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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 total factor productivity (TFP) together can account for from 68 to 95 percent of the cross-country variations 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 60 and above as in the data. All the factors, except income tax, are quantitatively important for determining cross-country differences in expenditure allocations. Although 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.

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

Key words: consumption expenditure, home production, labor supply, fiscal policy

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1 Introduction

While there is a large literature on the differences in labor supply across countries,[1] research on cross-country differences in consumption expenditure is limited. To evaluate the effect of 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 on the allocations of both time and consumption expenditure over the life cycle. According to the literature, home production is a critical factor in propagating the effect of policies, thus we examine the allocations across countries not only for market activities but also for home activities.[2]

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

In addition to time and expenditure allocations, there are also large differences in the tax and transfer 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 those in most European countries. More importantly, the cross-country correlations of market hours and expenditures (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 policies can be important factors in accounting for the differences in allocations of expenditure and time in the data.

We develop a model to formally evaluate the quantitative effects of these poli-

[1] See papers cited at the end of this section.

[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 include Austria, France, Italy, Netherlands, Norway, Spain, and the United Kingdom.

cies on allocations. Our life-cycle model features home production, endogenous retirement, 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. We calibrate the model to the United States and show that it matches well the data on the US expenditure and time allocations by age.

In our cross-country study, we allow Europe to differ from the United States not only in consumption tax, income tax, and social security system but also in TFP for market production. In general, most European countries have a lower TFP. 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, 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.

The model can account for 75% of the cross-country variation in aggregate market hours, 68% in aggregate home hours, and 95% in aggregate expenditures on both market goods and home inputs, as measured by the coefficient of determination. On average, across all the studied European countries, the model can account for 70% of the difference in aggregate market hours from the United States, 47% for home hours, and 99% for expenditure on home inputs, while slightly overestimating the difference in aggregate expenditure for market goods. 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. Decomposing the total effects, we find that the cross-country differences in TFP account for 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, while the combination of all three policies accounts for about 45% for hours and 55% for expenditures. Among the policies, consumption tax and social security each account for one-fifth of the average differences for both types of expenditures 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.

This paper is related to the literature studying life-cycle consumption profiles in the United States. Key mechanism to explain the hump-shaped life-cycle consumption profiles includes precautionary savings (Carroll (1997) and Gourinchas and Parker (2002)), durables and housing (Fernandez-Villaverde and Krueger (2007) and Yang (2009)), substitution between consumption and leisure (Bullard and Feigenbaum (2007)), and substitution between market and home-produced goods (Aguiar and Hurst (2013) and Dotsey et al. (2014)). All these papers study life-cycle consumption profiles in a single country and our contribution is to compare them across countries. 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 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 tax and transfer policies on the differences in labor supply between Europe and the United States. The literature emphasizes the importance of the following factors: substitution between consumption and leisure (Prescott (2004) and Ohanian et al. (2008)), substitution between market and home-produced goods (Rogerson (2008), Olovsson (2009), McDaniel (2011), and Duernecker and Herrendorf (2018)), subsidies on health and family cares in Nordic countries (Ngai and Pissarides (2011) and Ragan (2013)), progressivity of income tax and joint taxation (Chakraborty et al. (2015) and Bick and Fuchs-Schündeln (2018)). These papers all focus on the difference in the 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 these papers, 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 the cross-country difference in market hours late in life. In contrast to these two papers, 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 cross-country 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. We also study the effect of tax policies on cross-country difference in expenditure allocation while these papers on the labor supply difference between Europe and the United States 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 presents our life-cycle model. Section 4 calibrates the model to the US economy. Section 5 applies the model to Europe and decomposes the total effect of the model into the contribution by each policy 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 2005-2015 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 closest 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.

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.[5] 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 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 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

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

[5] It is not always trivial to distinguish between home production and leisure activities. 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.

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 as 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 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 of expenditure and time allocations with 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 normalized by the real GDP per adult in the United States.[11] The detailed construction process for the exenditure data is included in Appendix A.

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% or by 1.9-7.3 hours per week; in contrast, home hours in

[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.

