# Leisure Time and the Sectoral Composition of Employment*

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April 20, 2016

**Abstract**

In the second half of the twenty century we observe two important patterns of structural change; first, a large shift of employment from the agriculture and manufacturing sectors to the service sector, and, second, a sustained increase in the amount of time devoted to leisure activities. We relate these two patterns of structural change by arguing that during leisure time we consume recreational services. The observed increase in leisure time then implies an increase in the consumption of these services, which introduces a new mechanism of structural change. In order to measure the relevance of this mechanism, we construct a multi-sector exogenous growth model with biased technological change. The new feature of the model is the introduction of recreational activities, which depend on both leisure time and on the consumption of recreational services. We introduce these activities by assuming a nested CES utility function. We show that the model explains the two patterns of structural change. We also show that the introduction of recreational activities improves the performance of the numerical simulations. Finally, we study the effects of fiscal policy. We show that the reduction in GDP due to an increase in the labor income tax is substantially larger when we consider that during leisure time we consume recreational services.

*JEL classification codes:* O41, O47.
*Keywords:* sectoral composition, leisure, non-homothetic preferences, elasticity of substitution, biased technological progress.

*Financial support from the Spanish Ministry of Education and Science through grant ECO2012-34046 and the Generalitat of Catalonia through grant SGR2014-493 is gratefully acknowledge.

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## 1. Introduction

The second half of the twenty century has been characterized by two important patterns of structural change. First, the process of structural change in the sectoral composition of employment. This process consists of a large shift of employment and production from the agriculture and manufacturing sectors to the service sector. Figures 1 and 2 illustrate this process in the case of the US economy, during the period 1947-2010. As follows from Figure 1, in the mid of the twenty century, almost 50% of employment was employed in the service sector, whereas by the end of the century 75% was employed in this sector. In contrast, employment in both the manufacturing and the agriculture sector declines during the second half of the twenty century. Figure 2 shows a similar pattern for the shares of value added in the three sectors. The recent multisector growth literature has explained these patterns of structural change as the result of non-homothetic preferences (Kongsamut, Rebelo and Xie, 2001) or changes in relative prices (Acemoglu and Guerrieri, 2008; Ngai and Pissarides, 2007). More recently, this literature has shown that the rise of the service sector can only be explained from combining both non-homothetic preferences and changes in relative prices (Boppart, 2014; Dennis and Iscan, 2008; Foellmi and Zweimuller, 2008). Herrendorf, Rogerson and Valentinyi (2014) offer an exhaustive review of this literature.

[Insert Figures 1 and 2]

Second, the change in the uses of time is another relevant process of structural change that has occurred during the second half of the last century. Using survey data, Aguiar and Hurst (2007) and Ramey and Francis (2009) show the evolution of the uses of time in the US economy during the second half of the last century. Figures 3 and 4 show these changes in the uses of time.[1] As follows from these figures, during the second half of the twenty century there has been a clear increase in the time devoted to leisure, that during the period increases from 45% of total time to 54%, and a reduction in the amount of time devoted to work.[2]

[Insert Figures 3 and 4]

The increase in the time devoted to leisure is mainly explained as the consequence of a wealth effect: as wealth increases, agents want to consume a larger amount of leisure and, therefore, they reduce the time devoted to work. Note that this explanation is completely independent of the multisectoral structure of the economy. There are few papers relating the patterns of structural change in the sectoral composition of employment with changes in the uses of time. Examples are the papers by Buera and Kaboski (2012), Gollin, Parente and Rogerson (2004) and Ngai and Pissarides (2008). In these papers, the relationship is based on home production and its different substitutability with the market production of the different sectors. More precisely, the reduction in home production explains the increase in the employment share of the service sector because it is a better substitute of services than of the goods produced in the other sectors. Greenwood and Vandenbroucke (2005) and Ngai and Pissarides

[1] Appendix E explains in detail the construction of the time series displayed in Figures 3 and 4.

[2] Duernecker and Herrendorf (2015) show similar patterns for France, Germany and United Kingdom.

(2008) also introduce leisure activities that combine leisure time with durable goods produced in the manufacturing sector. Again, the different substitutability of these activities with the market production of the different sectors contributes to explain the increase in the employment share of the service sector. In contrast, in this paper, we propose an explanation based on the recreational nature of leisure. Our main assumption is that during the leisure time we consume recreational services. The mechanism explaining the two patterns of structural change is then as follows. As the economy develops, households devote a larger amount of time to leisure activities, which consume recreational services. It follows that part of the increase in the service sector can be explained by the increase in leisure.

We quantify the impact on structural change of the proposed mechanism. To this end, we measure the fraction of the value added of the service sector explained by recreational services. The details of the procedure followed to obtain this fraction are explained in Appendix E and the results are displayed in Figure 5. As explained in Appendix E, data availability limits the period analyzed to be between 1947 and 2010. Figure 5 displays the time path of the fraction of the value added in the service sector directly explained by recreational activities. This fraction increases from 6% in 1947 to 14% in 2010. This increase is large and explains 26% of the observed increase in the service sector share of total value added. This clearly shows that the effect of leisure on sectoral composition is sizeable.

[Insert Figure 5]

In order to study the effects on structural change of recreational activities, we construct a multi-sector exogenous growth model. In the supply side, we distinguish between two sector specific technologies that are used to produce agriculture goods (both agriculture and manufacturing) and services. These technologies are differentiated only by the exogenous growth rate of total factor productivity (TFP). In the demand side, we assume that households obtain utility from consuming goods, services and recreational activities. Following Ngai and Pissarides (2007), we assume a constant elasticity of substitution (CES) utility function. Therefore, the only new feature of this model is the introduction of recreational activities. These activities are defined as a CES function relating the amount of time devoted to leisure and the consumption of recreational services. We assume that the elasticity of substitution of recreational activities (the elasticity between leisure time and recreational services) is different from the elasticity of substitution of consumption goods (among recreational activities, the consumption of goods and non-recreational services). In fact, the utility function considered in this paper is a non-homothetic version of the nested CES function introduced by Sato (1967).

Technological progress drives structural change through three different channels: a substitution channel, a wealth channel and a recreational channel. First, the substitution channel is due to the assumption of biased technological progress. Consistent with empirical evidence, we will assume that the sector experiencing the largest TFP growth is the goods sector. This biased technological progress causes the increase of the relative price of services in units of goods. As outlined by Ngai and Pissarides (2007), the effect on structural change of relative price changes depends on the value of the elasticity of substitution of consumption goods.

Second, we introduce a minimum consumption requirement on the consumption of goods. As a consequence, preferences are non-homothetic, which introduces a wealth channel. As income increases, the employment share of the sector with a large income elasticity will increase. Due to the minimum consumption requirement, this sector is the service sector and, thus, this channel contributes to explain the rise of the service sector.

Third, the recreational channel is the new mechanism of structural change introduced in this paper. Leisure rises with technological progress, which drives the increase in recreational services. Obviously, the effect of this mechanism on the sectoral composition will depend on the value of the elasticity of substitution of recreational activities.

The interaction between the three channels explains the process of structural change in this economy. This process drives the economy to different asymptotic long run equilibria, depending on the value of the two elasticities of substitution. These asymptotic equilibria will be differentiated by the long run values of four variables that measure structural change: leisure, the shares of employment devoted to the two sectors and the share of added value in the service sector explained by recreational services. Section 3 provides a complete characterization of these long run equilibria. We show that these long run asymptotic equilibria consist of corner solutions implying that the value of these variables converges to its minimum or maximum possible values. These corner solutions arise because technological progress is permanently biased towards a given sector and, therefore, they must be interpreted as the long run equilibrium that an economy would attain if the bias in technological progress were permanent. Interestingly, they inform about the direction of structural change implied by the model. We use this asymptotic equilibria to conclude that the observed patterns of structural change can only be explained if both elasticities of substitution are smaller than one and the elasticity of substitution of recreational activities is larger than the elasticity of substitution of consumption goods.

In Section 4, we calibrate and simulate the equilibrium. In this numerical analysis, we consider three different economies. The first one is our benchmark economy where individuals obtain utility from recreational activities. In the second economy, we do not consider these activities and we instead assume that individuals obtain utility directly from leisure. Finally, the third economy is a standard multisector growth model without leisure. From the comparison among these economies, we show that the performance of the simulated economies in explaining the observed patterns of structural change is enhanced by the introduction of recreational activities. Moreover, the benchmark economy also explains the observed increase in leisure time and the increase in the share of recreational services. We use the Akaike information criteria to conclude that recreational activities are a relevant feature of structural change.

In the last section, we study how the introduction of recreational activities changes the effect of fiscal policy on employment and gross domestic product (GDP). Following the analysis of Prescott (2004) and Rogerson (2008), we also study the effects of an increase in the labor income tax rate. We show that increasing this tax reduces employment and GDP, both in the benchmark economy with recreational activities and in the economy with leisure. However, the effect of this policy is substantially larger in the benchmark economy. This is due to the fact that the introduction of recreational activities increases the substitutability between leisure and consumption goods. An increase in the labor income tax reduces the wage after taxes, which reduces employment depending on the substitutability between leisure and consumption goods. The introduction of recreational services, by increasing the substitutability between leisure and consumption goods, increases the effect of taxes on employment and on GDP. This explains that the reduction in GDP due to a tax increase is substantially larger when we consider that individuals derive utility from leisure through recreational activities.

## 2. The model

We build a two-sector exogenous growth model. We distinguish between the service and the non-service sectors. The service sector only produces a consumption good, whereas the non-service sector produces both a consumption and an investment good. We assume that the consumption good produced in the service sector can be devoted to either recreational or non-recreational activities. Finally, we also assume that the non-service sector is the numeraire of the economy.

### 2.1. Firms

Each sector $i$ produces by using the following constant returns to scale Cobb-Douglas technology:

$$Y_i = A_i \left(s_i K\right)^{\alpha} \left(u_i L\right)^{1-\alpha}, \; i = s, g, \tag{2.1}$$

where $Y_i$ is the amount produced in sector $i$, $\alpha \in (0,1)$ is the capital output elasticity, $s_i$ is the share of total capital $K$ devoted to sector $i$, $u_i$ is the share of total employment $L$ employed in sector $i$, $A_i$ measures total factor productivity (TFP) in sector $i$, and the subindexes $s$ and $g$ amount for the services and goods sectors, respectively. Obviously, the capital shares and the employment shares satisfy $s_g + s_s = 1$ and $u_g + u_s = 1$. We assume that TFP grows in each sector at a constant growth rate $\gamma_i$. Consistent with empirical evidence, we assume that $\gamma_g > \gamma_s$.

Each individual has a time endowment of measure one that can devote to either leisure activities or labor. Let $l$ be the amount of time an individual devotes to work and $N$ the constant number of individuals. Then, total employment in the economy satisfies $L = lN$. It follows that (2.1) can be rewritten in per capita terms as

$$y_i = A_i \left(s_i k\right)^{\alpha} \left(u_i l\right)^{1-\alpha}, \; i = s, g, \tag{2.2}$$

where $y_i = Y_i/N$ and $k = K/N$.

Perfect competition and perfect factors' mobility imply that each factor is paid according to its marginal productivity and that marginal productivities equalize across sectors, implying that

$$r = \alpha p_i A_i \left(s_i k\right)^{\alpha-1} \left(u_i l\right)^{1-\alpha} - \delta, \tag{2.3}$$

and

$$w = (1-\alpha)\, p_i A_i \left(s_i k\right)^{\alpha} \left(u_i l\right)^{-\alpha}, \tag{2.4}$$

where $r$ is the rental price of capital, $w$ is the wage per unit of employment, $p$ is the relative price and $\delta \in (0,1)$ is the depreciation rate of capital. From using (2.3) and (2.4), we obtain $s_i = u_i$ and

$$p_s = \frac{A_g}{A_s}. \tag{2.5}$$

Given the assumed ranking of TFP growth rates, the relative price of services, $p_s$, increases. Obviously, the relative price of the goods sector is equal to one.

### 2.2. Consumers

Consumers are infinitely lived. Each consumer has a time endowment of measure one. As $l$ is the amount of time an individual devotes to work, $1-l$ is the amount of time devoted to leisure activities. Consumers obtain income from capital and labor and use it to invest and consume. Therefore, the consumers' budget constraint is

$$wl + rk = E + \dot{k}, \tag{2.6}$$

where $E = c_g + p_s c_s$ is total consumption expenditures.

