consumption of food and nonalcoholic beverages
Consumption of furnishings, equipment, appliances, tools, etc.
Gardening and pet care
Water, electricity, gas, and other fuels
Actual rent for renters and equivalent rent for homeowners
Consumption of communication
Transport, weighted by home-time share
Social protection

GDP (from the NIPA) and denote the share by s; second, we derive the ratio of expenditure for each age group to the average expenditure (across all ages) in the data ($\frac{c_{mt}+d_t}{\bar{c}_m+\bar{d}}$); third, the product of s and the expenditure ratio derived in the second step gives the adjusted total expenditure-to-income ratio by age group ($s\frac{c_{mt}+d_t}{\bar{c}_m+\bar{d}}$); fourth, the expenditure ratios for market and home are calculated by assigning the total expenditure ratio from step three according to the ratio between market and home expenditures from the data for each age group ($s_{c_{mt}} = s\frac{c_{mt}+d_t}{\bar{c}_m+\bar{d}}\frac{c_{mt}}{c_{mt}+d_t}$ for market and $s_{d_t} = s\frac{c_{mt}+d_t}{\bar{c}_m+\bar{d}}\frac{d_t}{c_{mt}+d_t}$ for home). The adjustment procedure gives an aggregate expenditure to income ratio of the same value as the PCE-to-GDP ratio in the NIPA and keeps the relative expenditures constant across age groups and across market and home expenses.

Expenditures across Countries. To compute comparable real expenditures across countries, we multiply the adjusted ratios of expenditure to economy-wide income, calculated from the above procedures, by real GDP per adult aged 25 and above. Real GDP per adult is calculated using GDP data from the Penn World Tables 10.0 and population distribution from the OECD. Normalizing the real GDP per adult in the United States to one, Table A.5 reports the constructed average expenditures by age group from Eurostat for Europe and from the CEX for the

United States.

Table A.5: Expenditures by Age

Country	Age	C_m	D
Austria	<30	0.18	0.19
Austria	30-44	0.22	0.26
Austria	45-59	0.23	0.28
Austria	60+	0.14	0.23
France	<30	0.13	0.17
France	30-44	0.19	0.26
France	45-59	0.18	0.25
France	60+	0.10	0.23
Italy	<30	0.13	0.20
Italy	30-44	0.16	0.25
Italy	45-59	0.18	0.28
Italy	60+	0.08	0.24
Netherlands	<30	0.17	0.15
Netherlands	30-44	0.24	0.25
Netherlands	45-59	0.24	0.26
Netherlands	60+	0.13	0.21
Norway	<30	0.17	0.20
Norway	30-44	0.26	0.34
Norway	45-59	0.26	0.32
Norway	60+	0.15	0.29
Spain	<30	0.12	0.15
Spain	30-44	0.15	0.19
Spain	45-59	0.16	0.23
Spain	60+	0.08	0.19
United Kingdom	<30	0.20	0.24
United Kingdom	30-44	0.25	0.29
United Kingdom	45-59	0.28	0.29
United Kingdom	60+	0.13	0.23
United States	<30	0.23	0.31
United States	30-44	0.29	0.40
United States	45-59	0.32	0.39
United States	60+	0.24	0.33

Notes: C_m denotes market-goods expenditure, and D denotes home-inputs expenditure.

B Solution to the Static Model

The representative agent solves the following problem:

$$\max_{c_m,d,n_h,n_m} U(c,l) = \frac{[\omega_3 c^{1-\frac{1}{\zeta_3}} + (1-\omega_3) l^{1-\frac{1}{\zeta_3}}]^{\frac{1-\gamma}{1-\frac{1}{\zeta_3}}} - 1}{1-\gamma}$$

subject to

$$c = [\omega_2 c_m^{1-\frac{1}{\zeta_2}} + (1-\omega_2) c_h^{1-\frac{1}{\zeta_2}}]^{\frac{1}{1-\frac{1}{\zeta_2}}} \tag{17}$$