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

Europe are higher by 10-37% or by 1.6-5.7 hours per week.[12] In addition, expenditures for market goods and home inputs are lower in European countries than in the United States by 19-54% and 21-47%, respectively.

Table 1: Aggregate Hours and Expenditures

Country	Levels				% Difference from US			
	N_m	N_n	C_m	D	N_m	N_n	C_m	D
Austria	0.208	0.180	0.195	0.249	-26	15	-31	-33
France	0.218	0.197	0.152	0.233	-22	26	-46	-37
Italy	0.242	0.214	0.134	0.252	-14	37	-53	-32
Netherlands	0.236	0.174	0.201	0.229	-16	11	-29	-38
Norway	0.261	0.181	0.229	0.293	-7	15	-19	-21
Spain	0.230	0.200	0.128	0.196	-18	28	-54	-47
United Kingdom	0.246	0.173	0.215	0.243	-12	10	-24	-35
Average Europe	0.234	0.188	0.179	0.242	-16	20	-36	-35
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.

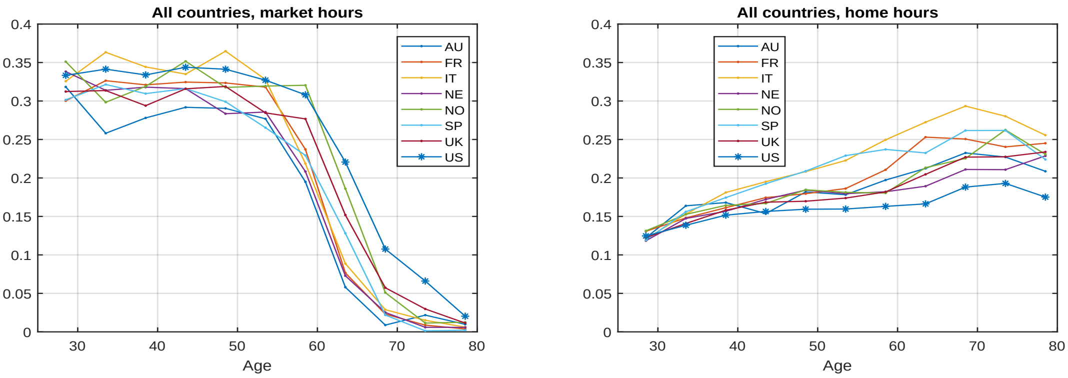
Hours and Expenditures by Age. Figure 1 displays the profiles for market and home hours by age in five-year segments. The hours profiles exhibit similar life-cycle patterns across countries. Market hours, in all countries, are flat for most of people's working lives before sharply decreasing in the late 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. Table A.5 reports the expenditures by 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 individuals approach retirement ages. For each age group, expenditures on both market goods and home inputs are 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.

[12] We classify gardening and pet activities as home production. Because Americans spend more time on these activities, re-classifying them as 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).

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% lower than in the United States while they are only 2-17% 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 to a much lesser extent than for market hours.

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

	Age < 60				Age 60+			
Country	N_m	N_n	C_m	D	N_m	N_n	C_m	D
Austria	-17	9	-26	-33	-77	21	-43	-30
France	-8	12	-40	-37	-72	36	-59	-29
Italy	-2	23	-44	-33	-66	51	-65	-26
Netherlands	-9	7	-23	-38	-72	13	-48	-36
Norway	-3	10	-16	-19	-34	25	-38	-11
Spain	-12	22	-49	-48	-61	35	-67	-42
United Kingdom	-8	5	-14	-26	-39	21	-47	-30
Average Europe	-9	12	-30	-33	-60	29	-52	-29

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.

