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***On the Allocation of Time***

Georg Duernecker    Berthold Herrendorf

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# On the Allocation of Time\*

Georg Duernecker (University of Mannheim)

Berthold Herrendorf (Arizona State University)

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## Abstract

We document for the US and Continental Europe that home–production time remained essentially flat during the last 50 years while changes in market time and leisure offset each other. We then focus on the US and France during 1970–2005 which are on the opposite sides of the spectrum: while US market time did not change much, French market time decreased most strongly. We document for the US and France that capital in home production and imputed labor productivities of home production have risen. We build a version of the growth model with capital in market and home production to account for the time allocation in both countries. We find that the interaction between taxes, home capital, and home–labor–augmenting technical change is crucial.

*Keywords:* time allocation; home production; leisure; taxes.

*JEL classification:* B1; J4.

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# 1 Introduction

How do people allocate their time among the different activities market work, home work, and leisure? After the seminal paper of Becker (1965) had started the modern literature on this classic question in economics, the more recent contributions of Prescott (2004) and Greenwood et al. (2005) put into the focus of research in quantitative macroeconomics. Prescott showed that taxes account for the different trends of hours worked in the market in the US and Europe.<sup>1</sup> Greenwood et al. showed that labor-saving equipment used at home is crucial for understanding the increase in long-run female labor force participation. Other recent contributions to the subsequent literature include Rogerson (2006), Ngai and Pissarides (2008), Rogerson (2008), Rendall (2010), McDaniel (2011), Guner et al (2012a,b), Ngai and Petrongolo (2013), and Bick and Fuchs-Schuendelen (2014).

In this paper we shed new light on the question how people in different countries allocate their time among market work, home work, and leisure. We start by documenting new facts from Multinational Time Use Surveys (MTUS henceforth) about the US and the large Continental European countries. For reasons of data availability, we then shift the focus to the US and France. While the stylized facts about the time allocation in the US were documented by Ramey and Francis (2009) and Aguiar and Hurst (2007), there is little comparable work about the time allocation in France, in particular about how the French split their non-market time between home production and leisure. We fill this gap in the literature for the period 1970–2005. From 1970 onwards we have all data required for our analysis and 2005 is well before the Great Recession, which we view as a special event to be studied separately. The key stylized fact that emerges from our analysis is that in both the US and France, changes in market hours and leisure roughly offset each other while hours devoted to home production stayed roughly constant. We also document new facts about home production during 1970–2005 by combining information from NIPA with our own calculations.<sup>2</sup> We document that capital used in home production and labor productivity of home production grew in both countries. To calculate labor produc-

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<sup>1</sup>Hours in this context always refer to hours per working-age population.

<sup>2</sup>In the body of the paper, we will explain these calculations in detail.

tivity of home production, we impute value added following the income approach outlined in Bridgman (2013), which combines data on factor prices and factor inputs into home production.

In order to account for the differences in the time allocations in the US and France, we build a version of the growth model with three key features: consumption is produced both in the market and at home whereas investment is produced only in the market; capital and labor are used in both market production and home production; the market–production function is Cobb–Douglas and the home–production function is CES in capital and labor. We calibrate this model to match the allocation of time, the labor productivities of market work and home work, and the relative prices of market and home investment in the US. We find that this requires that market–produced and home–produced consumption are complements as well as capital and labor used in home production are complements. We then feed into our model the actual French data series for taxes, for labor productivities in the market and at home, and for the relative prices of market and home investments. We find that the otherwise unchanged model accounts well for the time allocation in France. In particular it replicates that the time allocated to home-work remained roughly constant, that the time allocated to market work decreased by roughly the same number of hours as the time allocated to leisure increased, and that these changes were larger in France than in the US.

The work of Greenwood et al. (2005), Rogerson (2008), McDaniel (2011) are most closely related to our work. Greenwood et al. focused on the long–run trend of increasing female labor supply. They argued that a crucial factor behind this trend is the increase in labor–saving household capital that happened after the decline in their relative price. We find that while labor–saving capital used in home production is key for understanding the allocation of non–market time in the US during the last forty years or so, labor–augmenting technical change in home production is more important in France. Rogerson focused on the substitution between market work and home work in the US and Continental Europe and argued that differences in taxes mostly affect hours worked in market services. In contrast to our work, he did not consider capital as an input factor and he did not measure the labor productivity of home production and

did not have access to data on hours devoted to leisure and home production in Europe. His model has two implications about the allocation of non-market time that turn out to be counterfactual given our new evidence: Continental European hours worked at home go up; labor productivity at home goes down. McDaniel introduced capital into Rogerson's model, but she restricted its use to market production. We find that modeling capital in home production is critical to match the allocation of time between home production and leisure.

Our results are also related to the observation that the US has undergone the “marketization of services”, that is, home-produced consumption was replaced by market-produced consumption [Freeman and Schettkat (2005)]. A common interpretation is that American people replaced hours worked at home by hours worked in the market, but French people didn't because of high taxes [Rogerson (2008)]. The data do not support this interpretation, as both in the US and France hours worked at home stayed essentially flat at similar levels. It is important to realize that nonetheless there was marketization of services. Instead, our model implies that Americans in fact reduced the share of home-produced consumption in total consumption whereas the French didn't. In other words, our model implies that in terms of consumption services got marketized in the US but not in France. The reason why that did not lead to a corresponding increase in the French home hours worked is that the the French experienced a much stronger increase in the labor productivity of home production than the Americans, and this allowed the French to have a higher share of home consumption in total consumption at the same time as keeping their hours worked at home unchanged.

The rest of the paper is organized as follows. In the next section, we carefully document the facts about the European time allocation. In the subsequent section, we lay out our environment and characterize the equilibrium. Section 4 explains how we connect our model with the US data. Section 5 contains the results for France. Section 6 concludes. An appendix contains some technical details.

## 2 Facts

In this section, we document in some detail the new facts about the time allocation and home production.

### 2.1 Facts about the Allocation of Time

Our data sources are time use surveys that were standardized by the Multinational Time Use Study. We use standard definitions of market work, home work and leisure and we start by reporting the facts about the time allocation in the US and the three large Continental European countries France, Germany, and Italy<sup>3</sup>. An issue arise because outside of the US time use surveys are not conducted as regularly as in the US. We deal with that issue by interpolating and extrapolation the data points we have. Appendix A explains the details. Figures 1 show the results<sup>4</sup>. We can see that while market hours decline in all three European countries, it stayed roughly flat in the US. Moreover, if anything, hours worked at home declined somewhat in all countries and converged to similar levels towards the end of the sample. Hours allocated to leisure showed the opposite trends than market hours. While the US facts are well known from the work of Ramey and Francis (2009) and Aguiar and Hurst (2007), the facts for the other countries are much less appreciated in the literature. In independent work, Gimenez-Nadal and Sevilla-Sanz (2012) and Fang and McDaniel (2012) also documented facts about the allocation of time outside of the US. In contrast to us, neither of these paper developed models to account for these facts.

In what follows, we will narrow our focus on the US and France. The reason for this the lack of data for Italy for a number of key variables which we require later in our quantitative analysis. While in the case of Germany, the unification introduced serious data issues at the beginning of the 1990s. As a first step we therefore ignore Germany. We will return to it in future work.

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<sup>3</sup>Our definitions of market work, home work and leisure are detailed in Table 14 in the Appendix.

<sup>4</sup>The circles in this figure indicate the years in which time use surveys were conducted.

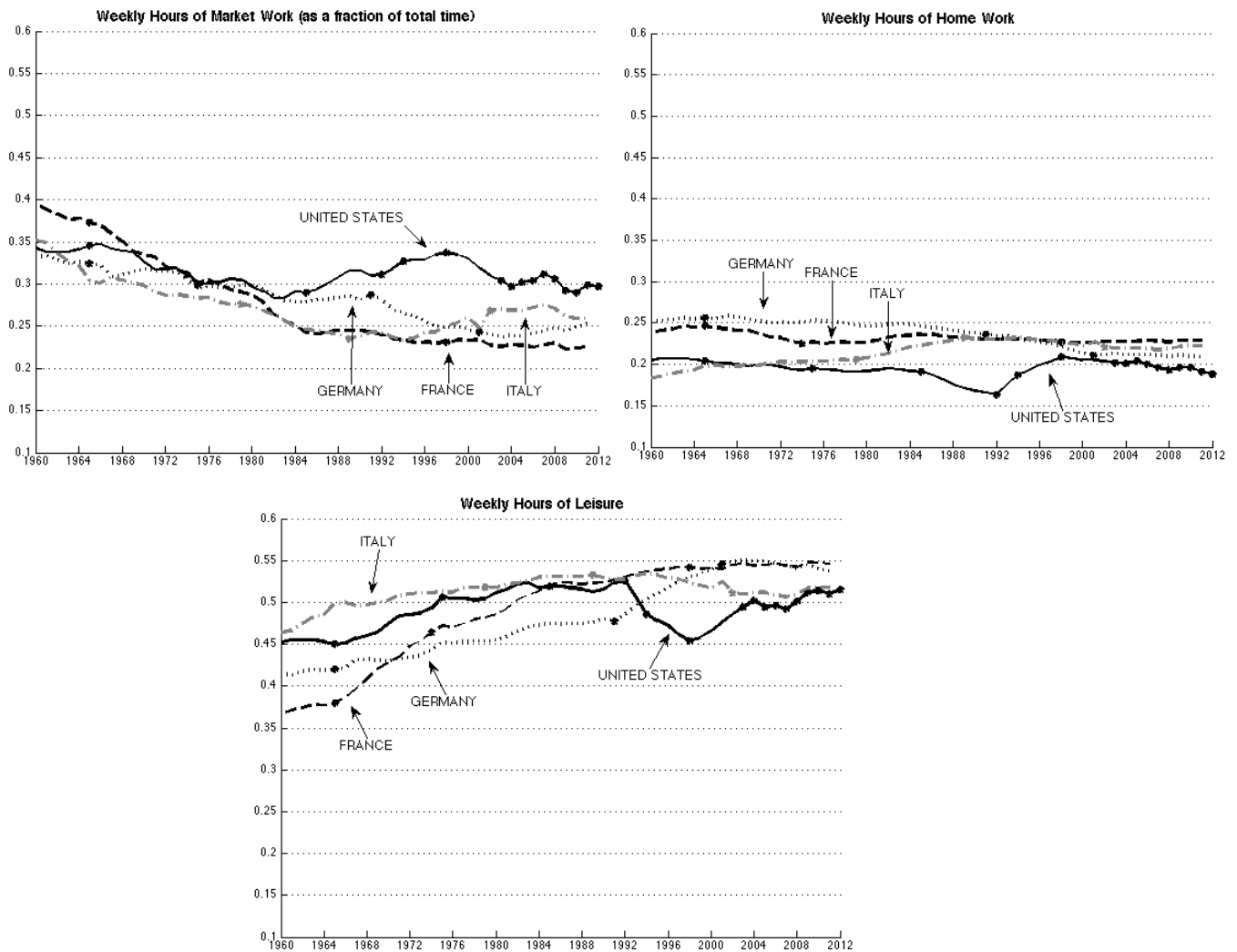


Figure 1: Allocation of Time in the US and Continental Europe 1960–2012

Table 1 reports the allocation of time in the US and France. All numbers listed in the table are expressed as hours per week of an average working-age person divided by the total hours available per week after sleep and personal care. The following facts about the allocation time among market work, home work, and leisure are implied by the table: changes in market hours and leisure roughly offset each other while hours devoted to home production roughly stayed constant; in 1970, people in the US and France devoted more hours to work (at home and in the market) than to leisure; in 2005, people in the US devoted more hours to work while people in France devoted more hours to leisure.