The consumers' utility is

$$u = \int_0^\infty e^{-\rho t} \ln C dt, \tag{2.7}$$

where $\rho > 0$ is the subjective discount rate and $C$ is the following composite consumption good:

$$C = \left[ \eta_g \left( c_g - \bar{c} \right)^{\frac{\varepsilon-1}{\varepsilon}} + \eta_s \left( x c_s \right)^{\frac{\varepsilon-1}{\varepsilon}} + \eta_l c_l^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}},$$

where $c_g$ is the amount consumed of goods, $c_s$ is the amount consumed of services, $c_l$ is the amount consumed of recreational activities, $x \in [0,1]$ is the fraction of services devoted to non-recreational activities, $\varepsilon > 0$ is the elasticity of substitution among the different consumption goods, $\bar{c}$ is a minimum consumption requirement and $\eta_i > 0$ measures the weight of the different consumption goods in the utility function. We assume that $\eta_s + \eta_l + \eta_g = 1$. We also assume that recreational activities depend on both leisure and the amount consumed of services, according to the following function:

$$c_l = \left\{ \beta \left[ (1-x) c_s \right]^{\frac{\sigma-1}{\sigma}} + (1-\beta) \left( 1 - l - \bar{l} \right)^{\psi \left( \frac{\sigma-1}{\sigma} \right)} \right\}^{\frac{\sigma}{\sigma-1}}, \tag{2.8}$$

where $\sigma > 0$ is the elasticity of substitution between recreational services and leisure, $\bar{l}$ is a minimum requirement of leisure, $\psi \in (0,1)$ determines the wage elasticity of the labor supply and $\beta \in [0,1]$ measures the weight of recreational services in recreational activities.[3] On the one hand, $\bar{l}$ is introduced to guarantee a minimum amount of leisure. On the other hand, the preference parameters $\psi$ disentangles $\sigma$ from the elasticity of substitution of the labor supply with respect to the wage. This is necessary in order to explain the observed increases in both leisure and in the fraction of recreational services.

[3] In our analysis we do not consider $\sigma = 1$ or $\varepsilon = 1$.

Consumers decide on leisure, the value of consumption expenditures, the sectoral composition of these expenditures and the fraction of services devoted to recreational activities, in order to maximize (2.7) subject to (2.6). The solution of this maximization problem is characterized by the following equations:

$$\frac{c_g}{E} = \frac{1}{\kappa_1} + \frac{\overline{c}}{E}\left(\frac{\kappa_1 - 1}{\kappa_1}\right), \tag{2.9}$$

$$\frac{p_s c_s}{E} = \left(1 - \frac{\overline{c}}{E}\right)\left(\frac{\kappa_1 - 1}{\kappa_1}\right), \tag{2.10}$$

$$x = \frac{\kappa_4}{1 + \kappa_4}, \tag{2.11}$$

$$1 - l = \bar{l} + \left(\frac{w\eta_g}{\eta_l\left(1-\beta\right)\psi\kappa_2^{\frac{\varepsilon-\sigma}{\varepsilon\sigma}}}\right)^{-\frac{\varepsilon}{(1-\varepsilon)\psi+\varepsilon}}\left(\frac{E-\overline{c}}{\kappa_1}\right)^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}, \tag{2.12}$$

and

$$\frac{\dot{E}}{E - \overline{c}} = r - \rho - \frac{\dot{\kappa}_7}{\kappa_7}, \tag{2.13}$$

where $\{\kappa_i\}_{i=1}^{7}$ are complex functions of both the prices and the wage that are obtained in Appendix B. Equations (2.9) and (2.10) characterize the sectoral composition of consumption expenditures, while (2.11) determines the fraction of services devoted to non-recreational activities. Equation (2.12) determines the amount of leisure and it then implicitly characterizes the labor supply. Finally, (2.13) is the Euler condition driving the intertemporal trade-off between consuming today and in the future.[4]

## 3. Equilibrium

Let $z = k/lA_g^{\frac{1}{1-\alpha}}$ be the capital stock per efficiency unit of employment in the economy. Using this definition and (2.3), we obtain the interest rate as

$$r = \alpha z^{\alpha-1} - \delta, \tag{3.1}$$

and using (2.4) we obtain

$$w = (1-\alpha)\, A_g^{\frac{1}{1-\alpha}} z^{\alpha}. \tag{3.2}$$

We define per capita GDP as $Q = p_s y_s + y_g$ and using (2.2) and (2.4) we obtain

$$Q = A_g^{\frac{1}{1-\alpha}} z^{\alpha} l. \tag{3.3}$$

Note that per capita GDP depends on the time devoted to work, $l$.

Let $q = E/Q$ be consumption expenditure per unit of GDP. Using this variable, the resource constraint of this economy can be written as

$$\dot{k} = Q\,(1-q) - \delta k. \tag{3.4}$$

[4] As follows from (2.13), the growth rate of consumption expenditures depends on the growth rate of $\kappa_7$ and, therefore, it depends on the growth rate of prices. Alonso-Carrera, Caballé and Raurich (2015) discuss why the growth of prices affects the Euler condition in multisector growth models.

The service sectors only produce a consumption good and, thus, the market clearing condition in these sectors is $y_s = c_s$. From using this market clearing condition and (2.10), (3.2) and (3.3), we obtain the employment share in the service sector,

$$u_s = \left(\frac{\kappa_1 - 1}{\kappa_1}\right)(q - \overline{v}), \tag{3.5}$$

where $\overline{v} = \overline{c}/Q$ is the minimum consumption requirement per unit of GDP. Obviously, the employment share in the goods sector is

$$u_g = 1 - u_s. \tag{3.6}$$

Finally, from using (2.12) and (3.3), we obtain the amount of time devoted to work

$$l = 1 - \bar{l} - \left(\frac{w\eta_g}{\eta_l (1-\beta)\psi\kappa_2^{\frac{\varepsilon-\sigma}{\varepsilon\sigma}}}\right)^{-\frac{\varepsilon}{(1-\varepsilon)\psi+\varepsilon}} \left(\frac{(q-\overline{v})A_g^{\frac{1}{1-\alpha}} z^{\alpha} l}{\kappa_1}\right)^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}. \tag{3.7}$$

Equations (2.11), (3.5), (3.6) and (3.7) show that the sectoral composition of the economy and the amount of time devoted to work depend on the relative price, the wage and the time path of the following three variables: $z$, $q$ and $\overline{v}$. In Appendix C, we obtain the following system of differential equations governing the time path of these three variables:

$$\frac{\dot{z}}{z} = \frac{\left[(1-q)z^{\alpha-1} - \delta - \frac{\gamma_g}{1-\alpha}\right] l + \left(1 - l - \bar{l}\right)\omega_{10}}{l - \left(1 - l - \bar{l}\right)\omega_{11}}, \tag{3.8}$$

$$\begin{aligned}\frac{\dot{q}}{q} = & \left[\left(1 - \frac{\overline{v}}{q}\right)\omega_8 + \alpha\right]\left(\delta + \frac{\gamma_g}{1-\alpha} - (1-q)z^{\alpha-1}\right) - \left(\delta + \rho + \omega_7 - \alpha z^{\alpha-1}\right)\left(1 - \frac{\overline{v}}{q}\right) - \frac{\gamma_g}{1-\alpha} + \\ & + \frac{\left\{(1-\alpha)\left(1-l-\bar{l}\right) + \left(1 - \frac{\overline{v}}{q}\right)\left[\omega_9 l - \left(1 - l - \bar{l}\right)\omega_8\right]\right\}\left\{\omega_{10} + \left[(1-q)z^{\alpha-1} - \delta - \frac{\gamma_g}{1-\alpha}\right]\omega_{11}\right\}}{l - \left(1 - l - \bar{l}\right)\omega_{11}}\end{aligned} \tag{3.9}$$

and

$$\frac{\dot{\overline{v}}}{\overline{v}} = -\gamma_g - \alpha(1-q)z^{\alpha-1} + \alpha\delta + (1-\alpha)\left(1 - l - \bar{l}\right)\left(\frac{\omega_{10} + \left[(1-q)z^{\alpha-1} - \delta - \frac{\gamma_g}{1-\alpha}\right]\omega_{11}}{l - \left(1 - l - \bar{l}\right)\omega_{11}}\right), \tag{3.10}$$

where $\{\omega_i\}_{i=1}^{11}$ are functions of the relative price and of the wage that are defined in Appendix C.

**Definition 3.1.** *Given initial conditions $z(0)$, $\overline{v}(0)$, $A_g(0)$ and $A_s(0)$, a dynamic equilibrium is a path of $\{z, q, \overline{v}, u_s, u_g, l, x, p_s, w\}_{t=0}^{\infty}$ that solves the system of differential equations (3.8), (3.9) and (3.10) and satisfies (2.11), (2.5), (3.2), (3.5), (3.6), (3.7), and $A_i = A_i(0)e^{-\gamma_i t}$, $i = s, g$.*

**Definition 3.2.** *A balanced growth path (BGP) equilibrium is an equilibrium path along which the interest rate and the ratio of capital to GDP remain constant.*

Appendix D proves the following four propositions that characterize properties of the BGP equilibrium.

**Proposition 3.3.** *There is a unique asymptotic BGP along which variables characterizing the sectoral composition remain constant.*

The assumption of permanent bias in technological progress implies that a BGP equilibrium can only be attained asymptotically when the variables characterizing the sectoral composition converge to a corner solution. As follows from (2.5) and (3.2), biased technological progress implies that both the relative price and the wage diverge to infinite. As a consequence, the variables characterizing the sectoral composition converge to a corner solution, where they take either its minimum or its maximum possible value, depending on the value of the elasticities of substitution $\varepsilon$ and $\sigma$. Obviously, this is a strong result driven by the assumption of permanent differences in the TFP growth rates. We then interpret this asymptotic equilibrium as providing information about the direction of structural change while there is a process of biased technological. The following propositions obtain the long run values of these variables.

**Proposition 3.4.** *The long run value of employment is*

$$l^* = \begin{cases} 0 & if \ \ \sigma < 1, \ \varepsilon < 1 \\ 1 - \bar{l} & otherwise. \end{cases},$$

The wage increases as the economy develops. This implies that if individuals can substitute leisure for other consumption goods employment will increase and converge to its maximum value. This happens when either $\sigma > 1$ or $\varepsilon > 1$. It follows that employment decreases as the economy grows only when leisure is complementary with respect to the other consumption goods, which requires that both $\varepsilon < 1$ and $\sigma < 1$. As Figures 3 and 4 clearly show that employment decreases as the economy develops, the plausible values of the parameters satisfy $\varepsilon < 1$ and $\sigma < 1$. In the following three propositions we show that these values of the elasticities of substitution are also consistent with the other observed patterns of structural change.

**Proposition 3.5.** *If $\sigma < 1$, $\varepsilon < 1$, the long run values of the ratio of capital to efficiency units and the ratio of consumption expenditures to GDP are*

$$z^* = \left( \frac{(1-\alpha)(\delta+\rho)+\gamma_g}{\alpha(1-\alpha)} \right)^{\frac{1}{\alpha-1}},$$

*and*

$$q^* = \begin{cases} 1 - \alpha \left( \frac{\delta + \frac{\gamma_g}{1-\alpha} - (1-\sigma)\left(\frac{\alpha\gamma_g}{1-\alpha} + \gamma_s\right)}{\delta+\rho+\frac{\gamma_g}{1-\alpha}} \right) & if \ \sigma > \varepsilon \\ 1 - \alpha \left( \frac{\delta + \frac{\gamma_g}{1-\alpha} - (1-\varepsilon)\left(\frac{\alpha\gamma_g}{1-\alpha} + \gamma_s\right)}{\delta+\rho+\frac{\gamma_g}{1-\alpha}} \right) & if \ \sigma < \varepsilon \end{cases}.$$

**Proposition 3.6.** *The long run values of the sectoral composition of employment are*

1. *$u_s^* = 0$ and $u_g^* = 1$ if $\varepsilon > 1$.*

*2.* $u_s^* = q^*$ *and* $u_g^* = 1 - q^*$ *if* $\varepsilon < 1$.

Proposition 3.6 shows that the employment share in services increases and converges to its maximum value if the different consumption goods are complementary goods ($\varepsilon < 1$). This result is already obtained in Ngai and Pissarides (2007). As these authors explain, when the price of services increases, the employment share in this sector increases only if the consumption goods are complements.

**Proposition 3.7.** *The long run value of the fraction of services devoted to non-recreational activities is*

$$1 - x^* = \begin{cases} 1 - \frac{1}{\beta^{\left(\frac{1-\varepsilon}{1-\sigma}\right)\sigma}\left(\frac{\eta_l}{\eta_s}\right)^{\varepsilon}+1} \text{ if } \sigma > 1 \\ 0 \text{ if } \sigma > 1 \text{ or } \sigma < 1 \text{ and } \sigma < \varepsilon \\ 1 \text{ if } 1 > \sigma > \varepsilon \end{cases}.$$

Figure 5 shows that the fraction of services devoted to recreational activities has increased. Proposition 3.7 shows that this happens when $\varepsilon < \sigma < 1$. As the economy develops, both leisure and consumption of services increases. However, the increase in the consumption of services is substantially larger and faster than the increase in leisure. As a consequence, if leisure and recreational services were strong complements, then the fraction of services devoted to recreational activities would decline. It follows that this fraction increases only when leisure and recreational services are not strong complements ($1 > \sigma > \varepsilon$).