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 borrowed from McDaniel (2020) and the social security tax rates are 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% in Spain to 24% in France, compared to 7.5% in the United States. The social security tax rates in Europe vary from 22% to 33%, compared with the rate of 10% 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: Correlations of Hours and Expenditures with Taxes

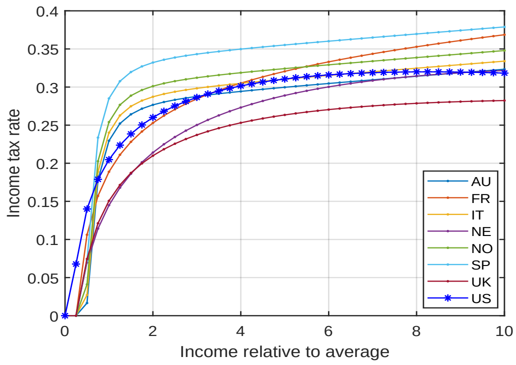
	Consumption	Social Security
N_m	-0.65	-0.51
N_h	0.54	0.88
C_m	-0.51	-0.89
D	-0.53	-0.80

Notes: N_m denotes market hours, N_h denotes home hours, C_m denotes market-goods expenditure, and D denotes home-inputs expenditure. Hours and expenditures by country are reported in Table 1. Tax rates by country are reported in Table 3.

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, 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

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).

from Guvenen et al. (2014) who 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.

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.

[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.

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

[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.

to one, the household's budget constraint is as follows:

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

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 Online Appendix A. 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 $\frac{c_m}{d}$.

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 of which are strongly correlated with wages. Table 5 shows that the correlations of $\frac{N_h}{D}$ with consumption

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

and social security taxes are both positive and with the two productivity measures are both negative. Such correlations imply 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. Such correlations imply 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 the elasticity of substitution 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's 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 $t = 1, 2, ..., T$, where 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. The income tax is progressive, and the average tax rate on labor income y is $\tau(y)$. We assume that half of the social security payment is subject to the income tax. 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 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 the 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:

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

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

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

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

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

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

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.

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

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 A.1 in the Online Appendix, 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.

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. A.1	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. A.1	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	fig. 2	Guvenen et al. (2014)
τ_c	consumption tax rate	7.5%	McDaniel (2020)

The deterministic life-cycle profile of labor productivity for the United States, e_t, is shown in the right panel of Figure A.1 in the Online Appendix.[17] Online

[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.

Appendix C.1 describes how we use the March supplement of the Current Population Survey (CPS) to construct the 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.

We take the idiosyncratic productivity shock from Huggett (1996). Specifically, 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 sixty-six. The retirement benefit at age sixty-six is borrowed from Huggett and Ventura (2000):

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

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% of the full pension. A household retiring at age sixty-four receives 87% of the full pension. A household retiring after age sixty-six receives 8% 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%, the average rates 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%, which comes from McDaniel (2020).

This will in turn generate even lower market hours. Hence, the quantitative effects we find are the lower bound of the policy effects.

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 expen-

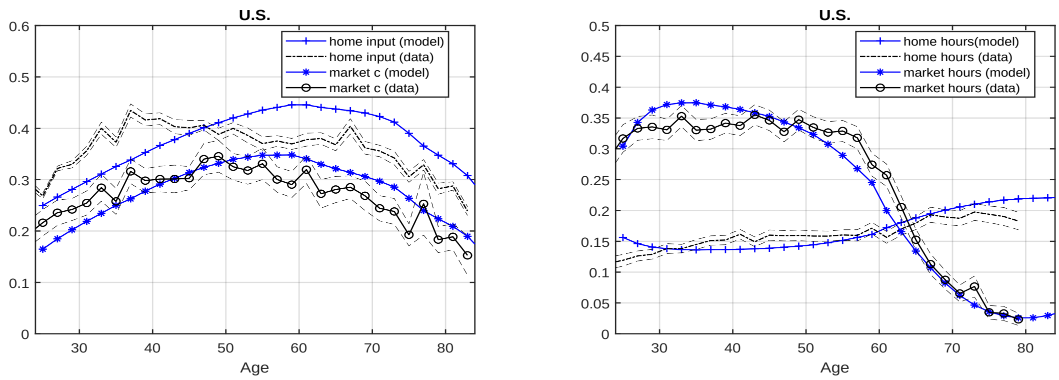
[18] In the stationary equilibrium, the following two conditions hold: $\frac{I}{Y} = (\delta^k + \phi)\frac{K}{Y}$ and $\frac{\alpha Y}{K} = r + \delta^k$. The first condition means that investment equals to depreciation of capital plus increase in capital due to population growth. The second condition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

ditures 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 3 compares the model-implied age profiles for hours and expenditure to economy-wide income ratios with the targeted profiles, along with the 95% 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 3: Age Profiles in the United States – Model *vs* Data