Table 1: Weekly hours per working-age population as a fraction of total available time

	US		France	
	1970	2005	1970	2005
Market production	32.6	30.2	33.5	22.7
Home production	19.9	20.4	23.7	22.8
Leisure	47.5	49.4	42.8	54.5

Sources: MTUS

## 2.2 Facts about Home Production

To calculate home capital, we obtain investment as the sum of the final expenditure on consumer durables in constant prices from the OECD. We then use the perpetual inventory method to construct stocks of capital used in home production. We convert capital in constant prices into capital in current prices by using the price index of investment in the current period. Appendix A contains more details.

To calculate labor productivity of home production, we impute value added following the income approach outlined in Bridgman (2013), which involves combining factor inputs with factor prices. The factor inputs are consumer durables from the OECD and hours worked at home from MTUS. The factor prices are a ten-year rates of return on government bonds and the hourly compensation of private household workers. We translate nominal value added into constant-price, constant-PPP value added by using the OECD price indexes for expenditure on close market substitutes to household consumption. The available price indexes refer to final expenditure whereas our imputed home production is value added. Using price indexes for final expenditure for value added categories works better the smaller the share of intermediate inputs in final expenditure are. In the next iteration of the paper, we will try to provide some evidence on that.



Table 2: Labor Productivity and Capital in Home Production

	US		France	
	1970	2005	1970	2005
Labor productivity, level	12.3	12.6	6.2	15.6
Labor productivity, annual growth rate	0.07%		2.78%	
Capital–output ratio	1.04	1.55	0.67	0.53

Sources: MTUS, OECD

Table 2 implies the following stylized facts about home production. Labor productivity of home production grew both in the US and in France, and the growth was much stronger in France. The capital–output ratio of home production in 1970 was larger in the US than in France. The capital–output ratio of home production grew in the US whereas it fell somewhat in France.

### 3 Model

#### 3.1 Environment

There is a measure one of identical households. Each household is endowed with one unit of time and positive amounts of the initial capital stocks for market and home production,  $K_{m0}$  and  $K_{h0}$ . Households derive utility from market– and home–produced consumption,  $C_m$  and  $C_h$ , and leisure,  $L$ . Preferences are represented by the following utility function:

$$U(C, L) = \alpha_u \log(C - \bar{C}) + (1 - \alpha_u) \log(L)$$

$$C = [\alpha_c C_m^{\sigma_c} + (1 - \alpha_c) C_h^{\sigma_c}]^{\frac{1}{\sigma_c}}$$

where  $\alpha_u, \alpha_c \in (0, 1)$  are relative weights,  $C$  is a composite consumption good,  $\bar{C}$  is a non–homotheticity term,  $L$  is leisure, and  $\sigma_c \in (-\infty, 1)$  determines the elasticity of substitution between market–produced and home–produced consumption (with  $\sigma_c = 0$  being the Cobb–

Douglas case).

The technology for producing market consumption,  $C_m$ , and investment into market capital and home capital,  $X_m$  and  $X_h$ , is represented by a Cobb–Douglas production function:

$$C_m + \frac{X_m}{A_{xm}} + \frac{X_h}{A_{xh}} = Y_m = (K_m)^{\alpha_m} (A_m H_m)^{1-\alpha_m}$$

$A_{xm}$  and  $A_{xh}$  are positive constants that determine the marginal rate of transformation between market consumption and the investments,  $K_m$  and  $H_m$  are capital and hours worked in the market,  $A_m$  is labor–augmenting technical progress, and  $\alpha_m$  is the capital–share parameter. The technology for home consumption is represented by a CES production function:

$$C_h = [\alpha_h (K_h)^{\sigma_h} + (1 - \alpha_h) (A_h H_h)^{\sigma_h}]^{\frac{1}{\sigma_h}}$$

$K_h$  and  $H_h$  denote capital and hours allocated to home production,  $A_h$  is labor–augmenting technological progress,  $\alpha_h$  is the capital–share parameter, and  $\sigma_h$  determines the elasticity of substitution between home capital and home hours. We do not a priori restrict that elasticity but calibrate it so as to match key features of home production.

Choosing market consumption as the numeraire,  $p_{cm} = 1$ , the household’s budget constraint is given as:

$$(1 + \tau_{cm})(C_m + p_{xh}X_h) + (1 + \tau_{xm})p_{xm}X_m = (1 - \tau_{hm})wH_m + (1 - \tau_{km})rK_m + \mathcal{T}$$

where  $p_{xh}$  and  $p_{xm}$  are the relative prices of investment for home and market capital,  $w$  and  $r$  denote the wage and interest rate in terms of market consumption,  $\tau_{cm}$ ,  $\tau_{xm}$ ,  $\tau_{hm}$ , and  $\tau_{km}$  denote the tax rates on consumption, investment for market production, labor income, and capital income and  $\mathcal{T}$  is a lump–sum rebate of the resulting tax revenues. Investment in home capital is taxed at the same tax rate as market consumption because it is composed of durable consumption goods and consumption taxes do not distinguish between durable and non–durable

consumption goods.<sup>5</sup> Dividing the budget constraint by consumption taxes gives:

$$C_m + p_{xh}X_h + (1 + \tau_x)p_{xm}X_m = (1 - \tau_w)wH_m + (1 - \tau_r)rK_m + T$$

where the effective tax rates are given as:

$$\begin{aligned}\tau_x &\equiv \frac{\tau_{xm} - \tau_{cm}}{1 + \tau_{cm}} \\ \tau_w &\equiv \frac{\tau_{hm} + \tau_{cm}}{1 + \tau_{cm}} \\ \tau_r &\equiv \frac{\tau_{km} + \tau_{cm}}{1 + \tau_{cm}}\end{aligned}$$

The household faces the following feasibility constraints:

$$K'_m = (1 - \delta_m)K_m + X_m$$

$$K'_h = (1 - \delta_h)K_h + X_h$$

$$1 = H_m + H_h + L$$

The first two constraints describe the accumulation of capital where  $\delta_m, \delta_h \in (0, 1)$  denote the depreciation rates on market and home capital. The third constraint specifies that the amounts of time allocated to market production, home production, and leisure must add up to the total time endowment of one.

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<sup>5</sup>A broader definition of home capital would include residential housing. We do not use that broader definition here because we think that the key margin of substitution between home capital and labor refers to consumer durables (e.g., washing machines) versus labor. See Greenwood and Hercowitz (1991) for a different treatment that includes residential housing in home capital.

## 3.2 Equilibrium

Putting the different ingredients together, the household's problem becomes:

$$\begin{aligned} \mathcal{L}_t = \sum_{t=0}^{\infty} \beta^t & \left\{ \alpha_u \log(C - \bar{C}) + (1 - \alpha_u) \log(L_t) + \gamma_{ct} \left( \left[ \alpha_c C_{mt}^{\sigma_c} + (1 - \alpha_c) C_{ht}^{\sigma_c} \right]^{\frac{1}{\sigma_c}} - C_t \right) \right. \\ & + \gamma_{ht} \left( \left[ \alpha_h K_{ht}^{\sigma_h} + (1 - \alpha_h) (A_{ht} H_{ht})^{\sigma_h} \right]^{\frac{1}{\sigma_h}} - C_{ht} \right) \\ & + \lambda_t \left[ (1 - \tau_{wt}) w_t H_{mt} + (1 - \tau_{rt}) r_t K_{mt} + T_t - C_{mt} - p_{xht} X_{ht} - (1 - \tau_{xt}) p_{xmt} X_{mt} \right] \\ & + \phi_{mt} \left[ (1 - \delta_m) K_{mt} + X_{mt} - K_{m,t+1} \right] \\ & + \phi_{ht} \left[ (1 - \delta_h) K_{ht} + X_{ht} - K_{h,t+1} \right] \\ & \left. + \mu_t \left[ 1 - L_t - H_{mt} - H_{ht} \right] \right\} \end{aligned}$$

The Appendix lists the first-order conditions to the household problem.

**Definition.** A competitive equilibrium are sequences of effective tax rates  $\{\tau_{xt}, \tau_{wt}, \tau_{rt}\}$ , prices  $\{p_{xht}, p_{xmt}, w_t, r_t\}$ , allocations  $\{H_{mt}, H_{ht}, L_t\}$ ,  $\{K_{m,t+1}, K_{h,t+1}\}$ ,  $\{X_{mt}, X_{ht}, C_{mt}, C_{ht}\}$  such that

- taking prices, wages, interest rates, effective tax rates and the initial capital stocks as given,  $\{H_{mt}, H_{ht}, L_t, K_{m,t+1}, K_{h,t+1}, X_{mt}, X_{ht}, C_{mt}, C_{ht}\}$  solve the problem of the household
- taking prices and wages as given,  $(H_{mt}, K_{mt})$  maximize profits
- markets clear.