We conclude that the equilibrium path implied by this model is compatible with the observed patterns of structural change when i) there is complementarity among the different consumption goods ($\varepsilon < 1$) and between leisure and recreational services ($\sigma < 1$) and ii) when the complementarity between leisure and services is smaller than the complementarity among the different consumption goods ($\sigma > \varepsilon$). The first condition is already obtained in Ngai and Pissarides (2007). The second condition is a contribution of this paper and it is related to the capacity of the model to explain the process of structural change between recreational and non-recreational activities. These constraints on the value of the elasticities of substitution are considered in the numerical analysis of the following section.

## 4. Structural change

In this section we simulate the economy in order to analyze if the mechanism proposed in this paper contributes to explain the observed patterns of structural change. To this end, we calibrate the parameters of the economy as follows: $\gamma_g = 1.37\%$ in order to have a long run GDP growth rate equal to 2% and $\gamma_s = 0.64\%$ in order to match the growth rate of prices obtained by Herrendorf, et al. (2013); we set $\alpha = 0.35$ in order to match the average value of the LIS in the US during this period; $\rho = 0.032$ so that the long run interest rate equals 5.2%; $\delta = 5.6\%$ in order to obtain a long run ratio of investment to capital equal to 7.6%; we normalize $A_g(0) = 1$ and we set $A_s(0) = 1.4633$ in order to obtain the initial relative prices of services in units of goods obtained by Herrendorf, et al. (2014). The values of the two elasticities, $\varepsilon = 0.25$ and $\sigma = 0.98$, are set to obtain the best fit in explaining the time path of $u_s$. We also assume that $z_0 = z^*$, which implies that the equilibrium exhibits almost balanced growth. This is consistent with the observed time path of the interest rate and of the ratio between capital to GDP in the US economy during the second half of the XX century. The rest of parameters, $\beta$, $\psi$, $\bar{l}$, $\bar{c}$, $\eta_s$ and $\eta_l$, are set to distinguish between three different economies. In Economy 1, these six parameters are set to match the value in 1947 and in 2010 of the following variables $l$, $x$ and $u_s$. Obviously, Economy 1 corresponds to our benchmark economy. In Economy 2, we assume that $\beta = 0$ implying that $x = 1$ and the rest of parameters are set as in Economy 1. In Economy 3, we assume that $\beta = 0$ and $\eta_l = 0$, which implies that $x = 1$ and $l = 1 - \bar{l}$. The rest of parameters are set to match the value in 1947 and 2010 of $u_s$. The parameters in the three economies are summarized in Table 1.

[Insert Table 1]

Figure 6 illustrates the patterns of structural change in Economy 1. As follows from this figure, this economy explains both the observed reduction in the amount of employment and the increase in the share of recreational services. Moreover, the model also explains the observed patterns in the process of structural change in the sectoral composition of employment. More precisely, the model explains the reduction in the employment shares of the goods sector (agriculture plus manufacturing sectors) and it also explains the increase in the employment share in the service sector. We conclude that the model provides a reasonable explanation of the patterns of structural change. This explanation is based on the interaction between three mechanisms: the substitution channel, the wealth channel and the recreational channel. The first one is the classical effect associated to biased technological change, whereas the second one is also a classical effect based on non-homothetic preferences. The third one is the new mechanism introduced in this paper and based on recreational activities. Table 2 shows the fraction of the increase in the service sector explained by these different mechanism. It shows that the recreational channel explains 15% of the observed increase in the employment share of the service sector.

[Insert Figure 6 and Table 2 ]

Figure 7 displays the patterns of structural change in Economy 2. In this economy, we assume that there are no recreational services and, therefore, we do not consider the recreational channel. This simulated economy captures the main trends of structural change in the sectoral composition of employment and also the increase in leisure. However, the performance is worse than in Economy 1. Figure 8 displays the patterns of structural change in Economy 3. In this economy, we assume that there is no leisure. The model explains the changes in the sectoral composition of employment. Again, the performance is worse than in Economy 1.

[Insert Figures 7 and 8]

Table 3 provides two different measures of performance: the sum of the square of the residuals and the Akaike information criteria. The first measure is a standard measure of performance of the simulations. From the comparison of the value of this measure in the three economies, we conclude that the introduction of recreational activities improves the performance of the simulated economies in explaining both the increase in leisure time and the changes in the sectoral composition of employment. This result is not surprising as the economy with recreational activities is more complex than the other two economies and includes an additional channel of structural change. In order to compare among these economies, we use the Akaike information criteria that takes into account the different complexity of these economies and its different performance. Using this criteria, we can safely conclude that recreational activities are an important channel of structural change.

[Insert Table 3]

## 5. Fiscal policy

Growth models with leisure introduce an adequate framework to study the effects of fiscal policy on both employment and GDP. Duernecker and Herrendorf (2015), Prescott (2004) and Rogerson (2008) among many others have studied the effects of increasing the labor income tax. This tax reduces the wage net of taxes and this causes the reduction of the labor supply when individuals can substitute leisure for consumption goods. In fact, the effects of labor taxes crucially depend on the substitution between leisure and the other consumption goods. As recreational activities crucially modify this substitution, the effects of taxes are modified when recreational activities are considered. To study this differential impact of labor income taxes, in this section we compare the effect of a tax increase in Economies 1 and 2. We follow Prescott (2004) and we consider the consequence of increasing the effective labor income tax from the US average level, 40%, to the French average level, 59%. For the sake of simplicity, we assume that government revenues are returned to the individuals as a lump-sum subsidy. It follows that labor income taxes only modify the labor supply implicitly obtained in (2.12) and (3.7). The wage in these two equations should be replaced by the wage net of taxes.

We calibrate again Economies 1 and 2 so that they explain employment and the sectoral composition when taxes are at the US level. Table 4 provides the new values of the parameters of these two economies.

[Insert Table 4]

Figure 9 shows the effects of this tax increase in Economy 2, where individuals directly derive utility from leisure. The tax increase reduces employment both initially and during the transition. The initial reduction of 1.79% is explained by the reduction in the wage net of taxes. This implies that GDP also decreases initially. This lower GDP reduces capital accumulation, which, in turn, reduces even further employment and GDP during the transition. As an example, In 2010, the employment and GDP loss due to the increase in taxes is around 4%.

[Insert Figure 9]

Figure 10 studies the effects of the tax increase in Economy 1, where individuals derive utility from recreational activities. As follows from this figure, the effects on employment and GDP are substantially larger than in Economy 2. Initially employment and GDP decrease about 3%. This larger initial reduction of GDP causes a larger reduction in capital accumulation, which, in turn, implies a larger GDP loss during the transition. In 2010, the employment and GDP loss is about 6%. It follows that the effect of taxes on both employment and GDP is twice larger when we take into account that individuals derive utility from leisure through the consumption of recreational activities. These activities introduce the possibility that individuals can substitute leisure time for services. As a consequence, after the tax increase, agents substitute to a larger extend leisure for consumption goods. This explains the larger impact that a tax increase has when we consider recreational activities.

[Insert Figure 10]

## 6. Concluding remarks

The purpose of this paper is to explain two important patterns of structural change observed during the second half of the last century; first, the large shift of employment and production from the agriculture and manufacturing sectors to the service sector, and, second, the sustained increase in leisure time. We contribute to existing literature on structural change by introducing a mechanism that relates these two patterns of structural change. We argue that during leisure time we consume recreational services. The observed increase in leisure time then implies an increase in the consumption of these services, which introduces a mechanism explaining structural change in the sectoral composition of employment. We measure the relevance of this mechanism and we make two contributions.

First, we measure the fraction of the value added of the service sector explained by recreational services. We show that this fraction has increased from 6% to 14% during the period 1947-2010. Obviously, this substantial increase provides support to our mechanism, which has a sizeable effect on sectoral composition. Indeed, we show that 26% of the observed increase in the added value share of the service sector is explained by the increase in recreational services.

Second, we construct a multi-sector exogenous growth model with biased technological change. The new feature of the model is the introduction of recreational activities, which depend on both leisure time and on the consumption of recreational services. We introduce these activities by assuming a nested CES utility function. We show that biased technological progress drives structural change through three different channels: a wealth channel, a substitution channel and the recreational channel. We calibrate the model and we show that the model explains the reduction in the time devoted to work, the increase in the fraction of recreational services and the changes in the sectoral composition of employment. Moreover, we compare the performance of our economy with recreational activities with the performance of other economies without these activities. We show that the introduction of recreational activities improves the performance of the simulated economies in explaining both the reduction in the amount of labor and the process of structural change. We use the Akaike information criteria to conclude that recreational activities are an important feature of structural change.

There are large differences in the amount of time devoted to work between the US and European economies. Prescott (2004) has convincingly argued that large part of these differences can be explained by the differences between the labor income taxes in the US and Europe. These taxes reduce employment and, as a consequence, they also reduce GDP. The effect of taxes crucially depends on the substitution between leisure and consumption goods. Recreational activities increase this substitution and, thus, modify the effect of taxes on employment and GDP. In particular, we show that the effect of a tax increase on the amount of employment and on the level of GDP is substantially larger when we assume that individuals derive utility from recreational activities.

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## A. Tables and Figures

**Table 1a. Parameters and Targets**

| Parameters | Targets |
|---|---|
| $\gamma_g = 0.013$ | Long run growth rate of GDP is 2% |
| $\gamma_s = 0.0064$ | Growth rate of $p_s^*$ |
| $\rho = 0.032$ | Long run interest rate is 5.2% |
| $\delta = 0.056$ | Long run ratio of capital to GDP is 7.6% |
| $\alpha = 0.35$ | Average value of the labor income share |
| $A_m(0) = 1$ | Normalization |
| $A_s(0) = 1.4633$ | $p_s(0) = 0.6833$ value in 1947* |
| $\sigma = 0.98$ | Best fit in the time path of $u_s$ |
| $\varepsilon = 0.25$ | Best fit in the time path of $u_s$ |
| $z_0 = z^*$ | Consistent with almost BGP. |

Notes: *. Herrendorf, et al. (2013)

**Table 1b. Preference Parameters**

| Parameters | Targets |
|---|---|
| **Economy 1** | |
| $\beta = 0.154$ | $x(1947) = 0.0632$ |
| $\overline{\eta}_l = 1.14$ | $l(1947) = 0.5572$ |
| $\overline{\eta}_s = 3.42$ | $u_g(1947) = 0.524$ |
| $\bar{l} = 0.387$ | $l(2010) = 0.453$ |
| $\psi = 0.445$ | $x(2010) = 0.135$ |
| $\bar{c} = 0.650$ | $u_g(2010) = 0.211$ |
| **Economy 2** | |
| $\beta = 0$ | $x(1947) = 1$ |
| $\overline{\eta}_l = 1.39$ | $l(1947) = 0.5572$ |
| $\overline{\eta}_s = 3.68$ | $u_g(1947) = 0.524$ |
| $\bar{l} = 0.397$ | $l(2010) = 0.453$ |
| $\psi = 0.445$ | $x(2010) = 1$ |
| $\bar{c} = 0.650$ | $u_g(2010) = 0.211$ |
| **Economy 3** | |
| $\beta = 0$ | $x(1947) = 1$ |
| $\overline{\eta}_l = 0$ | $l(1947) = 1 - \bar{l}$ |
| $\overline{\eta}_s = 3.98$ | $u_g(1947) = 0.524$ |
| $---$ | $l(2010) = 1 - \bar{l}$ |
| $---$ | $x(2010) = 1$ |
| $\bar{c} = 0.49$ | $u_g(2010) = 0.211$ |

Notes: *. Herrendorf, et al. (2013)

**Table 2. Accounting of Mechanisms (1947-2010)***

| *Employment share* ($u_s$)* | |
|---|---|
| Wealth effect | 36.36% |
| Substitution effect | 48.64% |
| Recreational effect | 15% |

* Percentage of total variation of employment share that is explained

**Table 3. Performance of the simulations**

| | **Economy 1** | | **Economy 2** | | **Economy 3** | |
|---|---|---|---|---|---|---|
| | SSR* | AIC** | SSR | AIC | SSR | AIC |
| $u_s$ | 0.13 | -335.40 | 0.16 | -310.35 | 0.29 | -231.65 |
| $l$ | 0.07 | -405.04 | 0.07 | -401.92 | ..... | |
| $x_s$ | 0.04 | -484.08 | ..... | | ..... | |

* SSR is the sum of the square of the residuals.