(a) Expenditure (b) Hours

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

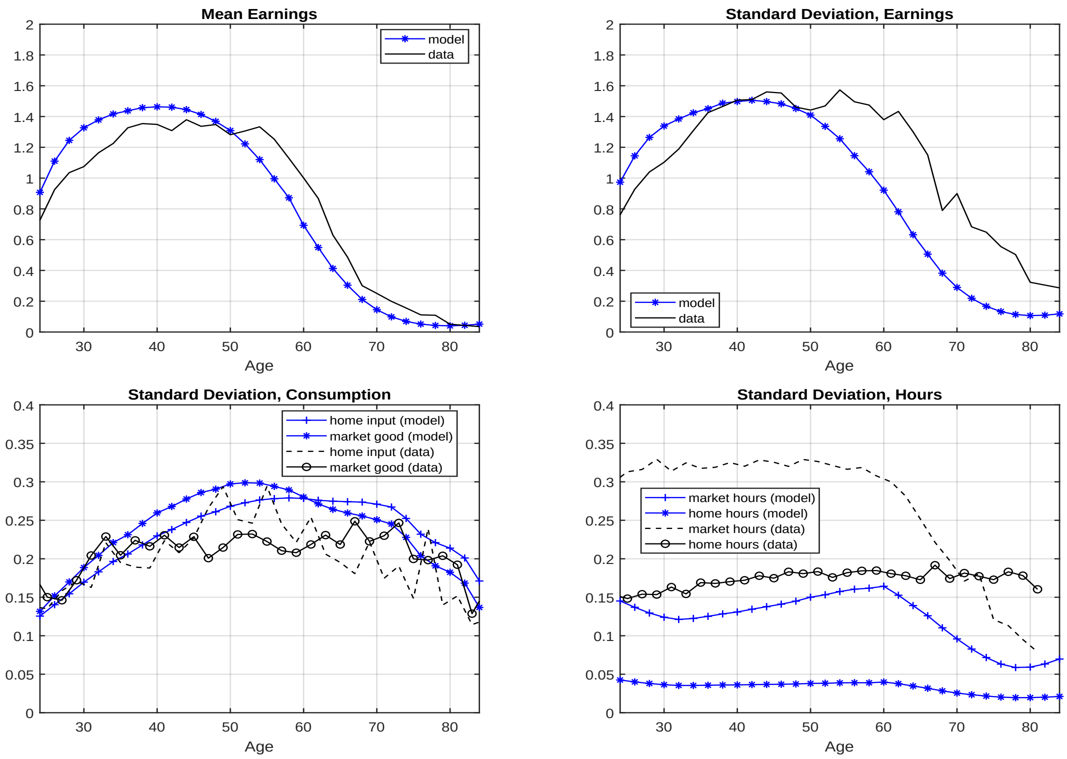
The model also matches the aggregate variables in the data. Table 8 compares the model predictions to the data with GDP per adult normalized to one in both the model and the data. In the table, the investment-to-GDP ratio is the only targeted moment, and it is matched exactly. The model-implied aggregate 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%, 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 4: 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 4. 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 4). 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 Europe and the United States have the same preferences but 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 each policy 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% in Spain to 24% in France, compared to 7.5% 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 to be 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 A.1 in the Online Appendix 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% and 33%, compared to the rate of 10% 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% in the United Kingdom to 21% in Norway. We adjust the depreciation rate to generate differences in this ratio.[19] The resulting 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% and is within the values used in the literature. The implied replacement rate for social security is between 13-51%.