Eliminating the multipliers, the first-order conditions to the household problem imply 4 consolidated conditions that have obvious intuitive interpretations. In displaying them we highlight the tax rates to emphasize where the distortions occur. First, the optimal allocation of time between leisure and market work equalizes the marginal utilities of leisure and market work:

$$(1 - \alpha_u) L_t^{-1} = \alpha_u \frac{C_t^{1-\sigma_c}}{C_t - \bar{C}} \alpha_c C_{mt}^{\sigma_c - 1} (\mathbf{1} - \tau_{wt}) w_t \quad (1)$$

The marginal utility of market work is distorted by the income tax  $\tau_{wt}$ .

Second, the optimal allocation of time between home work and market work equalizes the marginal utilities of homework and market work:

$$(1 - \alpha_c)C_{ht}^{\sigma_c - \sigma_h}(1 - \alpha_h)A_{ht}^{\sigma_h}H_{ht}^{\sigma_h - 1} = \alpha_c C_{mt}^{\sigma_c - 1}(\mathbf{1} - \tau_{wt})w_t \quad (2)$$

Again, the marginal utility of market work is distorted by the income tax  $\tau_{wt}$ .

Third, the optimal allocation of market capital satisfies the following Euler equation:

$$\begin{aligned} (\mathbf{1} + \tau_{xt})p_{xmt} \frac{C_t^{1-\sigma_c}}{C_t - \bar{C}} C_{mt}^{\sigma_c - 1} = \\ \beta \frac{C_{t+1}^{1-\sigma_c}}{C_{t+1} - \bar{C}} C_{m,t+1}^{\sigma_c - 1} [(\mathbf{1} - \tau_{r,t+1})r_{t+1} + (\mathbf{1} + \tau_{x,t+1})p_{xm,t+1}(1 - \delta_m)] \end{aligned} \quad (3)$$

This Euler equation is distorted by the investment taxes today and tomorrow and the capital–income tax tomorrow. Fourth, the optimal allocation of home capital satisfies the following Euler equation:

$$p_{xht} \frac{C_t^{1-\sigma_c}}{C_t - \bar{C}} \alpha_c C_{mt}^{\sigma_c - 1} = \beta \frac{C_{t+1}^{1-\sigma_c}}{C_{t+1} - \bar{C}} [(1 - \alpha_h)C_{h,t+1}^{\sigma_c - \sigma_h} \alpha_h K_{h,t+1}^{\sigma_h - 1} + p_{xh,t+1} \alpha_c C_{m,t+1}^{\sigma_c - 1} (1 - \delta_h)] \quad (4)$$

This Euler equation is not distorted by taxes because the tax on investment in household capital cancels with the tax on market consumption.

We have 14 endogenous variables:  $p_{xh}, p_{xm}, w, r, H_m, H_h, L, K'_m, K'_h, X_m, X_h, C, C_m, C_h$ . To determine these, we have the four conditions (1)–(4) from above. In addition, the feasibility

constraints and the first-order conditions to the firm's problem imply another 10 conditions:

$$\begin{aligned}
p_{xm} &= \frac{1}{A_{xm}}, & p_{xh} &= \frac{1}{A_{hx}} \\
K'_m &= (1 - \delta_m)K_m + X_m, & K'_h &= (1 - \delta_h)K_h + X_h \\
1 &= H_m + H_h + L \\
r &= \alpha_m Y_m K_m^{-1}, & w &= (1 - \alpha_m) Y_m H_m^{-1} \\
C &= [\alpha_c C_m^{\sigma_c} + (1 - \alpha_c) C_h^{\sigma_c}]^{1/\sigma_c} \\
C_m + \frac{X_m}{A_{xm}} + \frac{X_h}{A_{xh}} &= (K_m)^{\alpha_m} (A_m H_m)^{1-\alpha_m} \\
C_h &= [\alpha_h (K_h)^{\sigma_h} + (1 - \alpha_h) (A_h H_h)^{\sigma_h}]^{1/\sigma_h}
\end{aligned}$$

## 4 Connecting the Model with the U.S. Data

We start by calibrating the model to the US economy during 1970–2005. We normalize  $A_m = A_{xm} = A_{xh} = 1$  in 1970. We use the information provided on McDaniel's webpage to calculate effective tax rates.<sup>6</sup> We calculate the following parameters directly from the data:

- $\beta = 0.96$ : standard value
- $\delta_m$  and  $\delta_h$ : depreciation rates of market capital and consumer durables in NIPA
- $\alpha_m = 0.365$ : match factor income shares from the BEA.
- $\{A_{xmt}\}$ : match US relative prices of capital formation from OECD
- $\{A_{xht}\}$ : match US relative prices of consumer durables from OECD<sup>7</sup>

This leaves six parameters and the series for technological change, which we cannot calibrate individually: the three relative weights  $\alpha_u, \alpha_c, \alpha_h$ , the two elasticity parameters  $\sigma_c, \sigma_h$ , the subsistence term  $\bar{C}$ , and  $\{A_{mt}, A_{ht}\}$ . We calibrate them jointly to hit six data targets and the annual time series for market and home labor productivity:

<sup>6</sup>See <http://www.caramcdaniel.com/researchpapers> and McDaniel (2007) for a additional details.

<sup>7</sup>There are different concept of what constitutes capital used in home production. The broadest concept includes residential housing. The narrowest concept includes only household appliances. Consumer durables is between these two concepts. We use it here because comparable data are available from NIPA for both the US and France.

- US hours worked in the market:  $H_{m,70}, H_{m,05}$  (from MTUS)
- US hours worked at home:  $H_{h,70}, H_{h,05}$  (from MTUS)
- US share of home capital investment in market output:  $p_{xh,70}X_{h,70}/Y_{m,70}, p_{xh,05}X_{h,05}/Y_{m,05}$  (from the OECD)
- Annual US labor productivities of market production:  $\{Y_{m,t}/H_{m,t}\}$  for  $t = 1970, \dots, 2005$ . (from the OECD)
- Annual US labor productivity of home production:  $\{Y_{h,t}/H_{h,t}\}$  for  $t = 1970, \dots, 2005$ . (from own calculations)

Since we have a non-homotheticity term in the utility function, we cannot impose balanced growth on our equilibrium path. We therefore add the initial and final capital–output ratios in market and home production as targets to pin down the initial and final capital stocks:<sup>8</sup>

- $p_{m,70}K_{m,70}/Y_{m,70}, p_{m,05}K_{m,05}/Y_{m,05}$  (from the BEA)
- $p_{h,70}K_{h,70}/Y_{h,70}, p_{h,05}K_{h,05}/Y_{h,05}$  (from BEA and own calculations)

Table 3: Average Annual Growth Rates

		Data	Model
Labor Productivity of Market Production	$Y_m/H_m$	1.74	1.74
Labor Productivity of Home Production	$Y_h/H_h$	0.07	0.07
Technical Change in Market Production	$\Delta A_m$		1.07
Technical Change in Home Production	$\Delta A_h$		-0.26
Technical Change in Market Investment	$\Delta A_{xm}$		1.04
Technical Change in Home Investment	$\Delta A_{xh}$		3.07

Table 3 shows that we hit the targets for labor productivity exactly. Interestingly, we end up with negative labor–augmenting technical change at home although labor productivity at home

<sup>8</sup>Given that we don't model intermediate inputs, output equals value added.

grew. The reason why both of these statements can be true in our model is because of massive investments in consumer durables, which were spurred by the large fall in the relative price of home capital that our model maps into large technical progress of 3.07% per year. There are two interpretations for negative labor–augmenting technical change: Americans forgot how to do basic chores at home; women with the high human capital left the home (selection).

The model has no trouble hitting the six joint targets either. As can be seen in Tables 4, we hit all targets exactly.

Table 4: Targets of the Joint Calibration

		Data		Model	
		1970	2005	1970	2005
Hours worked in the market	$H_m$	32.6	30.2	32.6	30.2
Hours worked at home	$H_h$	19.9	20.4	19.9	20.4
Share of consumer durables in GDP	$\frac{p_{xh}X_h}{Y_m}$	0.11	0.10	0.11	0.10
Capital–output ratio in the market	$\frac{p_{xm}K_m}{Y_m}$	2.99	3.14	2.99	3.14
Capital–output ratio at home	$\frac{p_{xh}K_h}{Y_h}$	1.04	1.55	1.04	1.55

The calibrated parameter values are in Table 5. We emphasize the following properties: market–produced and home–produced consumption come out as complements; home capital and home labor come out as complements also; there is a small subsistence level of consumption. To see that the subsistence level is small, Table 6 expresses it as a share of total consumption. Note that papers which calibrate the elasticity of substitution between home consumption and market services find that the elasticity is larger than Cobb–Douglas and the aggregate of market services and home consumption is a complement to consumption goods. Since we first aggregate market–produced goods and services to market–produced consumption and then aggregate market–produced and home–produced consumption, our elasticity of substitution is an average of two elasticities, one of which is larger than Cobb–Douglas and one smaller.