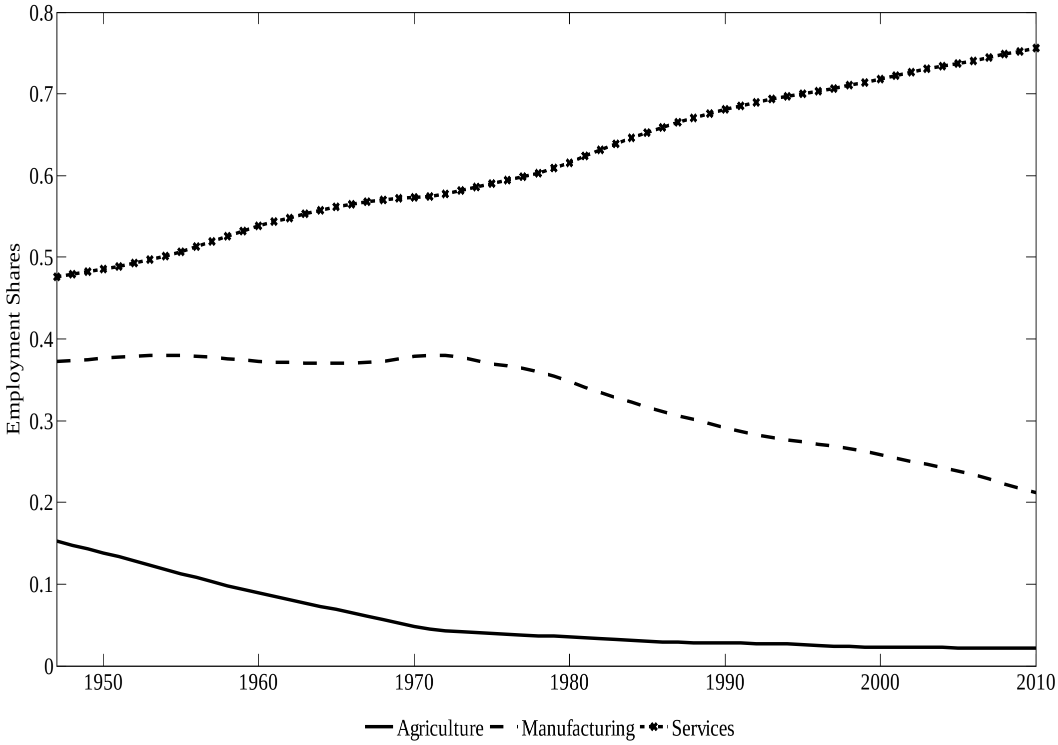
** Akaike information criterion.

**Table 4. Parameters and Targets. Labor Tax rate equal to 40%**

| | |
|---|---|
| **Economy 1** | |
| $\beta = 0.233$ | $x\,(1947) = 0.0632$ |
| $\overline{\eta}_l = 1.040$ | $l\,(1947) = 0.5572$ |
| $\overline{\eta}_s = 3.413$ | $u_g\,(1947) = 0.524$ |
| $\bar{l} = 0.387$ | $l\,(2010) = 0.453$ |
| $\psi = 0.445$ | $x\,(2010) = 0.135$ |
| $\bar{c} = 0.650$ | $u_g\,(2010) = 0.211$ |
| **Economy 2** | |
| $\beta = 0$ | $x\,(1947) = 1$ |
| $\overline{\eta}_l = 1.393$ | $l\,(1947) = 0.557$ |
| $\overline{\eta}_s = 3.685$ | $u_g\,(1947) = 0.524$ |
| $\bar{l} = 0.397$ | $l\,(2010) = 0.453$ |
| $\psi = 0.445$ | $x\,(2010) = 1$ |
| $\bar{c} = 0.650$ | $u_g\,(2010) = 0.211$ |

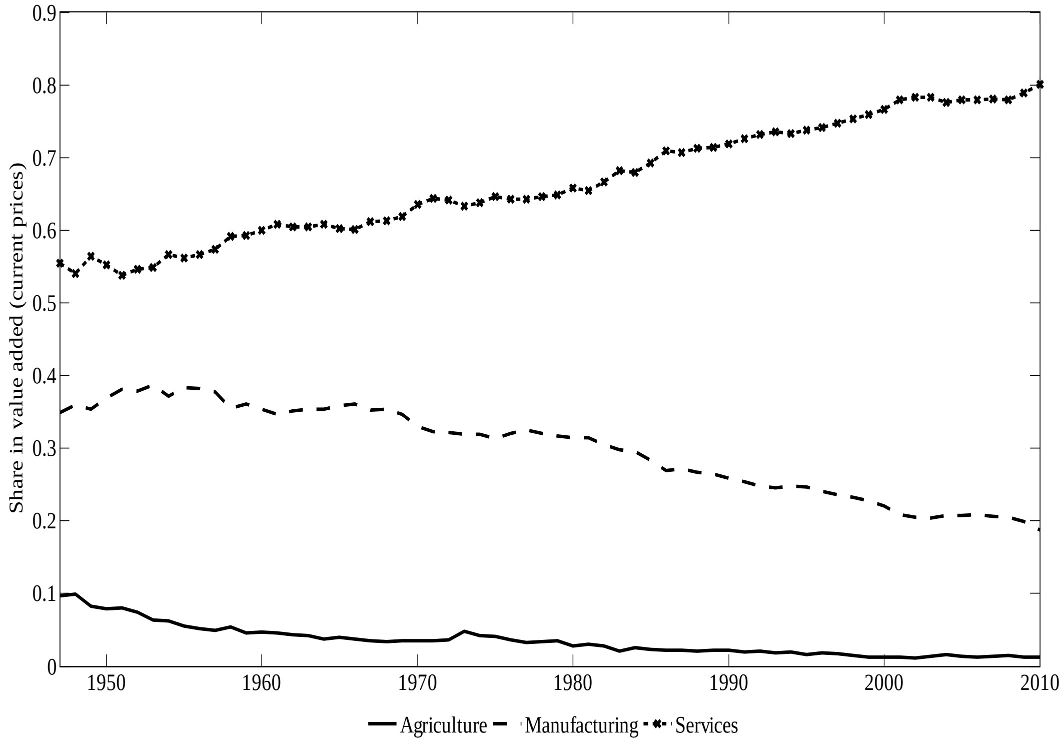
Notes: *. Herrendorf, et al. (2013)