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

[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

	Parameter			Targets, Data			Targets, Model		
Country	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.

use three statistics to evaluate the model performance. The first is the ratio of the average European percentage difference from the United states between the model and the data. This statistic measures the average European percentage difference from the United States in the data explained by the model. The second statistic is the correlation coefficient between the model prediction and the data. The last statistic, our main measure for the success of the model, is the coefficient of determination as used in Chakraborty et al. (2015) which measures the variation in the data captured by the model. The coefficient of determination is defined as:

$$R^2 = 1 - SSE/SST, \tag{17}$$

where $SSE = \sum_i (x_{i,model} - x_{i,data})^2$ and $SST = \sum_i (x_{i,data} - x_{US})^2$. $x_{i,model}$ is the value predicted by the model for country i, $x_{i,data}$ is the data value of variable x in that country, and x_{US} is the value of variable x in the data for the United States.

Aggregate Hours and Expenditures. Table 10 reports the three statistics discussed earlier to evaluate the model performance on the allocation of aggregate hours and expenditures. The third row reports the model implied average European percentage differences on hours and expenditures from the United States against the data which are reported in the fourth row.[20] 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. As reported in row

[20]Table A.2 in the Online Appendix reports the percentage differences on hours and expenditures from the United States for each European country.

five of Table 10, on average, across all the studied European countries, the model can account for 70% of the difference in market hours from the United States, 47% for home hours, and 99% for expenditure on home inputs, while slightly overestimating the difference in expenditure for market goods.[21] The correlation coefficients between the model predictions and the data are all positive and sizable. Our main success measure, the coefficient of determination between the model predictions and the data, is reported in the last row and marked in blue. The values for this statistic show that the model can account for 75% of the cross-country variation in market hours, 68% in home hours, and 95% in expenditures on both market goods and home inputs.

Table 10: Model Evaluation for Aggregate Hours and Expenditures

(1)		N_m	N_h	C_m	D
(2)	Ave. % Diff from US				
(3)	Model	-11	10	-44	-34
(4)	Data	-16	20	-36	-35
(5)	% Explained, (3)/(4)	70	47	121	99
(6)	Correlation	0.18	0.85	0.96	0.61
(7)	**Coeff. Determination**	**0.75**	**0.68**	**0.95**	**0.95**

Notes: "Ave. % Diff from US" is the average European percentage difference from the United states, calculated as (Europe/US-1)*100. "% explained" is the ratio of "Ave. % Diff from US" in the model to that in the data.

The key mechanisms for these results are summarized as follows. In the model, lower TFP and higher taxes in Europe favor home production over market production, which in turn increases home goods and home hours and reduces 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 calibration 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.

[21]The model-implied government spending to GDP ratios are also reasonably close to the data. Please see Table A.3 in the Online Appendix.

We calculate hours and expenditures for the four age groups (<30, 30-44, 45-59, 60+) in each country and compute the same statistics as in Table 10 with the pooled data across the age groups. As reported in Table A.4 of the Online Appendix, the percent explained for hours and expenditures, the correlation coefficients, and the coefficients of determination are all comparable to the corresponding values reported in Table 10. Figures A.2 and A.3 in the Online Appendix plot the model predictions on hours and expenditures by age group against the data and show that the model predictions line up with the data extremely well. The linear regression coefficients of the model predictions against the data are all positive and significant at 1% 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.

To further evaluate the model performance by age, Figure 5 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.