Table 5: Calibrated Parameter Values

Relative weight on consumption	$\alpha_u$	0.54
Relative weight on market–produced consumption	$\alpha_c$	0.79
Relative weight on home capital	$\alpha_h$	0.08
Elasticity between market– and home–produced consumption	$\frac{1}{1-\sigma_c}$	0.76
Elasticity between home capital and home labor	$\frac{1}{1-\sigma_h}$	0.88
Non–homotheticity term	$\bar{C}$	0.10

Table 6:  $\bar{C}/C$ 

	US	France
1970	0.17	0.28
2005	0.11	0.13

## 5 France

### 5.1 Feeding into the model French productivities and taxes

We leave the calibrated deep parameters unchanged and ask how well our model accounts for the allocation of time in France if we feed in the French initial and terminal capital stocks, French labor productivity in market and in home production, and French taxes. In particular, as for the US, we target the initial and final capital–output ratios in market and home production:

- $p_{mt}K_{mt}^F/K_{mt}^F$  in 1970 and 2005 from the OECD
- $p_{ht}K_{ht}^F/Y_{ht}^F$  in 1970 and 2005 from own calculations

To obtain the sequences for  $\{A_{m,t}^F, A_{h,t}^F\}$ , we target:

- $\{A_{m,t}^F\}$ : match French labor productivities of market production from OECD
- $\{A_{h,t}^F\}$ : match French labor productivity of home production calculated ourselves

Moreover, we feed into the model:

- $\{A_{xm,t}^F\}$  to match French relative prices of capital formation from OECD
- $\{A_{xh,t}^F\}$  to match French relative prices of consumer durables from OECD

We also feed into the model the French effective taxes from McDaniel's webpage:

- $\{\tau_{x,t}^F, \tau_{w,t}^F, \tau_{r,t}^F\}$

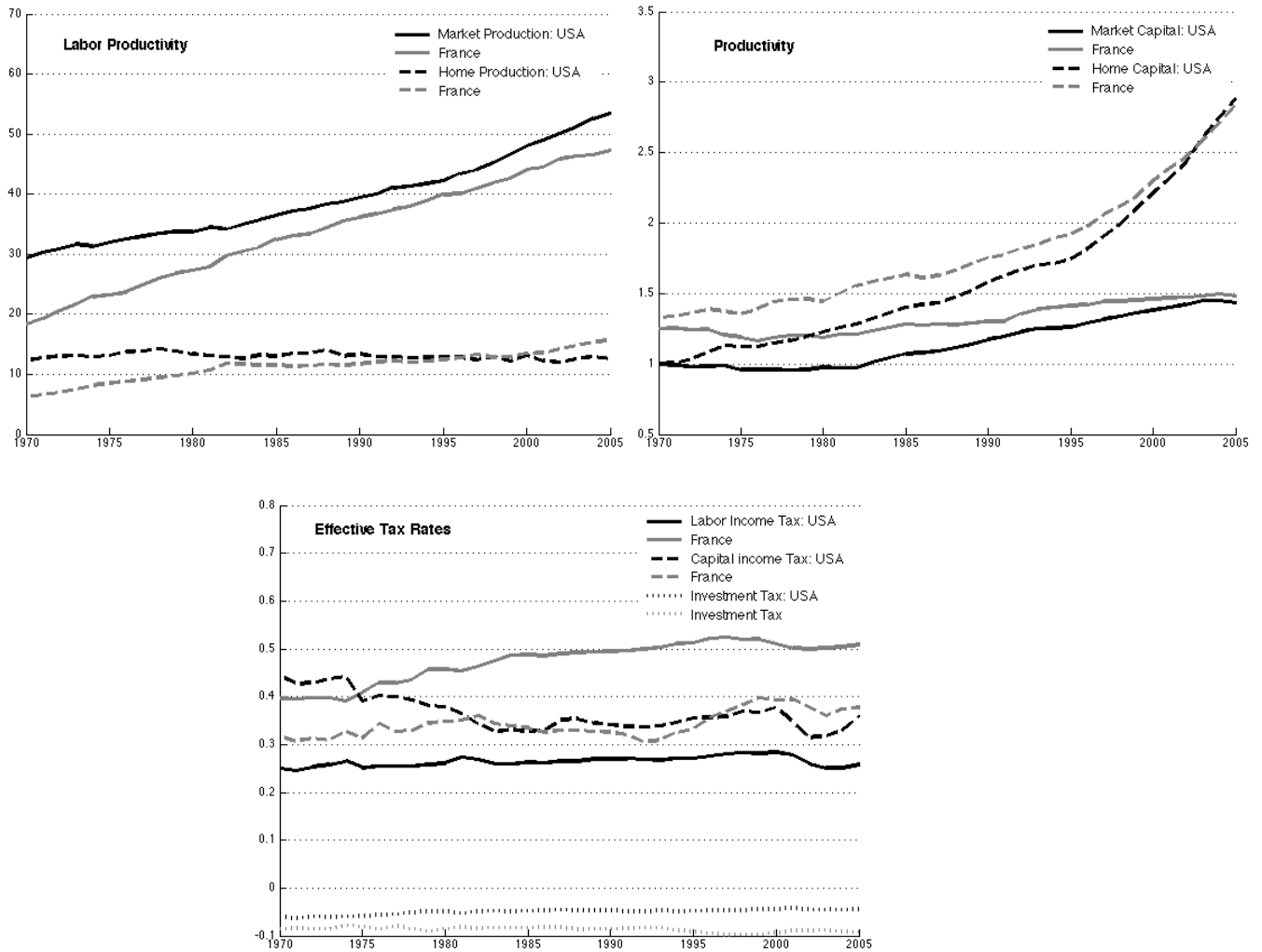


Figure 2: US versus French Productivities and Taxes

Figures 2a–2c depict the series for labor productivity and effective taxes in both countries. Regarding labor productivity, we can see that in 1970 there were gaps between the US and France both in the market and at home. Moreover, in the market France closed much of this gap and at home France actually overtook the US. Regarding taxes, the figures show the well

known fact that the main difference between the tax systems of the two countries is that the effective income taxes in France are much larger than in the US and increased considerably whereas in the US effective income taxes remained constant on average. Another noteworthy facts is that effective capital taxes in the US were initially larger than in France but came down considerably and are now similar in both countries.

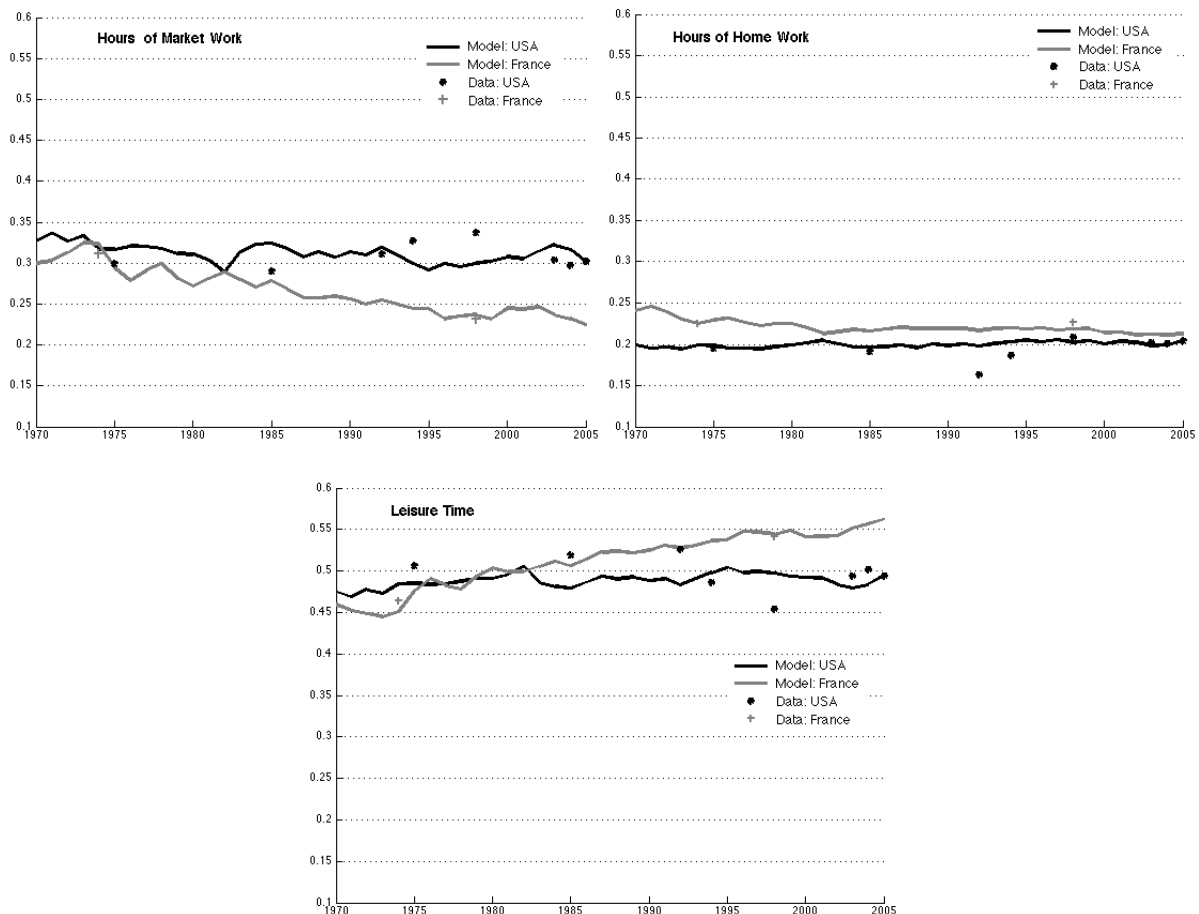


Figure 3: Time Allocation Predicted by the Model

The results of feeding in French taxes and productivities can be found in Figures 3 and 4. We find that our model matches the time allocations very well indeed. In particular, it does an excellent job at capturing that the decrease in market hours and the increase in home hours offset each other while level of home hours does not change much. Also the model matches very well the level and the evolution of the capital–output ratios in both countries.

Freeman and Schettkat (2005) and Rogerson (2008) observed that a large part of the increased US hours worked in the market occurred in market services. They argued that the reason for this is that as the economy develops, many services move out of the home into the market. Freeman and Schettkat called this “marketization of services” in the US. Rogerson formalized this idea in a model that combines the substitution of market– for home–produced services and the structural transformation between market goods and market services. He found that his model accounts well for the allocation of time between market and non–market activities in the US and Continental Europe. Our new evidence suggests that his model does not account well for the allocation of non–market time between home–production time and leisure, as it has the counterfactual prediction that French home hours should have increased which they didn’t. This raises the question whether our results speak against the hypothesis that there was marketization of services in the US but not in France. It turns that the answer to this question is negative.