**Figure 1. Sectoral composition of employment**



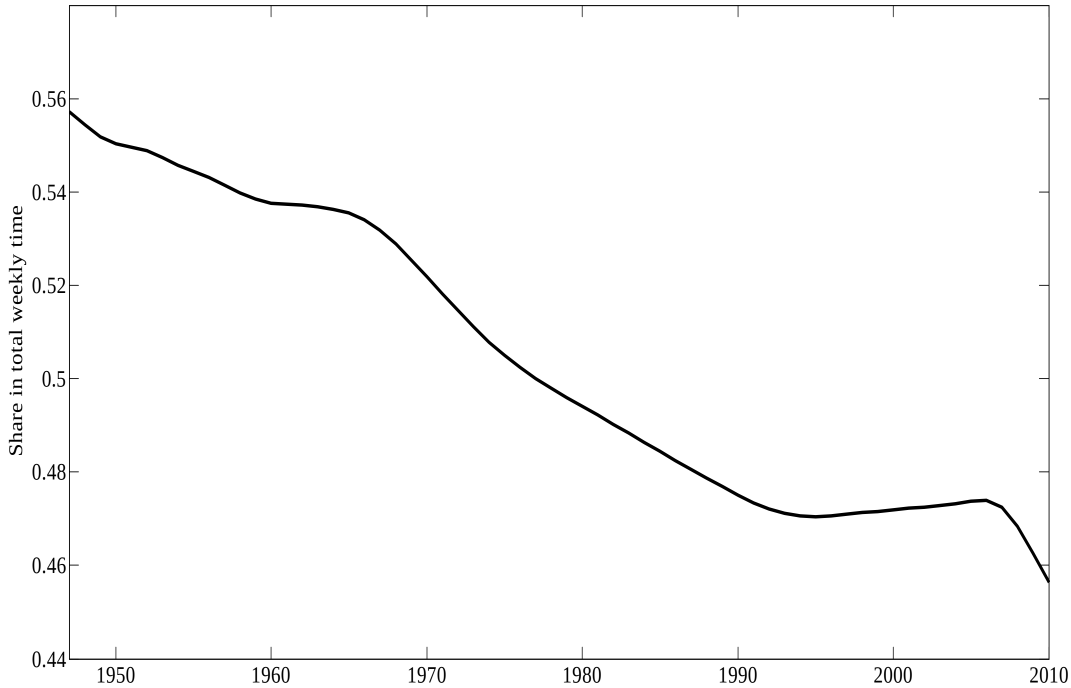

**Source.** M.P. Timmer, G.J .de Vries, and K.deVries (2014).

**Figure 2. Sectoral composition of GDP**



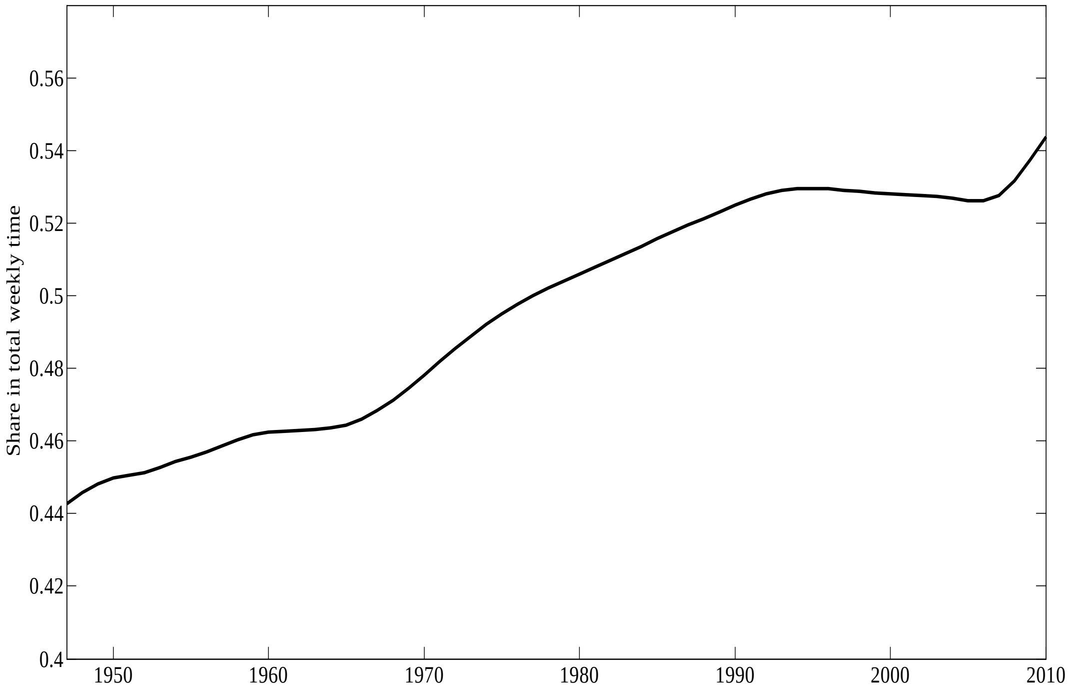

**Source.** M.P. Timmer, G.J .de Vries, and K.deVries (2014).

**Figure 3. Time devoted to work**



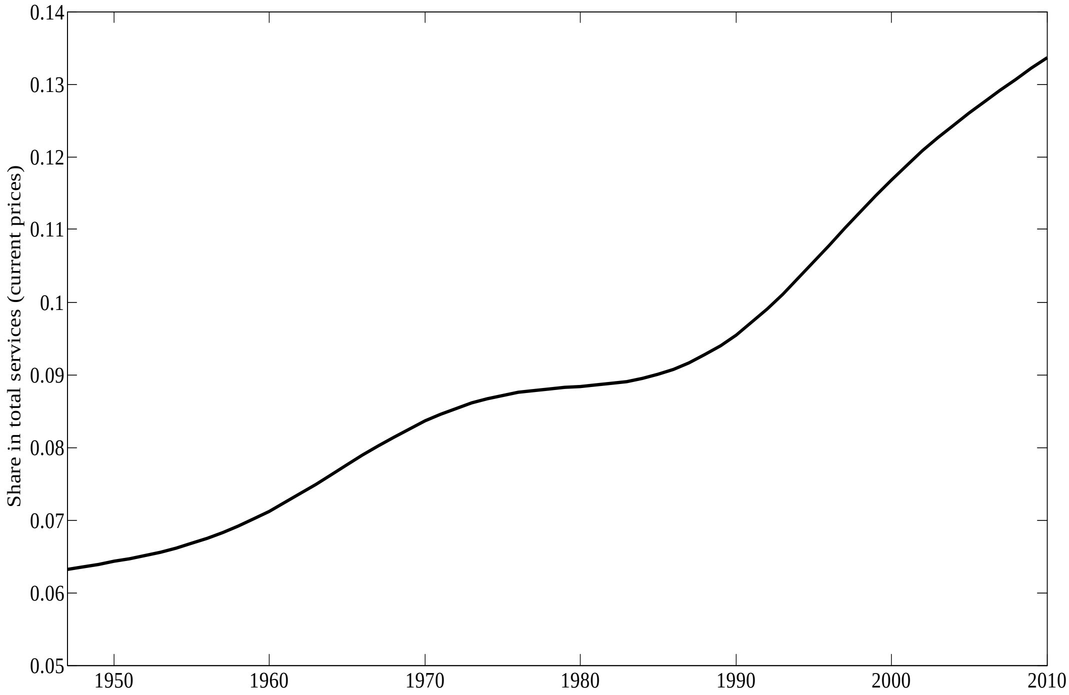

**Source.** Own elaboration. See Appendix E.

**Figure 4. Time devoted to leisure**




**Source.** Own elaboration. See Appendix E.

**Figure 5. Recreational services**




**Source.** Own elaboration. See Appendix E.

**Figure 6. Numerical simulations of Economy 1**

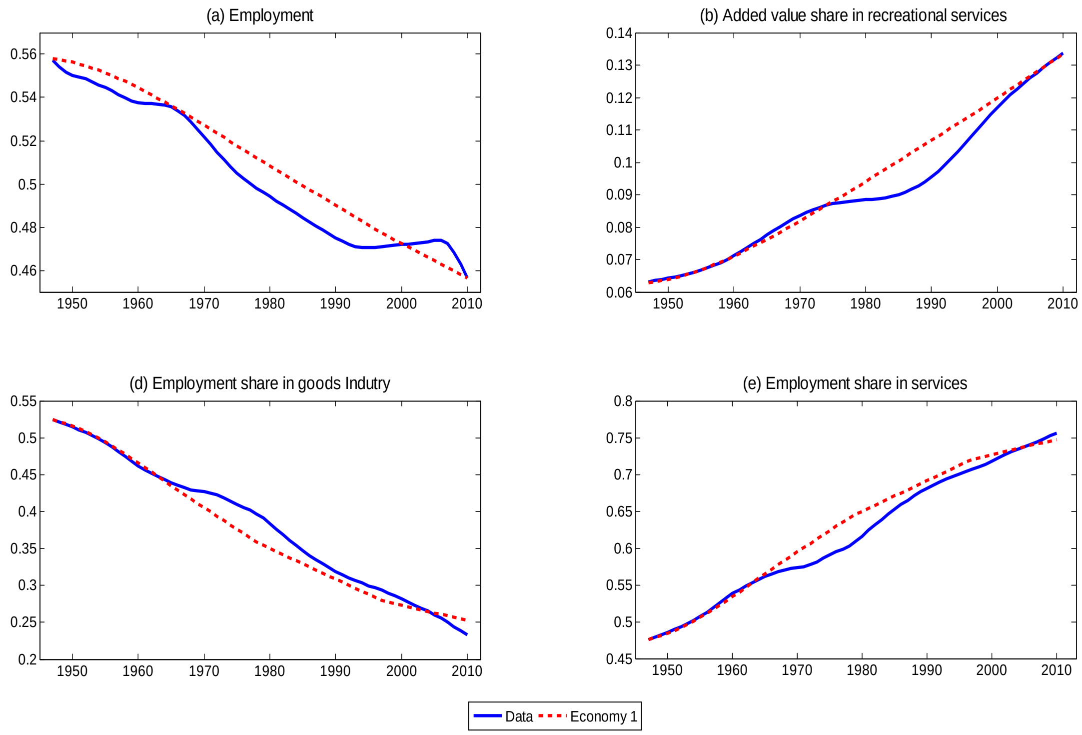


**Figure 7. Numerical simulations of Economy 2**

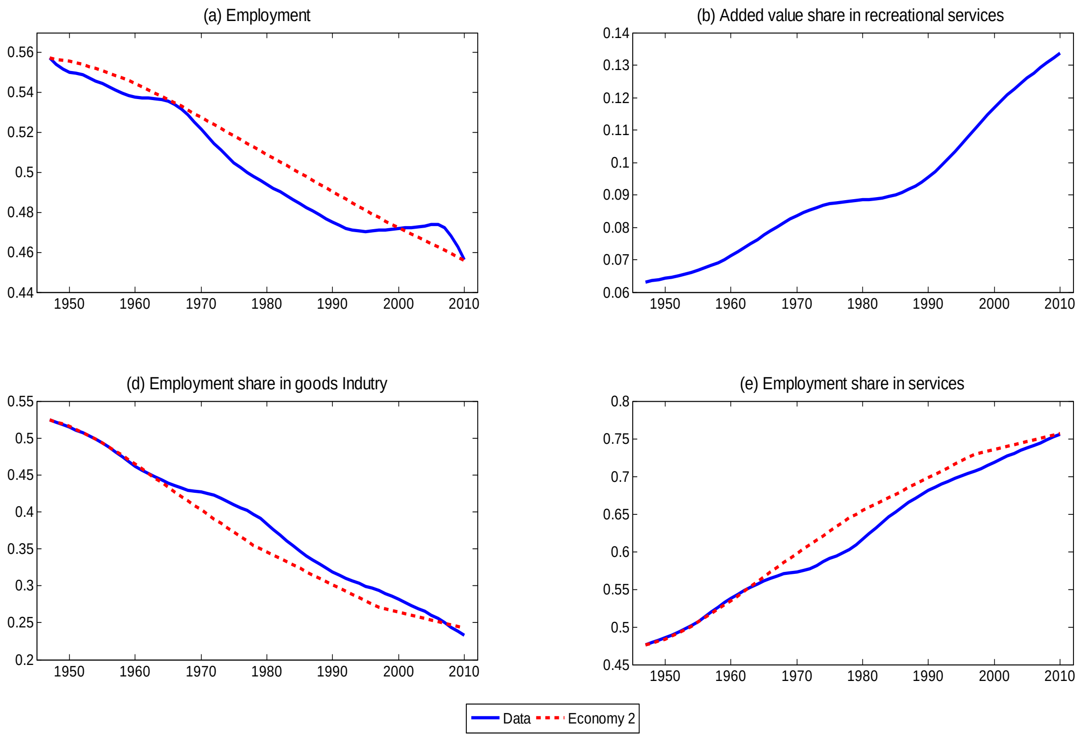


**Figure 8. Numerical simulations of Economy 3**

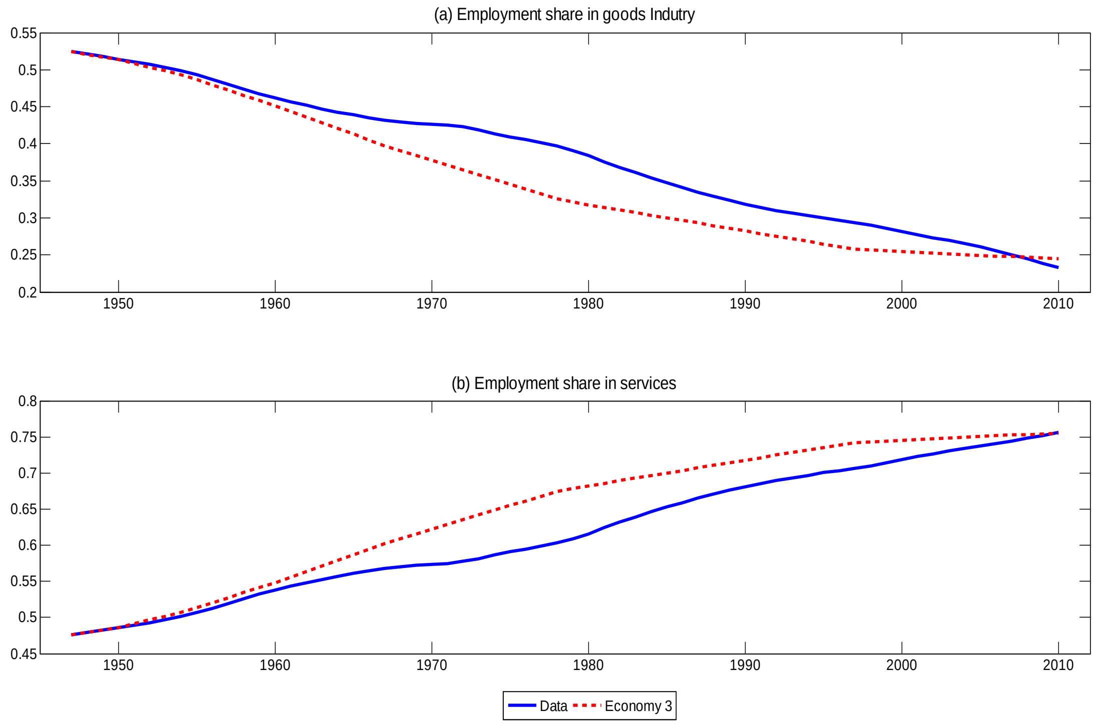


**Figure 9. Tax increase from 40% to 59% in Economy 2**

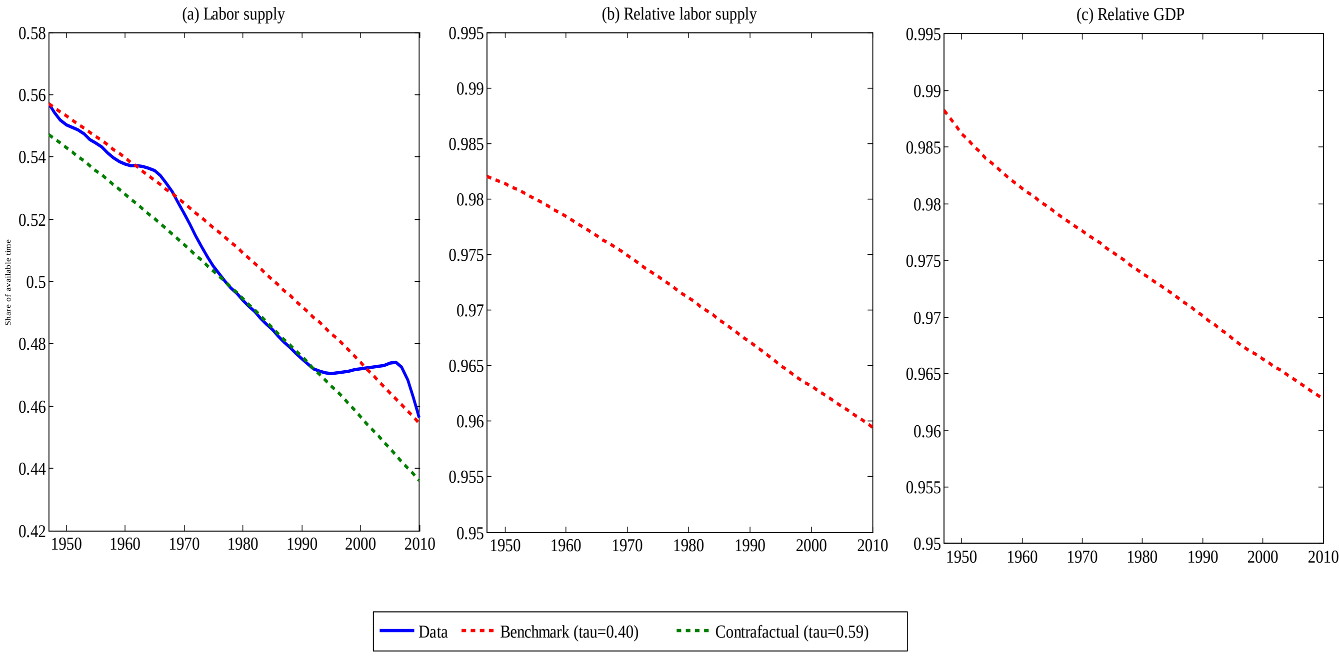
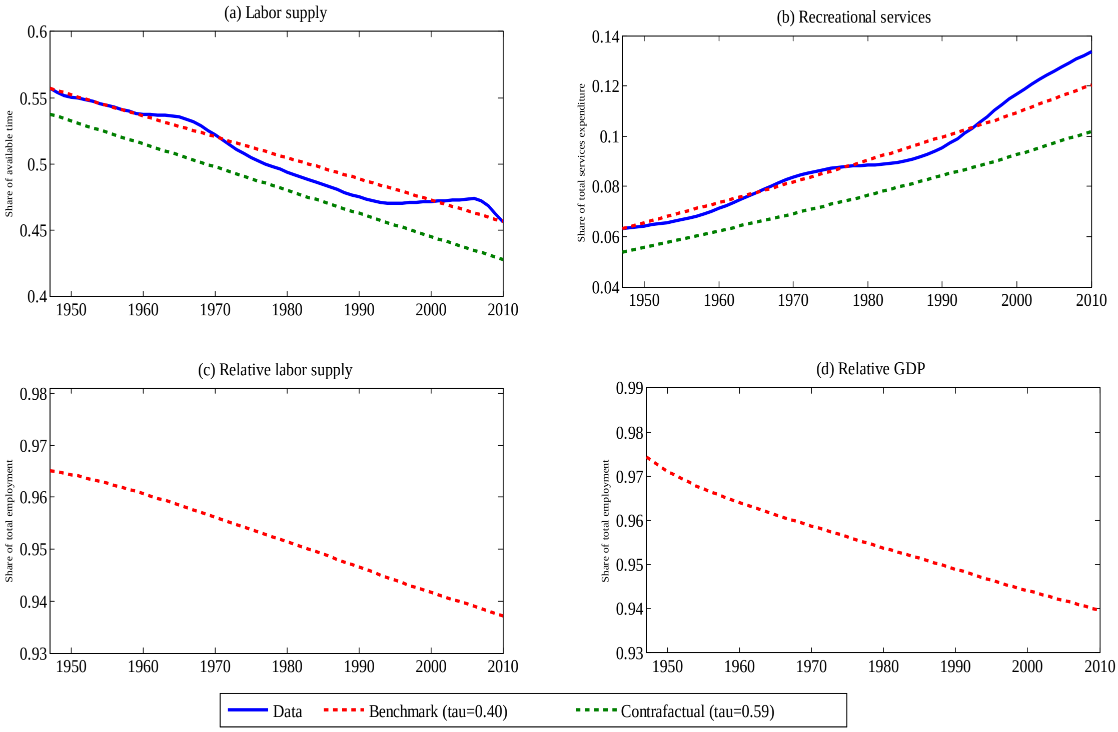