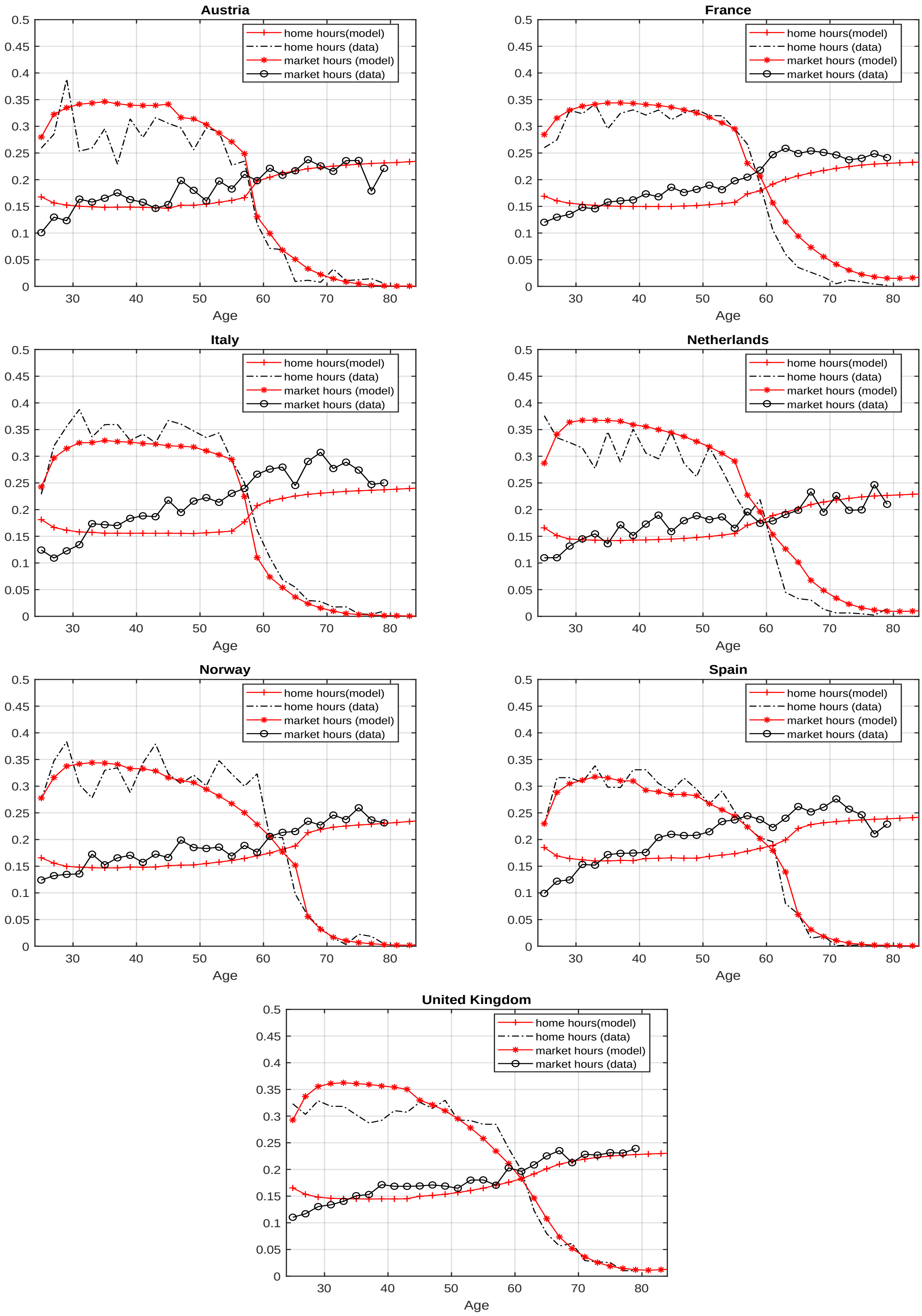
Table 2 shows that the cross-country differences in market hours are much larger for the age group of sixty and above. To evaluate the model's performance along this dimension, columns 2-5 of Table A.5 in the Online Appendix compare the percent differences in market hours from the United States between 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 44% lower for the group of sixty and above and thus account for 73% 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 9% lower for the group of less than sixty and thus account for 100% of the difference in market hours between average Europe and the United States for this younger group.[22]

5.3 Decomposition

This subsection decomposes the total model-generated differences between Europe and the United States into the contribution by each policy and TFP. In each decomposition, we replace one of the features in each of the simulated benchmark

[22]Online Appendix D.2 highlights the importance of modeling endogenous retirement and the associated policy details in accounting for the cross-country differences in market hours by age. Without these features, the model accounted average difference in market hours between the studied European countries and the United States reduces to 59% for the older group and to 88% for the younger group.

Figure 5: 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.

European economy with that in the United States. Table 11 reports the average percent explained by each feature for the aggregate allocations, defined as the ratio of the average percent difference from each European country's benchmark economy relative to the average model-generated percent difference from the United States as reported in row three of Table 10. Because the cross-country differences in allocations between prime ages and old ages are the largest for market hours, we report the average percent explained for market hours at each age group in Table 12 and report the results by age for other allocations in Online Appendix Table A.7.