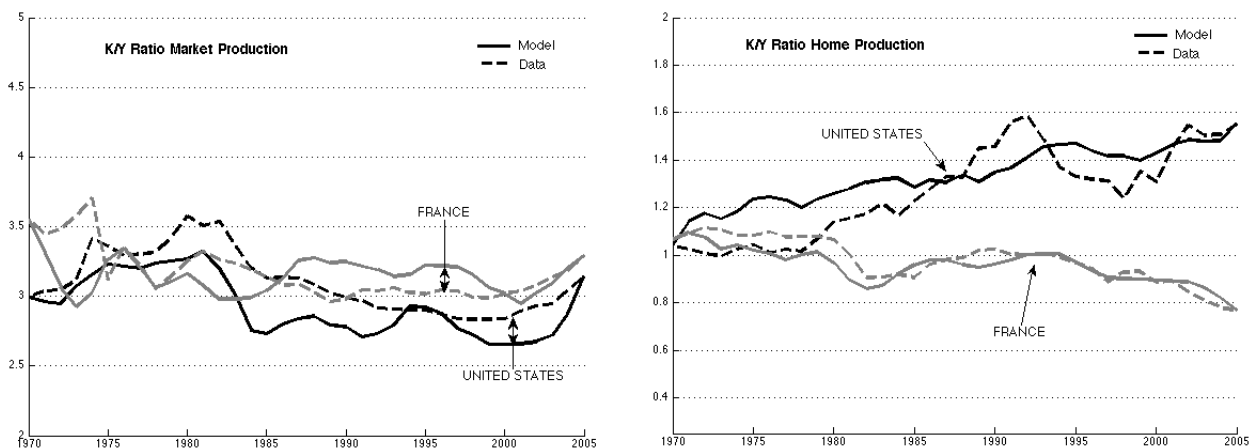


Figure 4: Capital to Output Ratios Predicted by the Model

To see that also in our model the US experienced marketization of services whereas France did not, it is instructive to shift the focus from the allocation of time to the composition of consumption. Figure 5 depicts the the ratio of home consumption over market consumption predicted by our model. We can see that while that ratio remained roughly constant in France, it declined strongly in the US. This implies that home–produced consumption became relatively less important in the US compared to market–produced consumption, which is consistent with

marketization of services. In our model, this behavior of consumption, however, does not translate into a similar behavior of hour worked in the market and at home. The simple reason is that changes in capital and labor-augmenting technical progress at home allow the consumption composition to change in the US although home hours remained roughly flat.

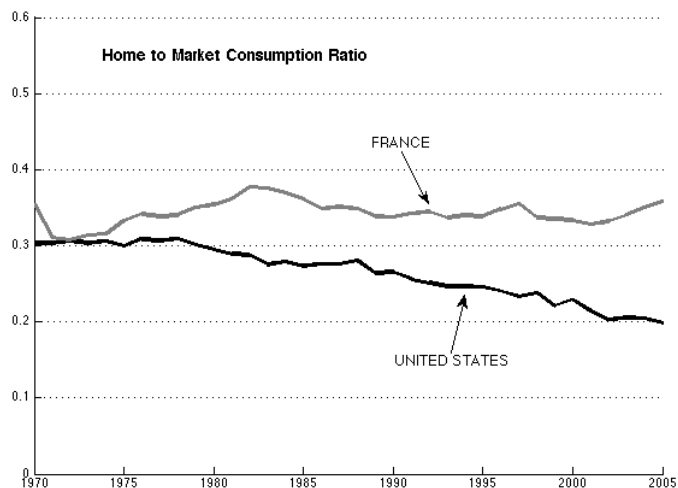


Figure 5: Consumption Composition implied by the Model

To build intuition for why our model is successful at replicating the main trends of time allocation in France, we now report additional facts from two counterfactual exercises: (i) eliminate capital from home production; (ii) feed only French taxes into the calibrated US economy.

## 5.2 Model without home capital

One way to gauge how important the role of home capital is in our model is recalibrate a version of the model that does not have home capital but has labor as the only input into home production:

$$Y_h = A_h H_h$$

This is what McDaniel (2011) and Rogerson (2008) assumed. Figures 6 show the results. We can see that this model version does have two counterfactual implications: French home hours decline; French leisure is initially much lower than in the data and subsequently increases much more than in the data.

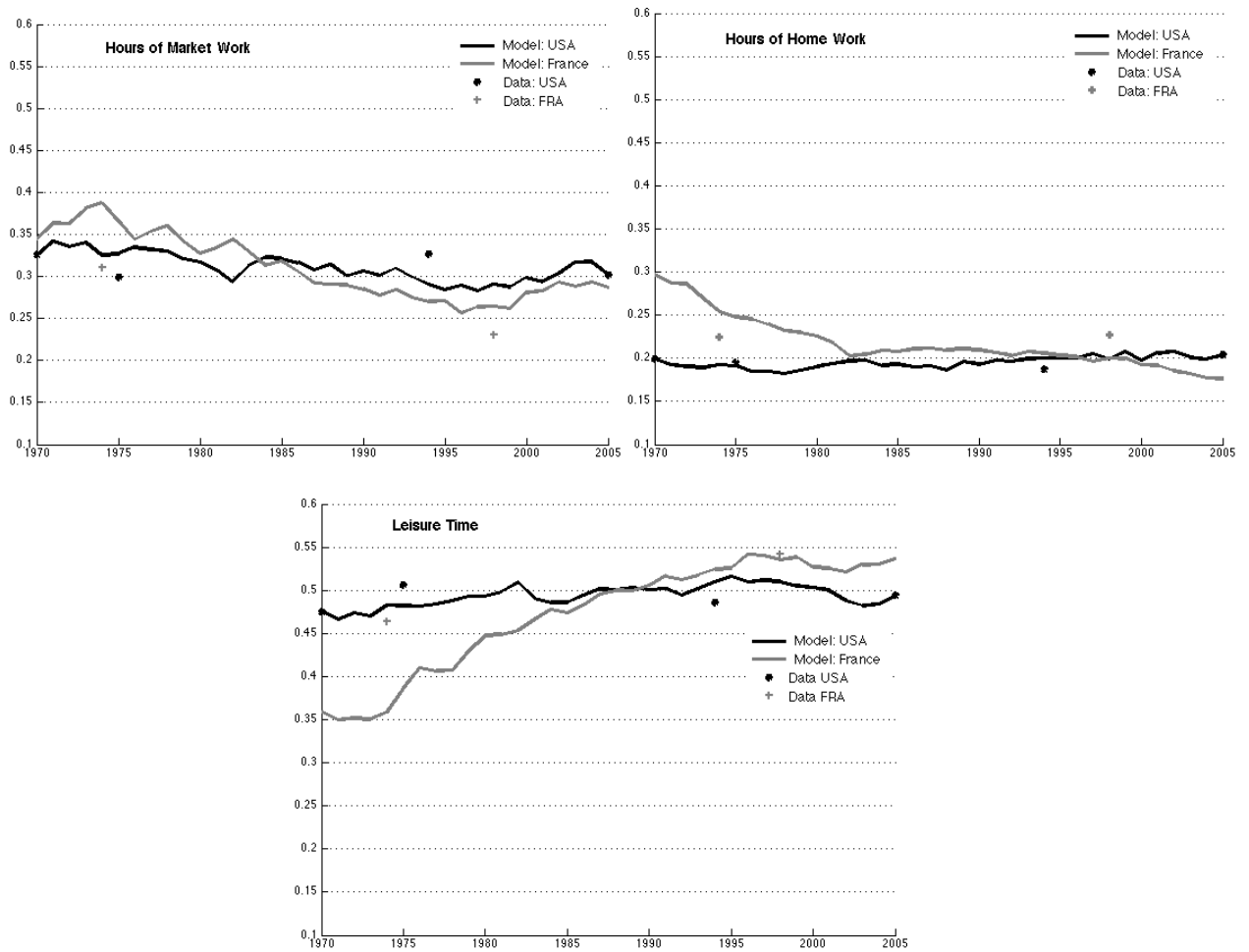


Figure 6: Time Allocation predicted by the the Model without Home Capital

### 5.3 US with French taxes only

Figure 7 reports what happens in our model when we only feed in the French taxes but leave the US capital stocks and labor productivities in place. We can see that the French taxes cause most of the changes in the time allocation.<sup>9</sup> We can also see that particularly at the beginning of the sample, taxes alone do not account fully for the behavior of hours worked at home and leisure. This implies that it is crucial for our results that in addition to processes for French taxes we feed in the processes for French labor productivities and we impose the initial and terminal French capital stocks in the market and at home.

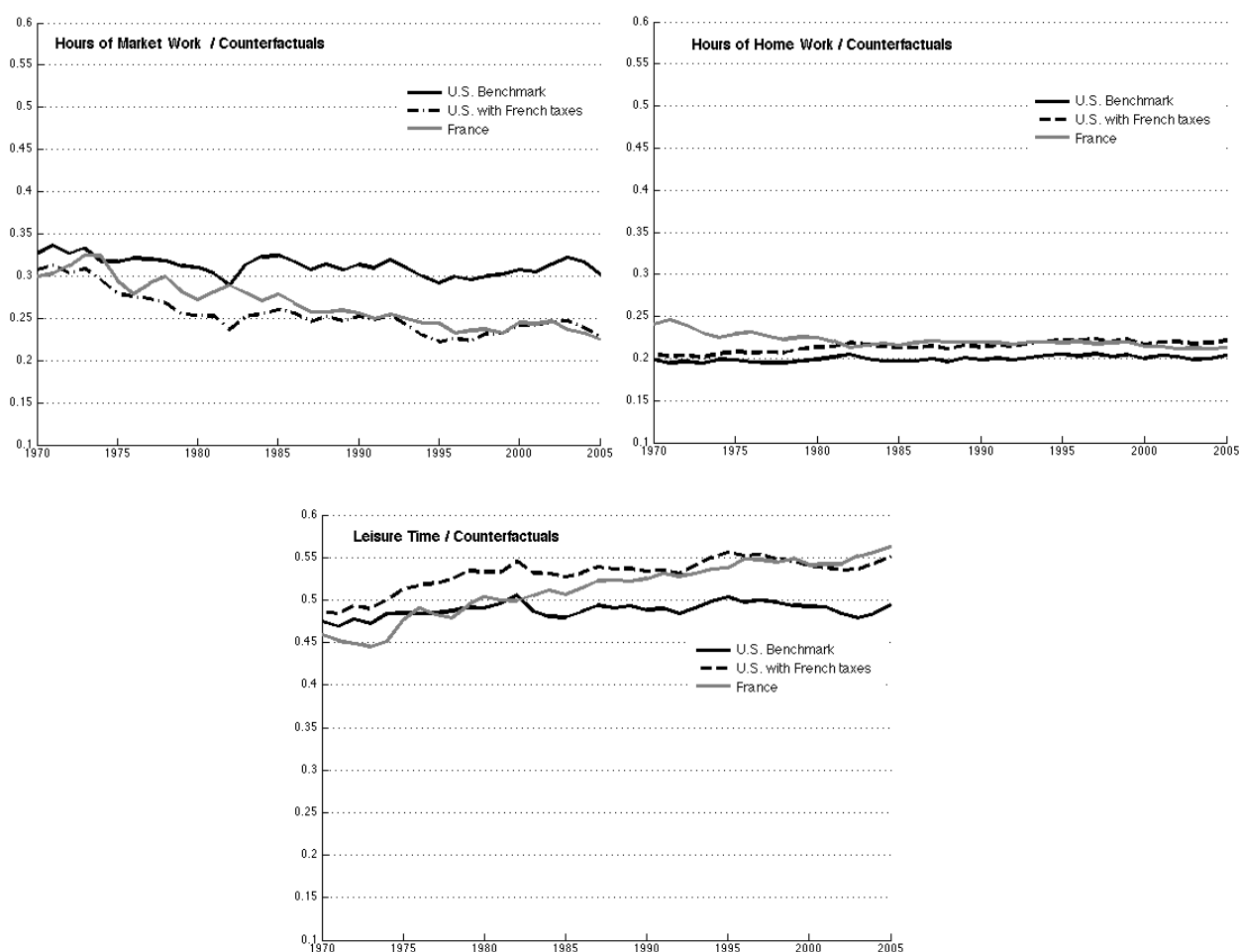


Figure 7: Time Allocation Predicted when the U.S. has French Taxes

<sup>9</sup>If we decompose the total effect of taxes further into the effects of the three effective taxes, we obtain the usual result that almost all the action comes from effective labor income taxes. This is not surprising because effective labor income taxes show the biggest differences between the US and France. The detailed results are available upon request.