**Figure 10. Tax increase from 40% to 59% in Economy 1**



## B. Solution of the consumers' problem

Consumers maximize the utility function subject to the budget constraint (2.6). The Hamiltonian present value associated to this maximization problem is

$$\mathcal{H} = \ln C + \lambda \left( wl + rk - c_g - p_s c_s \right).$$

The first order conditions with respect to $x$, $c_g$, $c_s$, $l$ and $k$ are, respectively,

$$\frac{x^{-\frac{1}{\varepsilon}}}{(1-x)^{-\frac{1}{\sigma}}} c_s^{\frac{\varepsilon-\sigma}{\varepsilon\sigma}} = \left( \frac{\eta_l \beta}{\eta_s} \right) c_l^{\frac{\varepsilon-\sigma}{\varepsilon\sigma}}, \tag{B.1}$$

$$C^{\frac{1-\varepsilon}{\varepsilon}} \eta_g \left( c_g - \bar{c} \right)^{-\frac{1}{\varepsilon}} = \lambda, \tag{B.2}$$

$$C^{\frac{1-\varepsilon}{\varepsilon}} \eta_s \left( x c_s \right)^{-\frac{1}{\varepsilon}} = \lambda p_s, \tag{B.3}$$

$$C^{\frac{1-\varepsilon}{\varepsilon}} \eta_l \psi c_l^{\frac{\varepsilon-\sigma}{\varepsilon\sigma}} \left(1-\beta\right) \left(1-\bar{l}-l\right)^{\frac{(\sigma-1)\psi-\sigma}{\sigma}} = \lambda w, \tag{B.4}$$

and

$$\dot{\lambda} = -\left( r - \rho \right) \lambda. \tag{B.5}$$

We proceed to obtain $c_l$, $c_s, c_g$, $l$, and $x$ as functions of prices, wages and total consumption expenditures, $E$, where $E = c_g + p_s c_s$. To this end, we combine (B.2) and (B.3) to obtain (2.9) and (2.10) in the main text, where the function $\kappa_1$ in this equations is

$$\kappa_1 = 1 + p_s \left( p_s \frac{\eta_g}{\eta_s} \right)^{-\varepsilon} \frac{1}{x}. \tag{B.6}$$

We next use (B.3), (B.4) and (B.1) to obtain

$$\left(1-x\right) c_s = \left( \frac{\psi \left(1-\beta\right) p_s}{w\beta} \right)^{-\sigma} \left(1-\bar{l}-l\right)^{(1-\sigma)\psi+\sigma}. \tag{B.7}$$

We substitute (B.7) in (2.8) to obtain

$$c_l = \kappa_2 \left(1-l-\bar{l}\right)^{\psi}, \tag{B.8}$$

where

$$\kappa_2 = \left[ \beta \left( \frac{\psi \left(1-\beta\right) p_s}{w\beta \left(1-\bar{l}-l\right)^{1-\psi}} \right)^{1-\sigma} + 1 - \beta \right]^{\frac{\sigma}{\sigma-1}}. \tag{B.9}$$

$\kappa_2$ can be rewritten as

$$\kappa_2 = \kappa_3 \left( \frac{w}{1-\beta} \right)^{\sigma}, \tag{B.10}$$

where

$$\kappa_3 = \left( \beta^{\sigma} \left(\psi p_s\right)^{1-\sigma} \left(1-\bar{l}-l\right)^{(1-\sigma)(\psi-1)} + \left(1-\beta\right)^{\sigma} w^{1-\sigma} \right)^{\frac{\sigma}{\sigma-1}}. \tag{B.11}$$

From combining (B.2), (B.4) and (B.8), we obtain (2.12) in the main text. We combine (B.8), (B.1), (2.12) and (2.10) to obtain (2.11) in the main text. The expression of the function $\kappa_4$ in equation (2.11) is

$$\kappa_4 = \left(\frac{\eta_l \beta}{\eta_s}\right)^{-\sigma} \left(\frac{\eta_s}{p_s \eta_g}\right)^{\varepsilon-\sigma} \left(\frac{w\eta_g}{\eta_l (1-\beta)\psi}\right)^{\frac{\psi(\varepsilon-\sigma)}{(1-\varepsilon)\psi+\varepsilon}} (c_g - \overline{c})^{\frac{(\sigma-\varepsilon)(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}} \kappa_2^{\left(\frac{(1-\sigma)\psi+\sigma}{(1-\varepsilon)\psi+\varepsilon}\right)\left(\frac{\sigma-\varepsilon}{\sigma}\right)}. \tag{B.12}$$

In what follows, we obtain the expression of the Euler condition. To this end, we first use (B.8) and (2.12) to obtain

$$c_l = \kappa_2^{\left(\frac{\sigma+\psi(1-\sigma)}{(1-\varepsilon)\psi+\varepsilon}\right)\frac{\varepsilon}{\sigma}} \left(\frac{w\eta_g}{\eta_l (1-\beta)\psi}\right)^{-\frac{\varepsilon\psi}{(1-\varepsilon)\psi+\varepsilon}} (c_g - \overline{c})^{\frac{\psi}{(1-\varepsilon)\psi+\varepsilon}}. \tag{B.13}$$

We next substitute (2.10) and (B.13) in the definition of $C$ to obtain

$$\left(\frac{C}{c_g - \overline{c}}\right)^{\frac{\varepsilon-1}{\varepsilon}} \frac{1}{\eta_g} = \kappa_6,$$

where

$$\kappa_6 = 1 + \overline{\eta}_s p_s^{1-\varepsilon} + \overline{\eta}_l {\kappa_5}^{1-\varepsilon}, \tag{B.14}$$

$$\kappa_5 = \kappa_2^{-\left(\frac{\sigma+\psi(1-\sigma)}{(1-\varepsilon)\psi+\varepsilon}\right)\frac{1}{\sigma}} \left(\frac{w}{(1-\beta)\psi}\right)^{\frac{\psi}{(1-\varepsilon)\psi+\varepsilon}} \overline{\eta}_l^{\frac{1-\psi}{(1-\varepsilon)\psi+\varepsilon}} (c_g - \overline{c})^{\frac{1-\psi}{(1-\varepsilon)\psi+\varepsilon}}, \tag{B.15}$$

$\overline{\eta}_s = \left(\eta_s/\eta_g\right)^{\varepsilon}$, and $\overline{\eta}_l = \left(\eta_l/\eta_g\right)^{\varepsilon}$. We rewrite (B.2) and substitute the previous relations to obtain

$$\lambda = \frac{1}{\kappa_6 (c_g - \overline{c})}. \tag{B.16}$$

From using (2.9), we obtain

$$\frac{1}{\lambda} = \kappa_7 (E - \overline{c}), \tag{B.17}$$

where

$$\kappa_7 = \frac{\kappa_6}{1 + \overline{\eta}_s p_s^{1-\varepsilon} \frac{1}{x}}. \tag{B.18}$$

Finally, from combining (B.5) and (B.17), the Euler condition (2.13) in the main text is obtained.

Note that equations (2.9)-(2.13) in the main text depend on $\{\kappa_i\}_{i=1}^{7}$. From using (B.6), (B.10), (B.11), (B.12), (B.15), (B.14) and (B.18) it follows that $\{\kappa_i\}_{i=1}^{7}$ are functions only of the relative price and the wage. This implies that $x$ only depends on prices and the wage.

## C. System of Differential equations

In this appendix we obtain the system of differential equations governing the time path of the variables $z$ and $q$. The fist step is to obtain the expression of $\dot{\kappa}_7/\kappa_7$. We first combine (B.18) and (B.12) to obtain

$$\kappa_7 = \frac{\kappa_6}{1 + \overline{\eta}_s p_s^{1-\varepsilon} + \beta^{\sigma} p_s^{1-\sigma} \omega_0}, \tag{C.1}$$

where

$$\omega_0 = \frac{\overline{\eta}_s}{\beta^\sigma} \frac{p_s^{\sigma-\varepsilon}}{\kappa_4},$$

and from using (B.12) it follows that

$$\omega_0 = \overline{\eta}_l^{\frac{\sigma+(1-\sigma)\psi}{(1-\varepsilon)\psi+\varepsilon}} \left[ \left(\frac{1}{\psi}\right)^{\psi} \left(\frac{w}{1-\beta}\right)^{\sigma(\psi-1)} \right]^{\frac{\sigma-\varepsilon}{(1-\varepsilon)\psi+\varepsilon}} (c_g - \overline{c})^{-\frac{(\sigma-\varepsilon)(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}} \kappa_3^{-\left(\frac{(1-\sigma)\psi+\sigma}{(1-\varepsilon)\psi+\varepsilon}\right)\left(\frac{\sigma-\varepsilon}{\sigma}\right)}. \tag{C.2}$$

We log-differentiate with respect to time the previous equation to obtain

$$\begin{aligned} \frac{\dot{\kappa}_7}{\kappa_7} &= \frac{\dot{\kappa}_6}{\kappa_6} - \frac{\left[(1-\varepsilon)\,\overline{\eta}_s p_s^{(1-\varepsilon)} + (1-\sigma)\,p_s^{1-\sigma}\beta^\sigma\omega_0\right](\gamma_g - \gamma_s)}{1+\overline{\eta}_s p_s^{1-\varepsilon} + \beta^\sigma p_s^{1-\sigma}\omega_0} \\ &\quad - \left(\frac{\beta^\sigma p_s^{1-\sigma}\omega_0}{1+\overline{\eta}_s p_s^{1-\varepsilon}+\beta^\sigma p_s^{1-\sigma}\omega_0}\right)\frac{\dot{\omega}_0}{\omega_0}. \end{aligned} \tag{C.3}$$

From using (C.2), we get

$$\frac{\dot{\omega}_0}{\omega_0} = \frac{\sigma\,(\psi-1)\,(\sigma-\varepsilon)}{(1-\varepsilon)\,\psi+\varepsilon}\frac{\dot{w}}{w} - \frac{(\sigma-\varepsilon)\,(\psi-1)}{(1-\varepsilon)\,\psi+\varepsilon}\left(\frac{\dot{c}_g}{c_g-\overline{c}}\right) - \left(\frac{(1-\sigma)\,\psi+\sigma}{(1-\varepsilon)\,\psi+\varepsilon}\right)\left(\frac{\sigma-\varepsilon}{\sigma}\right)\frac{\dot{\kappa}_3}{\kappa_3}. \tag{C.4}$$

We next use (B.16) and (B.5) to obtain

$$\frac{\dot{c}_g}{c_g-\overline{c}} = r - \rho - \frac{\dot{\kappa}_6}{\kappa_6}. \tag{C.5}$$

The growth rate of wages is obtained from (3.2) and it is

$$\frac{\dot{w}}{w} = \frac{\gamma_g}{1-\alpha} + \alpha\frac{\dot{z}}{z},$$

and we use (B.11) and (2.4) to obtain

$$\frac{\dot{\kappa}_3}{\kappa_3} = \omega_1 + \omega_2\frac{\dot{z}}{z} + \omega_3\frac{\dot{l}}{1-l-\overline{l}}, \tag{C.6}$$

where

$$\omega_1 = -\sigma\left(\frac{\beta^\sigma\,(\psi p_s)^{1-\sigma}\left(1-l-\overline{l}\right)^{(1-\sigma)(\psi-1)}\left(\gamma_g-\gamma_s\right) + (1-\beta)^\sigma\,w^{1-\sigma}\left(\frac{\gamma_g}{1-\alpha}\right)}{\beta^\sigma\,(\psi p_s)^{1-\sigma}\left(1-l-\overline{l}\right)^{(1-\sigma)(\psi-1)} + (1-\beta)^\sigma\,w^{1-\sigma}}\right), \tag{C.7}$$

$$\omega_2 = -\frac{\sigma\,(1-\beta)^\sigma\,w^{1-\sigma}\alpha}{\beta^\sigma\,(\psi p_s)^{1-\sigma}\left(1-l-\overline{l}\right)^{(1-\sigma)(\psi-1)} + (1-\beta)^\sigma\,w^{1-\sigma}}, \tag{C.8}$$

and

$$\omega_3 = -\frac{\sigma\,(\psi-1)\,\beta^\sigma\,(\psi p_s)^{1-\sigma}\left(1-l-\overline{l}\right)^{(1-\sigma)(\psi-1)}}{\beta^\sigma\,(\psi p_s)^{1-\sigma}\left(1-l-\overline{l}\right)^{(1-\sigma)(\psi-1)} + (1-\beta)^\sigma\,w^{1-\sigma}}. \tag{C.9}$$