$$c_h = [\omega_1 d^{1-\frac{1}{\zeta_1}} + (1-\omega_1)(n_h)^{1-\frac{1}{\zeta_1}}]^{\frac{1}{1-\frac{1}{\zeta_1}}} \tag{18}$$

$$(1+\tau_c)c_m + (1+\tau_c)d = (1-\tau_i)wn_m \tag{19}$$

$$l = 1 - (n_h + n_m) \tag{20}$$

B.1 Solution

Let μ be the Lagrange multiplier on the budget constraint. FOCs are given as follows:

$$(c_m) \qquad \frac{\partial U}{\partial c}\frac{\partial c}{\partial c_m} = (1+\tau_c)\mu, \tag{21}$$

$$(d) \qquad \frac{\partial U}{\partial c}\frac{\partial c}{\partial c_h}\frac{\partial c_h}{\partial d} = (1+\tau_c)\mu, \tag{22}$$

$$(n_h) \qquad \frac{\partial U}{\partial c}\frac{\partial c}{\partial c_h}\frac{\partial c_h}{\partial n_h} = \mu(1-\tau_i)w, \tag{23}$$

$$(n_m) \qquad \frac{\partial U}{\partial l} = \mu(1-\tau_i)w \tag{24}$$

From equations (22) and (23), we have the following:

$$\frac{\partial c_h}{\partial d}\frac{1-\tau_i}{1+\tau_c}w = \frac{\partial c_h}{\partial n_h}$$

Plugging in the derivatives gives us the following:

$$\frac{1-\tau_i}{1+\tau_c} w\omega_1 d^{-\frac{1}{\zeta_1}} = (1-\omega_1) n_h^{-\frac{1}{\zeta_1}},$$

$$\left(\frac{(1-\tau_i)w\omega_1}{(1+\tau_c)\,(1-\omega_1)}\right)^{-\zeta_1} d = n_h,$$

or

$$\Delta_{nh} \equiv \frac{n_h}{d} = \left(\frac{(1-\tau_i)w\omega_1}{(1+\tau_c)(1-\omega_1)}\right)^{-\zeta_1} \tag{25}$$

The ratio $\Delta_{ch} \equiv \frac{c_h}{d}$ can be solved from the definition of c_h in equation (18) directly:

$$\begin{aligned}\Delta_{ch} &\equiv \frac{c_h}{d} = \left(\omega_1 + (1-\omega_1)\Delta_{nh}^{1-\frac{1}{\zeta_1}}\right)^{\frac{1}{1-\frac{1}{\zeta_1}}} \\ &= \left(\omega_1 + (1-\omega_1)\left(\frac{(1-\tau_i)w\omega_1}{(1+\tau_c)(1-\omega_1)}\right)^{1-\zeta_1}\right)^{\frac{1}{1-\frac{1}{\zeta_1}}} \end{aligned} \tag{26}$$

From equations (21) and (22), we get the following:

$$\frac{\frac{\partial c}{\partial c_m}}{\frac{\partial c}{\partial c_h}} = \frac{\partial c_h}{\partial d}$$

Plugging in the derivatives, we find the following:

$$\frac{\omega_2}{1-\omega_2}\left(\frac{c_h}{c_m}\right)^{\frac{1}{\zeta_2}} = \left(\frac{c_h}{d}\right)^{\frac{1}{\zeta_1}} \omega_1 = \omega_1 \Delta_{ch}^{\frac{1}{\zeta_1}}$$

Thus we derive $\Delta_{cm} \equiv \frac{c_m}{d}$ as follows:

$$\Delta_{cm} \equiv \frac{c_m}{d} = \left(\frac{\omega_2}{(1-\omega_2)\omega_1}\right)^{\zeta_2} \Delta_{ch}^{1-\frac{\zeta_2}{\zeta_1}} \tag{27}$$

From the definition of c in equation (17), we get the following:

$$\Delta_c \equiv \frac{c}{d} = [\omega_2 \Delta_{cm}^{1-\frac{1}{\zeta_2}} + (1-\omega_2)\Delta_{ch}^{1-\frac{1}{\zeta_2}}]^{\frac{1}{1-\frac{1}{\zeta_2}}} \tag{28}$$