## 6 Conclusion

We have documented new facts about the time allocations in the US and France since 1970. Both in the US and France during the last forty years, market hours per working-age population decreased and leisure increased while hours devoted to home production did not change much. We have asked what accounts for the time allocations in the US and France. To answer this question, we have build a version of the growth model with market production, and home production and with capital in the production of home and market output. We have found that differences in income taxes and labor productivities are the key forces behind the differences in the time allocations in the US and France. Our next step is to extend the analysis to other countries, with Germany being on top of our list.

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## Appendix A: Data Work

### Appendix A.1: Interpolation and Extrapolation of Hours

#### Interpolation of hours

- Suppose we have time use data for 1965 and 1975 (as in the case of the U.S., for instance).
- **Market hours.** The average weekly time spent on market work (for individuals between 15 and 64 years) in 1965 and 1975 are equal to  $H_{m,65}=34.9$  hours and  $H_{m,75}=30.6$  hours respectively. We want to obtain a smooth interpolation which is based on the actual evolution of hours of work. To this end, we look at the evolution of average annual market hours per working age person between these two points in time. The data for market hours per working age person are taken from the GGDC database.
  - Step 1: Annual hours of market work per working age person are in row (1) of the table below.
  - Step 2: Compute the “forward” change in hours for each year with respect to the start year 1965. That is:  $H_{65}/H_{65}, H_{66}/H_{65}, H_{67}/H_{65}, \dots, H_{75}/H_{65}$ . See row (2).
  - Step 3: Compute the “backward” change in hours for each year with respect to the final year 1975. That is:  $H_{75}/H_{75}, H_{74}/H_{75}, H_{73}/H_{75}, \dots, H_{65}/H_{75}$ . See row (3).
  - Step 4: Compute the implied weekly, “forward” hours for each year as:  $H_{m,66}^f = H_{m,65} * H_{66}/H_{65}, H_{m,67}^f = H_{m,65} * H_{67}/H_{65}, \dots, H_{m,75}^f = H_{m,65} * H_{75}/H_{65}$ . See row (4)
  - Step 5: Compute the implied weekly, “backward” hours for each year as:  $H_{m,74}^b = H_{m,75} * H_{74}/H_{75}, H_{m,73}^b = H_{m,75} * H_{73}/H_{75}, \dots, H_{m,65}^b = H_{m,75} * H_{65}/H_{75}$ . See row (5)
  - Step 6: Interpolation. Taking the simple average of these two series is not an option because the resulting series would not go through the actual period-start and -end

points. Instead, we do a weighted interpolation:  $H_{m,66} = (9 * H_{m,66}^f + 1 * H_{m,66}^b)/10$ ,  $H_{m,67} = (8 * H_{m,67}^f + 2 * H_{m,67}^b)/10$ , ...,  $H_{m,74} = (1 * H_{m,74}^f + 9 * H_{m,74}^b)/10$ . See row (6), which is our final series for hours of market work.

year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
(1)	1194.6	1207.2	1199.6	1196.8	1201.5	1167.7	1144.1	1159.6	1172.0	1160.1	1114.4
(2)	1.000	1.010	1.004	1.002	1.006	0.978	0.958	0.971	0.981	0.971	0.933
(3)	1.072	1.083	1.076	1.074	1.078	1.048	1.027	1.041	1.052	1.041	1.000
(4)	34.9	35.3	35.1	35.0	35.1	34.1	33.4	33.9	34.3	33.9	32.6
(5)	32.8	33.2	33.0	32.9	33.0	32.1	31.4	31.9	32.2	31.9	30.6
(6)	<b>34.9</b>	35.1	34.6	34.3	34.3	33.1	32.2	32.5	32.6	32.1	<b>30.6</b>

Table 7: Interpolation of market hours

There are two different ways of computing home hours (and leisure). Let's start with Approach (i)

- **Total hours - Approach (i).** To be able to compute leisure and home hours, we, first, need a series for total disposable time. From the time use we have the total weekly disposable time in 1965 and 1975:  $H_{65} + L_{65} = 100.9$  hours and  $H_{75} + L_{75} = 102.4$  hours.
  - Step 1: Compute the percentage of market hours in total hours in 1965 and 1975. See rows (1) [total weekly time in hours], (2) [weekly market hours], (3) share of weekly market hours in total time.
  - Step 2: Linearly interpolate between the start- and the end-percentage. See row (4).
  - Step 3: Recover the total time for each year by dividing the market hours by the share of market hours. See row (5).
- **Home hours - Approach (i).** The time use data gives us two observations for home hours:  $H_{h,65} = 20.6$  and  $H_{h,75} = 20.0$ .
  - Step 1: Compute the share of weekly home hours in total weekly hours for 1965

and 1975. See rows (6) [total weekly time in hours], (7) [weekly home hours], (8) share of weekly home hours in total time.

- Step 2: Linearly interpolate between the start- and the end-percentage. See row (9).
- Step 3: Compute weekly home hours by multiplying the total weekly time by the share of home hours. See row (10).

- **Leisure - Approach (i).** The series for leisure is obtained by subtracting market hours and home hours from the total weekly time. See row (11).

year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
(1)	100.9										102.4
(2)	34.9										30.6
(3)	34.6										29.9
(4)	34.6	34.1	33.7	33.2	32.7	32.3	31.8	31.3	30.8	30.4	29.9
(5)	100.9	102.7	102.9	103.5	104.7	102.6	101.4	103.7	105.7	105.6	102.4
(6)	100.9										102.4
(7)	20.6										20.0
(8)	20.4										19.5
(9)	20.4	20.3	20.2	20.2	20.1	20.0	19.9	19.8	19.7	19.6	19.5
(10)	20.6	20.9	20.8	20.9	21.0	20.5	20.2	20.5	20.8	20.7	20.0
(11)	45.4	46.8	47.4	48.3	49.5	49.0	49.0	50.7	52.3	52.9	51.8

Table 8: Interpolation of total time, home hours and leisure, Approach (i)

We now turn to Approach (ii).

- **Total hours - Approach (ii).** From the time use we have the total time in 1965 and 1975:  
 $H_{65} + L_{65} = 100.9$  and  $H_{75} + L_{75} = 102.4$ .

- Step 1: Linearly interpolate between the start and the end values of total time. See row (1).
- Step 2: Compute the share of home hours in non-market time for 1965 and 1975 and linearly interpolate between the start and the end points. See row (2).

- **Home hours - Approach (ii):** Compute home hours for each year by multiplying the non-market time with the share of home hours in non-market time. Row (3).
- **Leisure - Approach (ii).** The series for leisure is obtained by subtracting market hours and home hours from the total weekly time. See row (4).

year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
(1)	100.9	101.0	101.2	101.3	101.5	101.6	101.8	101.9	102.1	102.2	102.4
(2)	31.2	30.9	30.6	30.2	29.9	29.5	29.2	28.8	28.5	28.2	27.8
(3)	20.6	20.4	20.3	20.2	20.1	20.2	20.3	20.0	19.8	19.8	20.0
(4)	45.4	45.6	46.2	46.8	47.1	48.3	49.3	49.4	49.7	50.4	51.8

Table 9: Interpolation of total time, home hours and leisure, Approach (ii)

- **Résumé:** We favor Approach (ii) for the following reason: Approach (i) implies a strong co-movement between market hours and total time. For instance, between 1974 and 1975, we see a decline in market hours from 32.1 to 30.6 weekly hours. At the same time, total hours drop from 105.6 to 102.4. Moreover, the series for total time is very volatile (because it's directly linked to market hours which fluctuate a lot). This is somewhat counterfactual - at least for the U.S. In the late 2000s, we have annual time use observations and we see that individuals change their total weekly time ( $H_m + H_h + L$ ) typically by less than an hours from one year to the next. Approach (ii) is consistent with this observations because it linearly interpolates the total time and does not link it to market hours.

## Extrapolation of hours

For some countries we need to extrapolate the hours series. For instance, the last time use observation for France is for 1998 but we want to know what the hours are in 2005. There are three different ways to do the extrapolation. All three approaches use the same way to compute market hours. So let's first look at how market hours are computed.

- Suppose we are looking at France, we have time use data for 1998, and we want to extrapolate the series until 2005.

- **Market hours.** The weekly market hours in 1998 are equal to  $H_{m,98}=24.5$ . As above, we make use of the data on the evolution of actual hours of work per working age person.

- Step 1: Market hours per working age person are in row (1) of the table below .
- Step 2: Compute the change in hours for each year with respect to the start year 1998. That is:  $H_{98}/H_{98}, H_{99}/H_{98}, H_{00}/H_{98}, \dots, H_{05}/H_{98}$ . See row (2).
- Step 3: Compute the implied weekly hours for each year as:  $H_{m,99}^f = H_{m,98} * H_{99}/H_{98}$ ,  $H_{m,00}^f = H_{m,98} * H_{00}/H_{98}, \dots, H_{m,05}^f = H_{m,98} * H_{05}/H_{98}$ . See row (3)

year	1998	1999	2000	2001	2002	2003	2004	2005
(1)	1005.4	1018.2	1014.1	1016.6	989.3	981.3	994.0	989.3
(2)	1.000	1.013	1.009	1.011	0.984	0.976	0.989	0.984
(3)	<b>24.5</b>	24.8	24.7	24.8	24.1	23.9	24.2	24.1

Table 10: Extrapolation of market hours

Now let's look at the three approaches to compute home hours and leisure in greater detail.