From using (B.15), (B.10) and (C.5) we get

$$\frac{\dot{\kappa}_5}{\kappa_5} = \zeta_1 + \zeta_2 \frac{\dot{z}}{z} + \zeta_3 \frac{\dot{l}}{1-l-\bar{l}} + \zeta_4 \frac{\dot{\kappa}_6}{\kappa_6}, \tag{C.10}$$

where

$$\begin{aligned}
\zeta_1 &= -\left(\frac{\sigma+\psi(1-\sigma)}{(1-\varepsilon)\psi+\varepsilon}\right)\frac{\omega_1}{\sigma} + \left(\frac{\sigma(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}\right)\frac{\gamma_g}{1-\alpha} - \zeta_4(r-\rho), \\
\zeta_2 &= -\left(\frac{\sigma+\psi(1-\sigma)}{(1-\varepsilon)\psi+\varepsilon}\right)\frac{\omega_2}{\sigma} + \left(\frac{\sigma(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}\right)\alpha, \\
\zeta_3 &= -\left(\frac{\sigma+\psi(1-\sigma)}{(1-\varepsilon)\psi+\varepsilon}\right)\frac{\omega_3}{\sigma}, \\
\zeta_4 &= -\frac{1-\psi}{(1-\varepsilon)\psi+\varepsilon}.
\end{aligned}$$

From using (B.14), we obtain

$$\frac{\dot{\kappa}_6}{\kappa_6} = \frac{(1-\varepsilon)\overline{\eta}_s p_s^{1-\varepsilon}\left(\gamma_g-\gamma_s\right) + (1-\varepsilon)\overline{\eta}_l {\kappa_5}^{1-\varepsilon}\frac{\dot{\kappa}_5}{\kappa_5}}{\kappa_6},$$

and we use (C.10) to obtain

$$\frac{\dot{\kappa}_6}{\kappa_6} = \omega_4 + \omega_5 \frac{\dot{z}}{z} + \omega_6 \frac{\dot{l}}{1-l-\bar{l}}, \tag{C.11}$$

where

$$\omega_4 = \frac{(1-\varepsilon)\overline{\eta}_s p_s^{1-\varepsilon}\left(\gamma_g-\gamma_s\right) + (1-\varepsilon)\overline{\eta}_l {\kappa_5}^{1-\varepsilon}\zeta_1}{\kappa_6 - (1-\varepsilon)\overline{\eta}_l {\kappa_5}^{1-\varepsilon}\zeta_4}, \tag{C.12}$$

$$\omega_5 = \frac{(1-\varepsilon)\overline{\eta}_l {\kappa_5}^{1-\varepsilon}\zeta_2}{\kappa_6 - (1-\varepsilon)\overline{\eta}_l {\kappa_5}^{1-\varepsilon}\zeta_4}, \tag{C.13}$$

and

$$\omega_6 = \frac{(1-\varepsilon)\overline{\eta}_l \kappa_5^{1-\varepsilon}\zeta_3}{\kappa_6 - (1-\varepsilon)\overline{\eta}_l {\kappa_5}^{1-\varepsilon}\zeta_4}. \tag{C.14}$$

We next use (C.5), (C.6) and (C.11) to rewrite (C.4) as

$$\frac{\dot{\omega}_0}{\omega_0} = \theta_1 + \theta_2 \frac{\dot{z}}{z} + \theta_3 \frac{\dot{l}}{1-l-\bar{l}}, \tag{C.15}$$

where

$$\begin{aligned}
\theta_1 = \; & \frac{\sigma(\psi-1)(\sigma-\varepsilon)\gamma_g}{[(1-\varepsilon)\psi+\varepsilon](1-\alpha)} - \frac{(\sigma-\varepsilon)(\psi-1)(r-\rho-\omega_4)}{(1-\varepsilon)\psi+\varepsilon} \\
& - \frac{[(1-\sigma)\psi+\sigma]\omega_1(\sigma-\varepsilon)}{[(1-\varepsilon)\psi+\varepsilon]\sigma},
\end{aligned} \tag{C.16}$$

$$\theta_2 = \frac{\sigma(\psi-1)(\sigma-\varepsilon)\alpha}{(1-\varepsilon)\psi+\varepsilon} + \frac{(\sigma-\varepsilon)(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}\omega_5 - \left(\frac{(1-\sigma)\psi+\sigma}{(1-\varepsilon)\psi+\varepsilon}\right)\left(\frac{\sigma-\varepsilon}{\sigma}\right)\omega_2, \tag{C.17}$$

and

$$\theta_3 = \frac{(\sigma-\varepsilon)(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}\omega_6 - \left(\frac{(1-\sigma)\psi+\sigma}{(1-\varepsilon)\psi+\varepsilon}\right)\left(\frac{\sigma-\varepsilon}{\sigma}\right)\omega_3. \tag{C.18}$$

We substitute (C.15) and (C.11) in (C.3) to obtain

$$\frac{\dot{\kappa}_7}{\kappa_7} = \omega_7 + \omega_8\frac{\dot{z}}{z} + \omega_9\frac{\dot{l}}{1-l-\bar{l}}, \tag{C.19}$$

where

$$\begin{aligned}\omega_7 \quad &= \quad \omega_4 - \frac{\left[(1-\varepsilon)\overline{\eta}_s p_s^{1-\varepsilon} + (1-\sigma)\beta^\sigma p_s^{1-\sigma}\omega_0\right](\gamma_g-\gamma_s)}{1+\overline{\eta}_s p_s^{1-\varepsilon}+\beta^\sigma p_s^{1-\sigma}\omega_0} \\ &\quad - \frac{\beta^\sigma p_s^{1-\sigma}\omega_0\theta_1}{1+\overline{\eta}_s p_s^{1-\varepsilon}+\beta^\sigma p_s^{1-\sigma}\omega_0},\end{aligned} \tag{C.20}$$

$$\omega_8 = \omega_5 - \frac{\beta^\sigma p_s^{1-\sigma}\omega_0\theta_2}{1+\overline{\eta}_s p_s^{1-\varepsilon}+\beta^\sigma p_s^{1-\sigma}\omega_0}, \tag{C.21}$$

and

$$\omega_9 = \omega_6 - \frac{\beta^\sigma p_s^{1-\sigma}\omega_0\theta_3}{1+\overline{\eta}_s p_s^{1-\varepsilon}+\beta^\sigma p_s^{1-\sigma}\omega_0}. \tag{C.22}$$

The second step is to obtain the growth rate of employment. We first combine (2.12) and (B.10) to obtain

$$1-l-\bar{l} = \left(\frac{w\eta_g}{\eta_l(1-\beta)\psi\kappa_2^{\frac{\varepsilon-\sigma}{\varepsilon\sigma}}}\right)^{-\frac{\varepsilon}{(1-\varepsilon)\psi+\varepsilon}}(c_g-\overline{c})^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}. \tag{C.23}$$

We use (B.18) and (B.6) to get

$$\kappa_1 = \frac{\kappa_6}{\kappa_7}. \tag{C.24}$$

We combine (C.23) and (C.24) to obtain

$$1-l-\bar{l} = (\psi^\varepsilon\overline{\eta}_l)^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}\kappa_3^{\frac{\varepsilon-\sigma}{((1-\varepsilon)\psi+\varepsilon)\sigma}}\left(\frac{w}{1-\beta}\right)^{\frac{-\sigma}{(1-\varepsilon)\psi+\varepsilon}}\left[\left(\frac{\kappa_7}{\kappa_6}(E-\overline{c})\right)\right]^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}, \tag{C.25}$$

and we log-differentiate this equation

$$\begin{aligned}-\frac{\dot{l}}{1-l-\bar{l}} \quad &= \quad \left(\frac{\varepsilon-\sigma}{((1-\varepsilon)\psi+\varepsilon)\sigma}\right)\frac{\dot{\kappa}_3}{\kappa_3} - \frac{\sigma}{(1-\varepsilon)\psi+\varepsilon}\frac{\dot{w}}{w} \\ &\quad + \frac{1}{(1-\varepsilon)\psi+\varepsilon}\left(\frac{\dot{E}}{E-\overline{c}} + \frac{\dot{\kappa}_7}{\kappa_7} - \frac{\dot{\kappa}_6}{\kappa_6}\right).\end{aligned} \tag{C.26}$$

We substitute the growth rate of wages, (C.5), (C.6), (C.11), (C.19) and (3.1) to rewrite (C.26) as follows

$$\frac{\dot{l}}{l} = -\left(\frac{1-l-\bar{l}}{l}\right)\left(\omega_{10}+\omega_{11}\frac{\dot{z}}{z}\right), \tag{C.27}$$

where

$$\omega_{10} = \frac{\left(\frac{\varepsilon-\sigma}{\sigma}\right)\omega_1 - \sigma\left(\frac{\gamma_g}{1-\alpha}\right) + \alpha z^{\alpha-1} - \delta - \rho - \omega_4}{(1-\varepsilon)\psi + \varepsilon + \left(\frac{\varepsilon-\sigma}{\sigma}\right)\omega_3 - \omega_6}, \tag{C.28}$$

and

$$\omega_{11} = \frac{\left(\frac{\varepsilon-\sigma}{\sigma}\right)\omega_2 - \sigma\alpha - \omega_5}{(1-\varepsilon)\psi + \varepsilon + \left(\frac{\varepsilon-\sigma}{\sigma}\right)\omega_3 - \omega_6}. \tag{C.29}$$

Finally, we proceed to obtain the system of differential equations governing the time path of $z$ and $q$. We first use (3.3) and (3.4) to obtain

$$\frac{\dot{k}}{k} = (1-q)\, z^{\alpha-1} - \delta. \tag{C.30}$$

We combine (2.13) and (3.1) to obtain

$$\frac{\dot{E}}{E} = \left(\frac{E-\overline{c}}{E}\right)\left(\alpha z^{\alpha-1} - \delta - \rho - \frac{\dot{\kappa}_7}{\kappa_7}\right). \tag{C.31}$$

From log-differentiating the definition of $z$ and using (C.30) we obtain the dynamic equation for $z$

$$\frac{\dot{z}}{z} = (1-q)\, z^{\alpha-1} - \delta - \frac{\gamma_g}{1-\alpha} - \frac{\dot{l}}{l},$$

which, using (C.27), can be rewritten as (3.8) in the main text. From using (C.27) and (3.8), we obtain

$$\dot{l} = -l\left(1-l-\overline{l}\right)\left(\frac{\omega_{10} + \left[(1-q)\, z^{\alpha-1} - \delta - \frac{\gamma_g}{1-\alpha}\right]\omega_{11}}{l - \left(1-l-\overline{l}\right)\omega_{11}}\right). \tag{C.32}$$

From log-differentiating the definition of $q$ and using (C.31), (C.19) and (C.32) we obtain (3.9) in the main text. Finally, we log-differentiate $\overline{v}$ and we use (C.19) and (C.32) to obtain (3.10) in the main text.

## D. Balanced Growth Path

In order to obtain the BGP of this economy we will follow a four steps procedure. First, we will compute the long run values of prices. Second, we will obtain the long run values of the auxiliary variables $\{\kappa_i\}_{i=1}^{6}$ and $\{\omega_i\}_{i=1}^{11}$. Third, we will compute the long run values of employment and of the transformed variables, $z$ and $q$, and, finally, we will obtain the long run sectoral composition of the economy.

First, as $\gamma_g > \gamma_s$, equations (2.5) and (3.2) imply that $\lim_{t\to\infty} w = \infty$,and $\lim_{t\to\infty} p_s = \infty$. Taking this into account, we obtain the long run values of the different auxiliary variables. We first use (B.15) and (2.12) to obtain

$$\kappa_5 = \frac{w\left(1-l-\overline{l}\right)^{1-\psi}\kappa_2^{-\frac{1}{\sigma}}}{(1-\beta)\psi},$$

and from using (B.10) and (B.11) we obtain

$$\begin{aligned}
\kappa_5 &= \kappa_3^{-\frac{1}{\sigma}} \frac{\left(1-l-\bar{l}\right)^{1-\psi}}{\psi} = \\
&= \left[\beta^{\sigma}\left(\psi\frac{p_s}{w}\right)^{1-\sigma}\left(1-l-\bar{l}\right)^{(1-\sigma)(\psi-1)} + (1-\beta)^{\sigma}\right]^{\frac{1}{1-\sigma}} \frac{\left(1-l-\bar{l}\right)^{1-\psi}}{\psi} w \\
&= \left[\beta^{\sigma} + \left(\frac{w\left(1-l-\bar{l}\right)^{(1-\psi)}}{\psi p_s}\right)^{1-\sigma}(1-\beta)^{\sigma}\right]^{\frac{1}{1-\sigma}} p_s.
\end{aligned}$$

Note first that $\left(1-l-\bar{l}\right)^{1-\psi} w/p_s$ diverges to infinite**.** To see this, note that the growth rate of this term in the long run is

$$-(1-\psi)\left(\frac{\dot{l}}{1-l-\bar{l}}\right) + \frac{\dot{w}}{w} - \frac{\dot{p}_s}{p_s} = \frac{\gamma_m}{1-\alpha} - (\gamma_m - \gamma_s) > 0.$$

Then, it follows that $\kappa_5^* = \infty$.