The ratio of $\Delta_l \equiv \frac{l}{d}$ can be solved by first combining equations (21) and (24):

$$\frac{\frac{\partial U_t}{\partial l}}{\frac{\partial U_t}{\partial c}} = \frac{\partial c}{\partial c_m}\frac{1-\tau_i}{1+\tau_c}w$$

Plugging in derivatives, we get the following:

$$\frac{1-\omega_3}{\omega_3}\left(\frac{c}{l}\right)^{1/\zeta_3} = \frac{1-\omega_3}{\omega_3}\left(\frac{\Delta_c\, d}{\Delta_l\, d}\right)^{1/\zeta_3} = \omega_2 \frac{c_m^{-\frac{1}{\zeta_2}}}{c^{-\frac{1}{\zeta_2}}}\frac{(1-\tau_i)}{(1+\tau_c)}w$$

Using the definition of Δ_{cm} and Δ_c, we have the following:

$$
\begin{aligned}
\Delta_l \equiv \frac{l}{d} &= \left(\frac{1-\omega_3}{\omega_3\omega_2 w}\frac{1+\tau_c}{1-\tau_i}\right)^{\zeta_3} \Delta_c (\frac{\Delta_c}{\Delta_{cm}})^{\frac{-\zeta_3}{\zeta_2}} \\
&= \left(\frac{1-\omega_3}{\omega_3\omega_2 w}\frac{1+\tau_c}{1-\tau_i}\right)^{\zeta_3} \left(\omega_2 + (1-\omega_2)\left(\frac{\Delta_{ch}}{\Delta_{cm}}\right)^{1-\frac{1}{\zeta_2}}\right)^{\frac{\zeta_2-\zeta_3}{\zeta_2-1}} \Delta_{cm} \\
&= \left(\frac{1-\omega_3}{\omega_3\omega_2 w}\frac{1+\tau_c}{1-\tau_i}\right)^{\zeta_3} \left(\omega_2 + (1-\omega_2)\left(\frac{(1-\omega_2)\omega_1}{\omega_2}\right)^{\zeta_2-1} \Delta_{ch}^{\frac{\zeta_2-1}{\zeta_1}}\right)^{\frac{\zeta_2-\zeta_3}{\zeta_2-1}} \Delta_{cm}
\end{aligned}
$$

Thus, we have solved the ratios of all other variables relative to d. Finally, we solve d from the budget constraint:

$$(1+\tau_c)\Delta_{cm} d + (1+\tau_c)d = (1 \ -\tau_i)w\left(1-(\Delta_{nh}+\Delta_l)\ d\right)$$

This gives us the following:

$$d = \frac{(1 \ -\tau_i)w}{(1+\tau_c)\Delta_{cm} + (1+\tau_c) + (1 \ -\tau_i)w(\Delta_{nh}+\Delta_l)} \tag{29}$$

We solve the rest of the allocations as follows:

$$
\begin{aligned}
n_h &= \Delta_{nh}\, d, && (30) \\
n_m &= 1-(\Delta_{nh}+\Delta_l)\ d, && (31) \\
c_m &= \Delta_{cm}\ d && (32)
\end{aligned}
$$

B.2 Proof of Results 1 and 2

Proof of Result 1: $\frac{n_h}{d}$ is increasing in τ_c and τ_i and is decreasing in w.
Equation (25) gives us the following

$$\log \Delta_{nh} = -\zeta_1 \log\left(\frac{(1-\tau_i)w\omega_1}{(1+\tau_c)(1-\omega_1)}\right) \tag{33}$$

Thus, we can solve and determine the sign of the following partial derivatives:

$$
\begin{aligned}
\frac{\partial \log \Delta_{nh}}{\partial \log w} &= -\zeta_1 < 0; && (34) \\
\frac{\partial \log \Delta_{nh}}{\partial \log (1-\tau_i)} &= -\zeta_1 < 0; && (35) \\
\frac{\partial \log \Delta_{nh}}{\partial \log (1+\tau_c)} &= \zeta_1 > 0 && (36)
\end{aligned}
$$

Thus, $\frac{n_h}{d}$ is increasing in τ_c and τ_i and is decreasing in w. Moreover, the effects of τ_c, τ_i, and w are increasing in ζ_1.