- **Total hours - Approach (1).** We, first, need a series for total disposable time. From the time use we have the total time in 1998 which is:  $H_{98} + L_{98} = 106.0$ .
  - Step 1: Compute the share of market hours in total hours in 1998. See rows (1) [total weekly time in hours], (2) [weekly market hours], (3) share of weekly market hours in total time.
  - Step 2: Assume that this share remains constant during the period from 1998 to 2005. See row (4).
  - Step 3: Recover the total time for each year by dividing the market hours by the share of market hours. See row (5).
- **Home hours - Approach (1).** The time use data gives us an observations for home hours in 1998:  $H_{h,98} = 24.1$ .

- Step 1: Compute the share of weekly home hours in total weekly hours for 1998. See rows (6) [total weekly time in hours], (7) [weekly home hours], (8) share of weekly home hours in total time.
- Step 2: Assume that this share is constant during the period from 1998 to 2005. See row (9).
- Step 3: Compute weekly home hours by multiplying the total weekly time by the share of home hours. See row (10).
- Step 4: The series for leisure is obtained by subtracting market hours and home hours from the total weekly time. See row (11).

year	1998	1999	2000	2001	2002	2003	2004	2005
(1)	106.0							
(2)	24.5							
(3)	23.1							
(4)	23.1	23.1	23.1	23.1	23.1	23.1	23.1	23.1
(5)	106.0	107.4	107.0	107.2	104.3	103.5	104.8	104.3
(6)	106.0							
(7)	24.1							
(8)	22.7							
(9)	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7
(10)	24.1	24.4	24.3	24.3	23.7	23.5	23.8	23.7
(11)	57.5	58.2	57.9	58.1	56.6	56.1	56.8	56.6

Table 11: Extrapolation of total time, home hours and leisure, Approach 1

- **Total hours, home hours and leisure - Approach (2).** We, first, need a series for total disposable time. From the time use we have the total time in 1998 which is:  $H_{98} + L_{98} = 106.0$ .

- Step 1: Assume that the total weekly time remains constant during the period from 1998 until 2005. See row (1):
- Step 2: Compute the share of weekly home hours in total weekly hours for 1998. See rows (2) [total weekly time in hours], (3) [weekly home hours], (4) share of

weekly home hours in total time.

- Step 3: Assume that this share is constant during the period from 1998 to 2005. See row (5).
- Step 4: Compute weekly home hours by multiplying the total weekly time by the share of home hours. See row (6).
- Step 5: Compute leisure by subtracting market hours and home hours from the total weekly time. See row (7).

year	1998	1999	2000	2001	2002	2003	2004	2005
(1)	106.0	106.0	106.0	106.0	106.0	106.0	106.0	106.0
(2)	106.0							
(3)	24.1							
(4)	22.7							
(5)	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7
(6)	24.1	24.1	24.1	24.1	24.1	24.1	24.1	24.1
(7)	57.5	57.2	57.3	57.2	57.9	58.1	57.8	57.9

Table 12: Extrapolation of total time, home hours and leisure, Approach 2

- **Total hours, home hours and leisure - Approach (3).** We, first, need a series for total disposable time. From the time use we have the total time in 1998 which is:  $H_{98} + L_{98} = 106.0$ .

- Step 1: Assume that the total weekly time remains constant during the period from 1998 until 2005. See row (1):
- Step 2: Compute the share of weekly home hours in weekly non-market hours for 1998. See rows (2) [weekly non-market time in hours], (3) [weekly home hours], (4) share of weekly home hours in non-market time.
- Step 3: Assume that this share is constant during the period from 1998 to 2005. See row (5).
- Step 4: Compute weekly home hours by multiplying the weekly non-market time by the share of home hours in non-market time. See row (6).



- Step 5: Compute leisure by subtracting market hours and home hours from the total weekly time. See row (7).

year	1998	1999	2000	2001	2002	2003	2004	2005
(1)	106.0	106.0	106.0	106.0	106.0	106.0	106.0	106.0
(2)	81.5							
(3)	24.1							
(4)	29.5							
(5)	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
(6)	24.1	24.0	24.0	24.0	24.2	24.2	24.1	24.2
(7)	57.5	57.3	57.3	57.3	57.8	57.9	57.7	57.8

Table 13: Extrapolation of total time, home hours and leisure, Approach 3

- **Résumé:** The differences between the three approaches are fairly small.

## Appendix A.2: Calculation of home labor productivity and home capital: France

### Home capital, Version 1

**Step 1:** Take the data from the OECD on final consumption expenditures (in national currency and current prices) on the following goods categories<sup>10</sup>: *P31CP051: Furniture and furnishings, carpets and other floor coverings, P31CP052: Household textiles, P31CP053: Household appliances, P31CP054: Glassware, tableware and household utensils, P31CP055: Tools and equipment for house and garden, P31CP061: Medical products, appliances and equipment, P31CP071: Purchase of vehicles, P31CP082: Telephone and telefax equipment, P31CP091: Audio-visual, photographic and information processing equipment, P31CP092: Other major durables for recreation and culture, P31CP093: Other recreational items and equipment, gardens and pets, P31CP095: Newspapers, books and stationery.*

<sup>10</sup>The label of the dataset is *Dataset: 5. Final consumption expenditure of households.*

There is an (almost) one-to-one mapping between these categories and those that the BEA includes in its variable Consumer Durable Goods. The availability of the OECD expenditures data differs across countries. For instance, for France, the data are available from 1959 onwards, whereas the series for Spain starts only in 2000. In our baseline scenario, we do not include housing into our measure of the capital stock. Only a certain fraction of the housing stock is used for household production (e.g. the kitchen), whereas the rest is used for different purposes. It is hard to quantify this fraction which is why we disregarded it at this point. We will consider alternative definitions of household capital in the future. Most likely, we will consider a broad and a narrow definition in addition to the baseline scenario. The broad definition includes consumer durables (as in the baseline) and housing whereas the narrow definition includes assets whose use is unambiguously linked to household production (such as household appliances).

**Step 2:** Use the perpetual investment method (PIM) to compute the stock for each asset category. Start by setting the initial stock of category  $i$ ,  $K_{1959}^i$  equal to initial investment  $I_{1959}^i$ . Then, use the standard formula to compute the series for  $\{K_t^i\}_{t=1960}^{2010}$  in a recursive manner:  $K_t^i = (1 - \delta^i)K_{t-1}^i + I_t^i$ . The depreciation rate is asset-specific and constant over time. The value of  $\delta^i$  is taken from the BEA and corresponds to the 1925-2012 average depreciation rate for each of the asset categories (computed as  $Depreciation_t^i / Stock_t^i$ ). Taking the 1960-2010 average or the 1970-2005 average instead of the 1925-2012 average makes only a very small difference. The depreciation rates for the different asset classes range from 14% to 31%. The high values of  $\delta^i$  guarantee that the capital stock computed via the PIM converges to the "true" stock relatively quickly. We compute the current-cost capital stock. This requires to, first, transform past investments into current-price investment. That is, to compute period- $t$  capital, we express the investment of periods  $t - 1, t - 2, \dots$  in prices of period  $t$  and, then, apply the PIM.

**Step 3:** Compute the total capital stock for each period by aggregating up the individual stocks:  $K_t^{CD} = \sum_i K_t^i$ .

## Home capital, Version 2

**Step 1:** Take the data from the OECD on final consumption expenditures (in national currency and current prices) on *P311B: Durable goods*. The OECD categorizes consumer expenditures into four different classes: *Durable goods*, *Semi-Durable goods*, *Non-Durable goods*, *Services*. It is not visible for an OECD-outsider how this categorization is done, i.e. which expenditure categories are included in each of these four groups. However, it is certain that *Durable goods* is a subset of what has been considered as Durable Goods in the Version 1 above (because the sum of expenditures is larger than the reported expenditures on *Durable goods*).

**Step 2:** Use the PIM to compute the stock. The depreciation rate is taken from the BEA and it is equal to the 1925-2012 average depreciation rate for Consumer Durable Goods.

The difference between the Version 1 total stock and the Version 2 stock is sizable (and equal to around 35%) but very stable over time. To illustrate: the stock increases between 1980 to 2010 by a factor 4.9 for Version 1 and by a factor of 4.8 for Version 2 (over the period 1990 to 2010 the numbers are 1.88 and 1.81).

## Labor Productivity in Home Production

**Step 1: Compute current-price value added.** Value added is the sum of two components and computed as follows:

$$VA = (r + \delta) * \text{capital input} + w * \text{labor input}$$

Now, let's talk about the computation of the individual components.

1. **Capital input** ... is equal to the nominal stock of consumer durables and it is computed as described above. In the baseline scenario, we use the procedure labelled as Version 1.  
*Data source:* see above.
2.  $\delta$  is the depreciation rate. We do not use some aggregate depreciation rate and multiply it with the aggregate home capital stock. To be more accurate, we compute instead the

aggregate home capital depreciation by using the capital stocks for each asset category (as described above) together with the asset-specific depreciation rates. I.e.  $\delta * K_t = \sum_i \delta^i K_t^i$ .

*Data source:* see above.

3. **r** is the gross return on consumer durables. Ideally we would like to have information on the rate of return of individual financial asset holdings. If we had this return, we could invoke an arbitrage argument and apply the same rate of return for household capital (that is: when the agent has two investment opportunities - household capital and financial assets - then the rate of return has to be equalized in equilibrium). We do not have this information for most OECD countries, so we use the nominal yield on the respective country's 10-year government bonds as a proxy. One way to improve this approximation would go as follows: we have the data on the rate of return on financial assets for a short period of time (2000-2010). For this period, we can compute the spread between this return and government 10-year bond returns. Then, we make the assumption that this spread is constant over time and add it to the observed government bond return to get the return on financial assets. **NOTE:** this modification will affect - if anything - only the level of home value added but not the change over time because of the constant spread.