Consumption Tax. When we apply the lower US consumption tax rate to Europe, market consumption becomes cheaper, and households choose to consume more of it and also increase market hours to produce more of it. Because home inputs and home time are substitutes ($\zeta_1 > 1$), a reduction in the tax rate leads households to substitute home hours with home inputs, and therefore they reduce home hours and increase home inputs. Quantitatively, consumption tax alone can account for 24% of the average model-generated difference in market hours between Europe and the United States, 26% for home hours, 20% for market-goods expenditure, and 22% for home-inputs expenditure.

Social Security System. As the social security tax rate falls from 22-33% to 10%, households increase their expenditures on both market goods and home inputs. From Table 11, the cross-country differences in the social security system contribute to 18% of the model-generated average difference from the United States in expenditure for market goods and 20% for home inputs. Table 12 shows that social security is the most important factor for the low market hours for age sixty and above in Europe. For this age group, it accounts for 53% of the average model difference in market hours between Europe and the United States. This result emerges because the number of years used in calculating social security benefits is lower in Europe and thus increases in this decomposition. Hence, to maximize social security benefits, households choose to retire later and work more in the market at older ages.

Income Tax. From Table 11, the quantitative effects of the cross-country differences in income tax on hours are comparable to those of the consumption tax and social security but are much smaller for expenditures. More importantly, as reported in Table 12, income tax is the second most important factor for the low European market hours for age sixty and above. For this age group it accounts for 40% of the model-generated average difference in Europe from the United States.

Policy *vs* TFP. To separate the effects of policies from the effects of TFP, we conduct a decomposition exercise with all US policy variables. On average, all three policies combined can account for about 45% of the model difference between Europe and the United States in expenditures on both market goods and home inputs, compared to a contribution of one-third for both types of expenditures from TFP. Among the policies, consumption tax and social security each account for one-fifth of the average differences in both types of expenditures whereas income tax has much smaller effects. As for hours, all policies combined can account for about 55% of the model differences on both market and home hours, compared to a contribution of one-third for both types of hours from TFP. Hence, the decomposition shows that policies are more important than TFP in accounting for the differences in the aggregate allocations between the United States and Europe. Across ages, Table 12 shows that, 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.

Table 11: Decomposition – Percent Explained for Aggregate Allocations

	N_m	N_h	C_m	D
Consumption Tax	24	26	20	22
Social Security	15	21	18	20
Income Tax	27	14	2	1
All Policies	56	55	44	46
TFP	33	34	32	33

Table 12: Decomposition – Percent Explained for Market Hours by Age

Age	< 30	30-44	45-59	60+
Consumption Tax	28	29	29	5
Social Security	-2	-12	12	**53**
Income Tax	28	35	0	**40**
All Policies	45	46	46	83
TFP	46	44	42	6

6 Conclusions

In this paper, we study cross-country differences in 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 expenditure and time use. More specifically, we found that Europeans work less in the market but spend more time in home production than Americans and that the differences are more pronounced for the age group of sixty and above. In addition, Europeans 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. 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% of the cross-country variations in aggregate hours and expenditures. The model can also account well for the hours and expenditures in the aggregate and by age. Consistent with the data, the model 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 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. For each country, the expenditure data are matched to the closest year available in the 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 grouping of the activities follows Aguiar and Hurst (2007). Market and home activities are summarized in Table A.2. All the remainder activities are classified as 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 the 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 Activity	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 closest to the survey years in the MTUS. Table A.1 lists the years used for MTUS and Eurostat. 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: 1) structure of consumption expenditure by age of the reference person and by consumption purpose and 2) mean consumption expenditure by age of the reference person. The first data set provides the average expenditure shares among total expenditure for each Classification of Individual Consumption by Purpose (COICOP) by age group. The

[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

second data set 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 in Eurostat are slightly different from those in the CEX. We group these categories into market goods and home inputs so that they are comparable to those for 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 GDP (from the NIPA) and denote the share by s; second, we derive the ratio of expen-

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

diture 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 yields 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.