Proof of Result 2: $\frac{c_m}{d}$ is decreasing in τ_c and τ_i and is increasing in w if $\zeta_2 > \zeta_1$. We first solve and determine the sign of the partial derivatives with respect to $log\Delta_{ch}$. Equation (26) gives us the following:

$$\begin{aligned} log\Delta_{ch} &= \frac{1}{1-\frac{1}{\zeta_1}} \log\left(\omega_1 + (1-\omega_1)\Delta_{nh}^{1-\frac{1}{\zeta_1}}\right) &(37)\\ &= \frac{1}{1-\frac{1}{\zeta_1}} \log\left(\omega_1 + (1-\omega_1)\left(\frac{(1-\tau_i)w\omega_1}{(1+\tau_c)(1-\omega_1)}\right)^{1-\zeta_1}\right) &(38)\end{aligned}$$

Note the following:

$$\frac{\partial \log \Delta_{ch}}{\partial \log \Delta_{nh}} = \frac{\partial \log \Delta_{ch}}{\partial \Delta_{nh}}\Delta_{nh} = \frac{(1-\omega_1)\Delta_{nh}^{1-\frac{1}{\zeta_1}}}{\left(\omega_1 + (1-\omega_1)\Delta_{nh}^{1-\frac{1}{\zeta_1}}\right)} > 0 \qquad (39)$$

Combined with the results in the proof of result 1, we further determine the sign of the following partial derivatives:

$$\begin{aligned} \frac{\partial \log \Delta_{ch}}{\partial \log w} &= \frac{\partial \log \Delta_{ch}}{\partial \log \Delta_{nh}}\frac{\partial \log \Delta_{nh}}{\partial \log w} < 0; &(40)\\ \frac{\partial \log \Delta_{ch}}{\partial \log(1-\tau_i)} &= \frac{\partial \log \Delta_{ch}}{\partial \log \Delta_{nh}}\frac{\partial \log \Delta_{nh}}{\partial \log(1-\tau_i)} < 0; &(41)\\ \frac{\partial \log \Delta_{ch}}{\partial \log(1+\tau_c)} &= \frac{\partial \log \Delta_{ch}}{\partial \log \Delta_{nh}}\frac{\partial \log \Delta_{nh}}{\partial \log(1+\tau_c)} > 0 &(42)\end{aligned}$$

Moving on to Δ_{cm}, equation 27 gives us the following:

$$log(\Delta_{cm}) = \zeta_2 log\left(\frac{\omega_2}{(1-\omega_2)\omega_1}\right) + \left(1-\frac{\zeta_2}{\zeta_1}\right) log\Delta_{ch} \qquad (43)$$

We can see easily that $\frac{\partial \log \Delta_{cm}}{\partial \log \Delta_{ch}} = 1 - \frac{\zeta_2}{\zeta_1} < 0$ iff $\zeta_1 < \zeta_2$. Thus, we can see that iff $\zeta_1 < \zeta_2$, the following is true:

$$\begin{aligned} \frac{\partial \log \Delta_{cm}}{\partial \log w} &= \frac{\partial \log \Delta_{cm}}{\partial \log \Delta_{ch}}\frac{\partial \log \Delta_{ch}}{\partial \log w} > 0; &(44)\\ \frac{\partial \log \Delta_{cm}}{\partial \log(1-\tau_i)} &= \frac{\partial \log \Delta_{cm}}{\partial \log \Delta_{ch}}\frac{\partial \log \Delta_{ch}}{\partial \log(1-\tau_i)} > 0; &(45)\\ \frac{\partial \log \Delta_{cm}}{\partial \log(1+\tau_c)} &= \frac{\partial \log \Delta_{cm}}{\partial \log \Delta_{ch}}\frac{\partial \log \Delta_{ch}}{\partial \log(1+\tau_c)} < 0. &(46)\end{aligned}$$