*Data source:* FRED, Saint Louis Fed

4. **Labor input** ... is the annual aggregate amount of time (measured in hours) spent on household work by individuals aged between 15-64 years. This variable is computed as the product of the annual individual hours of household work and the total population aged between 15 and 64 years. We do not capture the household work done by individuals younger than 15 and older than 64 years (also not for the U.S.). There is limited or no time use data for these age groups and that is why we do not consider them.

The annual individual hours of household work are computed as the weekly individual hours of household work times 52. The weekly individual hours of household work are computed from the Multinational Time Use Study (MTUS).

*Data sources:* MTUS (individual time use data), OECD (population aged 15-64 years).

5.  $w$  is the return on the labor input. To compute  $w$ , we use data on the hourly compensation of private household workers, i.e. people who are directly employed by households to do household work. The main assumption is that the marginal product of these household workers is the same as the marginal product of a non-household worker who is doing household work. We use data from the EU-KLEMS on (i) total annual hours worked by private HH workers and (ii) the total labor compensation of private HH workers. We divide the latter by the former to obtain the hourly compensation which is our measure of  $w$ .

**Step 2: Compute constant-price home value added.** The central question here is, which price index to use to convert current-price into constant-price value added. We explore two different approaches: (a) the price index of value added of the household sector, (b) the price index of private consumption expenditures on goods and services which have a home-produced substitute. The key disadvantage of the first approach is that the main component of household sector value added is housing services (rents and owner-occupied housing), hence the price index would give us the price of housing which is somewhat unrelated to what we are trying to capture by household production (also, we do not consider housing capital as input in household production. Approach (b) is not ideal either because it a final expenditure price and not a value added price. The idea behind (b) is as follows: all home-produced goods and services have a market-produced substitute. That is, all home production could be outsourced to the market. Hence, when we look at the market price of goods and services which could be produced by the household, then we have an approximation of the price of the household's actual output. This consideration abstracts from issues regarding the composition of household output. That is, it assumes that the output bundle of the home sector is comparable to the composition of home-substitutes produced in the market.

In the baseline case, we chose (b) and compute the price index as follows. We take the data provided by the OECD on final consumption expenditures of households on *Food and non-*

*alcoholic beverages, Clothing, Maintenance and repair of the dwelling, Goods and services for routine household maintenance, Out-patient services, Hospital services, Operation of personal transport equipment, Transport services, Restaurants and hotels, Personal care*<sup>11</sup>. This is our list of market-produced goods and services which have a home-produced substitute. To compute a single price index, we divide the sum of current price expenditures by the sum of constant price expenditures (the constant-price series is NOT chained - hence we can do the summation). The base year of this index is 2005.

Finally, we divide the value of nominal value added by the price index to obtain the constant price value added.

**Step 3: PPP-adjustment.** To make the series comparable across countries, we do a PPP-adjustment of the constant price series. Again, the question is, what PPP factor to use? Obviously, there is no data on PPP for home value added, so we have to come up with a proxy. The OECD provides data on PPPs for a large class of final expenditure categories for the year 2005. We proceed as in Step 2 above and construct a composite PPP using the PPPs for those expenditure categories which have a home produced substitute. In particular, we compute the aggregate PPP factor as the expenditure-weighted average of the PPPs of the following categories: *Food and non-alcoholic beverages, Clothing and footwear, Housing, water, electricity, gas and other fuels, Household furnishings, equipment and maintenance, Health, Transport, Restaurants and hotels.*

Finally, we divide the constant price series of home value added by the PPP factor to obtain the adjusted series

**Step 4: Labor productivity.** In the last step, we divide the constant price, constant PPP series of home value added by the annual aggregate hours of household work (mentioned above in Step 1) to obtain labor productivity.

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<sup>11</sup>The dataset is called *Dataset: 5. Final consumption expenditure of households.*

## Appendix A.3: Calculation of home labor productivity and home capital: U.S.

**Step 1: Compute current-price value added.** This is done in the same way as above. I.e. value added is the sum of two components and computed as follows:

$$VA = (r + \delta) * \text{capital input} + w * \text{labor input}$$

1. The **capital input** is equal to the nominal stock of consumer durables. There's no need to do the PIM because the BEA provides data for the nominal stock of consumer durables (BEA Table 8.1)
2. The depreciation is taken from the BEA Table 1.3.
3. The gross return on consumer durables  $r$  is set equal to the return on financial assets. This return is computed as the *Personal income receipts on assets* (BEA Table 2.1) divided by total *financial assets* (Flow of Funds) net of *equity in noncorporate business* (Flow of funds).
4. As above, the **labor input** is the annual aggregate amount of time (measured in hours) spent on household work by individuals aged between 15-64 years. This variable is computed in the same way as above.
5. The return on the labor input  $w$  is computed as above as the *Compensation of private HH workers* (BEA 6.2) divided by the *FTE private HH workers thousands* (BEA 6.5).

**Step 2: Compute constant-price home value added.** We use the same price index as above and it is computed using the following final expenditure categories: *Food and nonalcoholic beverages purchased for off-premises consumption, Food produced and consumed on farms, Garments, Household supplies, Outpatient services, Hospital and nursing home services, Motor vehicle services, Ground transportation, Purchased meals and beverages, Nursery, elementary, and secondary schools, Personal care and clothing services, Social services*

and religious activities, Household maintenance. The data is taken from BEA tables 2.4.3 and 2.4.5.

## Appendix A.4: Definition of Time Use

Table 14: Definitions of market work, home work, and leisure

Home work: AV 6:11	Leisure: AV 12,15,17:40	Market work: AV 1:3,5
Personal care: AV 13,14,16	Education: AV 4	
AV 1 Paid work	AV 15 Meals and snacks	AV 29 Visit friends at their homes
AV 2 Paid work at home	AV 16 Sleep	AV 30 Listen to radio
AV 3 Paid work, second job	AV 17 Free time travel	AV 31 Watch television or video
AV 4 School, classes	AV 18 Excursions	AV 32 Listen to records, tapes, cds
AV 5 Travel to/from work	AV 19 Active sports participation	AV 33 Study, homework
AV 6 Cook, wash up	AV 20 Passive sports participation	AV 34 Read books
AV 7 Housework	AV 21 Walking	AV 35 Read papers, magazines
AV 8 Odd jobs	AV 22 Religious activities	AV 36 Relax
AV 9 Gardening	AV 23 Civic activities	AV 37 Conversation
AV 10 Shopping	AV 24 Cinema or theatre	AV 38 Entertain friends at home
AV 11 Childcare	AV 25 Dances or parties	AV 39 Knit, sew
AV 12 Domestic travel	AV 26 Social clubs	AV 40 Other leisure
AV 13 Dress/personal care	AV 27 Pubs	
AV 14 Consume personal services	AV 28 Restaurants	

## Appendix B: First-order Conditions of the Household Problem

The first-order conditions to household's problem stated in the body of the paper are given by:



$$\begin{aligned}
\frac{\partial \mathcal{L}_t}{\partial L_t} &: (1 - \alpha_u)L_t^{-1} - \mu_t = 0 \\
\frac{\partial \mathcal{L}_t}{\partial C_{mt}} &: \alpha_u \frac{C_t^{1-\sigma_c}}{C_t - \bar{C}} \alpha_c C_{mt}^{\sigma_c-1} - \lambda_t = 0 \\
\frac{\partial \mathcal{L}_t}{\partial H_{mt}} &: \lambda_t(1 - \tau_{wt})w_t - \mu_t = 0 \\
\frac{\partial \mathcal{L}_t}{\partial H_{ht}} &: \alpha_u \frac{C_t^{1-\sigma_c}}{C_t - \bar{C}} (1 - \alpha_c) C_{ht}^{\sigma_c-\sigma_h} (1 - \alpha_h) A_{ht}^{\sigma_h} H_{ht}^{\sigma_h-1} - \mu_t = 0 \\
\frac{\partial \mathcal{L}_t}{\partial K_{mt+1}} &: -\phi_{mt} + \beta [\lambda_{t+1}(1 - \tau_{rt+1})r_{t+1} + \phi_{mt+1}(1 - \delta_m)] = 0 \\
\frac{\partial \mathcal{L}_t}{\partial K_{ht+1}} &: -\phi_{ht} + \beta \left[ \alpha_u \frac{C_{t+1}^{1-\sigma_c}}{C_{t+1} - \bar{C}} (1 - \alpha_c) C_{ht+1}^{\sigma_c-\sigma_h} \alpha_h K_{ht+1}^{\sigma_h-1} + \phi_{ht+1}(1 - \delta_h) \right] = 0 \\
\frac{\partial \mathcal{L}_t}{\partial X_{mt}} &: -\lambda_t(1 + \tau_{xmt})p_{xmt} + \phi_{mt} = 0, \quad \frac{\partial \mathcal{L}_t}{\partial X_{ht}} : -\lambda_t p_{xht} + \phi_{ht} = 0
\end{aligned}$$

The first-order conditions to the modified household problem with  $C_h = A_h H_h$  are given by:

$$\begin{aligned}
\frac{\partial \mathcal{L}_t}{\partial L_t} &: (1 - \alpha_u)L_t^{-1} - \mu_t = 0 \\
\frac{\partial \mathcal{L}_t}{\partial C_{mt}} &: \alpha_u \frac{C_t^{1-\sigma_c}}{C_t - \bar{C}} \alpha_c C_{mt}^{\sigma_c-1} - \lambda_t = 0 \\
\frac{\partial \mathcal{L}_t}{\partial H_{mt}} &: \lambda_t(1 - \tau_{wt})w_t - \mu_t = 0 \\
\frac{\partial \mathcal{L}_t}{\partial H_{ht}} &: \alpha_u \frac{C_t^{1-\sigma_c}}{C_t - \bar{C}} (1 - \alpha_c) A_{ht}^{\sigma_c} H_{ht}^{\sigma_c-1} - \mu_t = 0 \\
\frac{\partial \mathcal{L}_t}{\partial K_{mt+1}} &: -\phi_{mt} + \beta [\lambda_{t+1}(1 - \tau_{rt+1})r_{t+1} + \phi_{mt+1}(1 - \delta_m)] = 0 \\
\frac{\partial \mathcal{L}_t}{\partial X_{mt}} &: -\lambda_t(1 + \tau_{xmt})p_{xmt} + \phi_{mt} = 0
\end{aligned}$$