C The Computation Algorithm

This appendix describes the computation algorithm. To solve the steady-state equilibrium numerically, we discretize the stochastic productivity process into a five-state Markov chain. The state space for average social security earnings is discretized into a grid of fifteen points, and the state space for assets is discretized into an unevenly spaced grid of thirty points. The choice variables are searched over a grid of two hundred points for home inputs and fifty points for market hours; they are continuous for other variables. When computing the expected values next period, we use piecewise linear interpolation to approximate value functions for the points not on the state grids.

We solve for the steady-state equilibrium in the United States as follows:

1. Guess the interest rate r and the wage rate w.

2. Guess the amount of accidental bequests.

3. Solve the value function and policy functions for the last period of life. By backward induction, repeat at each age until reaching the first period in life.

4. Starting from the initial distribution at the beginning of the life cycle, compute the stationary distribution of households by forward induction using the policy functions.

5. Check whether the amount of associated accidental bequests equals the initial guess. If not, go back to step 2 and update accidental bequests.

6. Check whether market-clearing conditions hold. If not, go to step 1 and update the initial guesses.

The European economy is solved similarly, except that we do not need to iterate over interest rate and wage rate to check for market-clearing conditions.

D Age-efficiency Profile

We use the March supplement of the Current Population Survey to construct the age-efficiency profile e_t.[25] We compute hourly wages using earnings and usual hours worked at an individual's main job. For the decision about labor-market participation, it is important to know the potential wage offered if nonworking individuals were to choose to work. But these wage offers cannot be observed. Following Neal and Johnson (1996), we use the least absolute deviations (LAD) estimator to impute wages for individuals who are not working. The LAD estimator is the solution to the following optimization problem:

$$\min_{\beta} \sum |y_i - x_i \beta|$$

[25] CPS microdata are obtained from IPUMS: http://cps.ipums.org.

Here y_i is wage and x_i is a vector that contains observables such as age, education, race, marital status, and gender. In addition to current marital status, we include an indicator variable representing whether an individual was ever married.

Using the estimated equations, we impute a wage for individuals who do not have an observed wage because they are either unemployed or are out of the labor force. To compute the age-efficiency profile, we average wages by age, where the wage comes from the data for individuals with a wage observation and is imputed from the regression equation for individuals without a wage observation. The average wage for each two-year age group is then normalized to the average wage of individuals aged twenty-four to twenty-five. The generated average wages for prime-aged individuals are quite similar to the actual average wages in the data because of the high labor force participation rate of prime-aged individuals.

E Social Security Program by Country

The social security program differs by country in the following dimensions: the tax rate on workers τ_s and firms τ_f, the earnings cap that the tax is subject to $y_{\max}$, the number of working years used in calculating the social security benefits t_m, and the policies to calibrate the benefit $pen(t_r,y_s)$ including the normal retirement age, the reduction (increase) in pension benefits if claimed earlier (later) than the normal retirement age, and the benefit-replacement rate at the normal retirement age.[26] The benefit-replacement rate at the normal retirement age pen is endogenously calibrated to the social security spending to GDP ratio and is reported in Table 9. The other components of the program are exogenous and are reported in Table E.6. Column "Cap" shows the income cap relative to the economy-wide average income. Column "Years" reports the number of working years used in calculating the social security benefits t_m. Because our model period is two years, we re-set the normal retirement age (column "NRA") of sixty-five to sixty-six for France, Italy, the Netherlands, Norway, and Spain. In Austria and the United Kingdom, retirement age is 65 for men and 60 for women. We take the simple average and set the retirement age to 62.

In Austria, the benefits are reduced by 4.2% each year up to a maximum of 15% reduction for early retirement. In France, the normal retirement age is sixty-five and the benefits are reduced by 5% per year between age 60-64 and increased by 5% between age 66-70. Because our model period is two years, we re-set the normal retirement age to sixty-six and calculate the pension at retirement ages of 60 to 70

[26]Information for the policy details are from Erosa et al. (2012), Laun and Wallenius (2016), the international updates for social security on the U.S. Social Security Administration website (https://www.ssa.gov/policy/docs/progdesc/index.html), and OECD Pension at a Glance (https://www.oecd-ilibrary.org/finance-and-investment/oecd-pensions-at-a-glance).

relative to age sixty-six. In Italy, the early retirement benefits are 82.28% for age 58, 86.58 for age 60, 91.46% for age 62, and 96.96% for age 64 of the normal retirement age 65. In the Netherlands, the benefits for early retirement are a fraction of the benefits for the normal retirement age. The fractions are 70% for age 61-64, 55% for age 60, 45% for age 59, 38% for age 58, 32% for age 57, 28% for age 56. In addition, regardless of the retirement age, from the normal retirement age onward, each worker will get their normal retirement benefits. In Spain, the benefits are reduced by 7.5% a year for age 54-58, 7% a year for age 59-61, 6.5% a year for age 62-63, and 6% a year for age 64. In the United Kingdom, the benefits are increased by 10.4% a year up to age 70 for men and up to age 65 for women. We take the simple average and set the oldest retirement age of delaying retirement to 68. In the United States, the polices are as described in the main text.

Based on these policy details, for each country we compute the early and late retirement benefits as a fraction of the benefits for the normal retirement age. The last column of Table E.6 reports these fractions with the value at the normal retirement age normalized to one.

Table E.6: Social Security Policies by Country

Country	Worker Rate	Firm Rate	Cap	Years	NRA	Fraction of Benefits by Retire Age								
	τ_s	τ_f	$y_{\max}$	t_m		54	56	58	60	62	64	66	68	70
Austria	0.10	0.13	1.28	22	62	–	–	0.85	0.92	1.00	–	–	–	–
France	0.09	0.14	3.00	32	66	–	–	–	0.71	0.81	0.90	1.00	1.10	1.19
Italy	0.09	0.24	3.26	32	66	–	–	0.82	0.87	0.91	0.97	1.00	–	–
Netherlands	0.18	0.06	0.76	36	66	–	0.72	0.79	0.88	0.94	0.97	1.00	–	–
Norway	0.08	0.14	no cap	20	66	–	–	–	–	–	–	1.00	–	–
Spain	0.05	0.24	1.51	16	66	0.22	0.36	0.51	0.65	0.79	0.91	1.00	1.06	1.12
United Kingdom	0.11	0.13	1.45	20	62	–	–	–	–	1.00	1.20	1.42	1.62	–
United States	0.05	0.05	2.47	36	66	–	–	–	–	0.75	0.87	1.00	1.16	1.32

Notes: The income cap that the tax is subject to is $y_{\max}$ and column "Cap" shows the income cap relative to the economy-wide average income. Column "Years" reports the number of working years used in calculating the social security benefits t_m. NRA is normal retirement age. The last column reports the early and late retirement benefits as a fraction of the benefits for the normal retirement age.

F More Results from Simulation

Government spending to GDP ratio. Table F.7 compares the government spending to GDP ratio between model and data for the benchmark simulation.

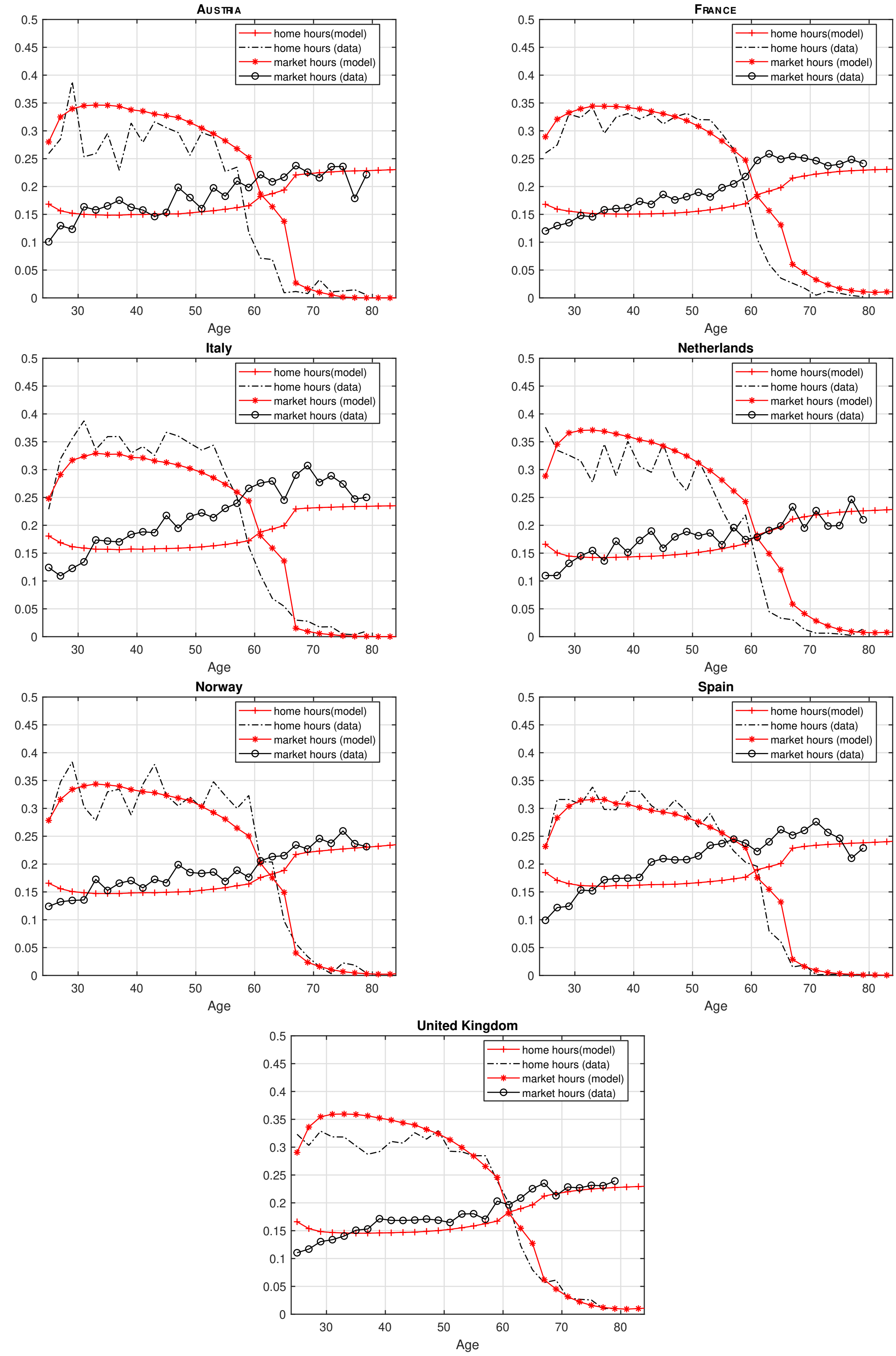
Table F.7: Government Spending to GDP Ratio

Country	Model	Data
Austria	0.242	0.228
France	0.252	0.275
Italy	0.260	0.227
Netherlands	0.223	0.287
Norway	0.308	0.247
Spain	0.269	0.230
United Kingdom	0.212	0.233
Average Europe	0.252	0.247
United States	0.193	0.193

Notes: Data for government spending to GDP ratios are calculated from National Accounts for each country.

Exogenous Retirement Figure F.1 plots the model implied market hours and home hours against the data for each country in the model with exogenous retirement.

Figure F.1: Age Profiles of Hours in the Model with Exogenous Retirement



Notes: Model and data hours comparison. Fixing retirement at age 66. Hours in the data are constructed from the Multinational Time Use Study and are reported as a fraction of the total available time—one hundred hours per week.