We next use (B.14) to obtain

$$\kappa_6^* = \begin{cases} 1 \text{ when } \varepsilon > 1 \\ \infty \text{ when } \varepsilon < 1 \end{cases},$$

and we use (B.11) to obtain

$$\kappa_3 = \left(\beta^{\sigma}\left(\frac{\psi p_s\left(1-\bar{l}-l\right)^{(\psi-1)}}{w}\right)^{1-\sigma} + (1-\beta)^{\sigma}\right)^{\frac{\sigma}{\sigma-1}} w^{-\sigma}, \tag{D.1}$$

which implies that $\kappa_3^* = 0$. From using (B.9) we obtain

$$\kappa_2^* = \begin{cases} (1-\beta)^{\frac{\sigma}{\sigma-1}} \text{ when } \sigma < 1 \\ 0 \text{ when } \sigma > 1 \end{cases}.$$

In order to obtain the long run value of $\kappa_4$, we use (B.8), (B.13) and (B.9) to rewrite (B.12) as

$$\kappa_4 = \beta^{-\sigma}\left(\frac{\eta_s}{\eta_l}\right)^{\varepsilon}\left[\beta^{\sigma} + \left(\frac{w\left(1-\bar{l}-l\right)^{(1-\psi)}}{p_s\psi}\right)^{1-\sigma}(1-\beta)^{\sigma}\right]^{\frac{\sigma-\varepsilon}{\sigma-1}}$$

Then, we obtain that

$$\kappa_4^* = \begin{cases} \left(\frac{\eta_s}{\eta_l}\right)^{\varepsilon}\beta^{\left(\frac{1-\varepsilon}{\sigma-1}\right)\sigma} \text{ if } \sigma > 1 \\ \infty \; if \; \varepsilon > \sigma \text{ and } \sigma < 1 \\ 0 \text{ if } 1 > \sigma > \varepsilon \end{cases}.$$

From using (2.11), we obtain the long run value of

$$x^* = \begin{cases} \frac{1}{\beta^{\left(\frac{1-\varepsilon}{1-\sigma}\right)\sigma}\left(\frac{\eta_l}{\eta_s}\right)^{\varepsilon}+1} \text{ if } \sigma > 1 \\ 1 \text{ if } \sigma < \min(1,\varepsilon) \\ 0 \text{ if } 1 > \sigma > \varepsilon \end{cases},$$

and from using (B.6) we obtain that

$$\kappa_1^* = \begin{cases} 1 \text{ when } \varepsilon > 1 \\ \infty \text{ when } \varepsilon < 1 \end{cases},$$

From (C.7), (C.8) and (C.9), we obtain

$$\omega_1^* = \begin{cases} -\frac{\sigma\gamma_g}{1-\alpha} & if \quad \sigma < 1 \\ -\sigma\left(\gamma_g - \gamma_s\right) & if \quad \sigma > 1 \end{cases},$$

$$\omega_2^* = \begin{cases} -\alpha\sigma & if \quad \sigma < 1 \\ 0 & if \quad \sigma > 1 \end{cases},$$

and

$$\omega_3^* = \begin{cases} 0 & if \quad \sigma < 1 \\ \sigma\left(1-\psi\right) & if \quad \sigma > 1 \end{cases}.$$

Next, we obtain

$$\begin{aligned}
\zeta_1^* &= -\left(\frac{\sigma + \psi\left(1-\sigma\right)}{\left(1-\varepsilon\right)\psi + \varepsilon}\right)\frac{\omega_1^*}{\sigma} + \left(\frac{\sigma\left(\psi - 1\right)}{\left(1-\varepsilon\right)\psi + \varepsilon}\right)\frac{\gamma_g}{1-\alpha} - \zeta_4^*\left(r-\rho\right), \\
\zeta_2^* &= -\left(\frac{\sigma + \psi\left(1-\sigma\right)}{\left(1-\varepsilon\right)\psi + \varepsilon}\right)\frac{\omega_2^*}{\sigma} + \left(\frac{\sigma\left(\psi - 1\right)}{\left(1-\varepsilon\right)\psi + \varepsilon}\right)\alpha, \\
\zeta_3^* &= -\left(\frac{\sigma + \psi\left(1-\sigma\right)}{\left(1-\varepsilon\right)\psi + \varepsilon}\right)\frac{\omega_3^*}{\sigma}, \\
\zeta_4^* &= -\frac{1-\psi}{\left(1-\varepsilon\right)\psi + \varepsilon}.
\end{aligned}$$

We use the long run values of $\kappa_5$ and $\kappa_6$ and equations (C.12) (C.13) and (C.14) to obtain the long run values of $\omega_4$, $\omega_5$ and $\omega_6$

$$w_4^* = \begin{cases} \frac{(1-\varepsilon)\zeta_1}{1-(1-\varepsilon)\zeta_4} \text{ if } \sigma < 1 \text{ and } \varepsilon < 1 \\ \left(1-\varepsilon\right)\frac{\overline{\eta}_s\left(\gamma_g - \gamma_s\right) + \overline{\eta}_l \beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\zeta_1}{\overline{\eta}_s + \overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}} - (1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\zeta_4} \text{if } \sigma > 1 \text{ and } \varepsilon < 1 \\ 0 \;\; if \quad \varepsilon > 1 \end{cases},$$

$$\omega_5^* = \begin{cases} \frac{(1-\varepsilon)\zeta_2}{1-(1-\varepsilon)\zeta_4} \; if \text{ if } \sigma < 1 \text{ and } \varepsilon < 1 \\ \frac{(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\zeta_2}{\overline{\eta}_s + \overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}} - (1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\zeta_4} \text{ if } \sigma > 1 \text{ and } \varepsilon < 1 \\ 0 \; if \quad \varepsilon > 1 \end{cases},$$

and

$$\omega_6^* = \begin{cases} \frac{(1-\varepsilon)\zeta_3}{1-(1-\varepsilon)\zeta_4} \text{ if } \sigma < 1 \text{ and } \varepsilon < 1 \\ \frac{(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\zeta_3}{\overline{\eta}_s + \overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}} - (1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\zeta_4} \text{if } \sigma > 1 \text{ and } \varepsilon < 1 \\ 0 \text{ if } \varepsilon > 1 \end{cases}.$$

From (C.16), (C.17) and (C.18), we also obtain the following long run values:

$$\theta_1^* = \frac{\sigma(\psi-1)(\sigma-\varepsilon)}{(1-\varepsilon)\psi+\varepsilon}\left(\frac{\gamma_g}{1-\alpha}\right) - \frac{(\sigma-\varepsilon)(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}(r-\rho-\omega_4^*) - \left(\frac{(1-\sigma)\psi+\sigma}{(1-\varepsilon)\psi+\varepsilon}\right)\left(\frac{\sigma-\varepsilon}{\sigma}\right)\omega_1^*,$$

$$\theta_2^* = \frac{\sigma(\psi-1)(\sigma-\varepsilon)}{(1-\varepsilon)\psi+\varepsilon}\alpha + \frac{(\sigma-\varepsilon)(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}\omega_5^* - \left(\frac{(1-\sigma)\psi+\sigma}{(1-\varepsilon)\psi+\varepsilon}\right)\left(\frac{\sigma-\varepsilon}{\sigma}\right)\omega_2^*,$$

and

$$\theta_3^* = \frac{(\sigma-\varepsilon)(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}\omega_6^* - \left(\frac{(1-\sigma)\psi+\sigma}{(1-\varepsilon)\psi+\varepsilon}\right)\left(\frac{\sigma-\varepsilon}{\sigma}\right)\omega_3^*.$$

From using (C.2), (C.23) and (B.10), we obtain

$$\omega_0 = \overline{\eta}_l \psi^{\varepsilon-\sigma}\left(1-l-\overline{l}\right)^{(\sigma-\varepsilon)(1-\psi)}\kappa_3^{\frac{\varepsilon-\sigma}{\sigma}},$$

which implies that the long run value satisfies

$$\omega_0^* = \begin{cases} \infty \text{ if } \sigma > \varepsilon \\ 0 \text{ if } \sigma < \varepsilon \end{cases}. \tag{D.2}$$

Note that

$$\begin{aligned} \omega_0 &= \frac{\overline{\eta}_l \psi^{\varepsilon-\sigma}\left(1-l-\overline{l}\right)^{(\sigma-\varepsilon)(1-\psi)}}{w^{\varepsilon-\sigma}}\left[\beta^\sigma\left(\frac{\psi p_s\left(1-\overline{l}-l\right)^{(\psi-1)}}{w}\right)^{1-\sigma} + (1-\beta)^\sigma\right]^{\frac{\varepsilon-\sigma}{\sigma-1}} \quad \text{(D.3)} \\ &= \overline{\eta}_l p_s^{\sigma-\varepsilon}\left[\beta^\sigma + \left(\frac{\psi p_s\left(1-\overline{l}-l\right)^{(\psi-1)}}{w}\right)^{\sigma-1}(1-\beta)^\sigma\right]^{\frac{\varepsilon-\sigma}{\sigma-1}}. \end{aligned}$$

This expression is used together with (C.20), (C.21), (C.22), (C.28) and (C.29) to obtain

$$w_7^* = \begin{cases} \omega_4^* - (1-\sigma)\left(\gamma_g-\gamma_s\right) - \theta_1 \text{ if } \varepsilon < \sigma \text{ and } \sigma < 1 \\ \omega_4^* - (1-\varepsilon)\left(\gamma_g-\gamma_s\right) \text{ if } \varepsilon > \sigma,\ \sigma < 1 \text{ and } \varepsilon < 1 \\ \omega_4^* \text{ if } \varepsilon > 1 \\ \omega_4^* - \frac{(1-\varepsilon)\overline{\eta}_s + (1-\sigma)\beta^\sigma\overline{\eta}_l\beta^{\sigma\frac{\varepsilon-\sigma}{\sigma-1}}}{\overline{\eta}_s+\beta^\sigma\overline{\eta}_l\beta^{\sigma\frac{\varepsilon-\sigma}{\sigma-1}}}\left(\gamma_g-\gamma_s\right) - \frac{\beta^\sigma\overline{\eta}_l\beta^{\sigma\frac{\varepsilon-\sigma}{\sigma-1}}\theta_1}{\overline{\eta}_s+\beta^\sigma\overline{\eta}_l\beta^{\sigma\frac{\varepsilon-\sigma}{\sigma-1}}} \text{ if } \sigma > 1 \text{ and } \varepsilon < 1 \end{cases},$$

$$\omega_8^* = \begin{cases} \omega_5^* - \theta_2 \text{ if } \sigma < 1 \text{ and } \varepsilon < \sigma \\ \omega_5^* \text{ if } 1 > \varepsilon > \sigma \text{ or } \varepsilon > 1 \\ \omega_5^* - \frac{\beta^\sigma\overline{\eta}_l\beta^{\sigma\frac{\varepsilon-\sigma}{\sigma-1}}\theta_2}{\overline{\eta}_s+\beta^\sigma\overline{\eta}_l\beta^{\sigma\frac{\varepsilon-\sigma}{\sigma-1}}} \text{ if } \sigma > 1 \text{ and } \varepsilon < 1 \end{cases},$$

$$\omega_9^* = \begin{cases} \omega_6^* - \theta_3 \text{ if } \varepsilon < \sigma < 1 \\ \omega_6^* \text{ if either } 1 > \varepsilon > \sigma \text{ or } \varepsilon > 1 \\ \omega_6^* - \frac{\beta^\sigma\overline{\eta}_l\beta^{\sigma\frac{\varepsilon-\sigma}{\sigma-1}}\theta_3}{\overline{\eta}_s+\beta^\sigma\overline{\eta}_l\beta^{\sigma\frac{\varepsilon-\sigma}{\sigma-1}}} \text{ if } \sigma > 1 \text{ and } \varepsilon < 1 \end{cases},$$

$$
\omega_{10}^{*}=\begin{cases}
\alpha z^{\alpha-1}-\delta-\rho-\frac{\gamma_g}{1-\alpha} \text{ if } \varepsilon<1 \text{ and } \sigma<1\\
\dfrac{-(\varepsilon-\sigma)\left(\gamma_g-\gamma_s\right)-\sigma\left(\frac{\gamma_g}{1-\alpha}\right)+\alpha z^{\alpha-1}-\delta-\rho-(1-\varepsilon)\varsigma}{(1-\varepsilon)\psi+\varepsilon+(\varepsilon-\sigma)(1-\psi)-\frac{(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\left(\frac{\sigma+\psi(1-\sigma)}{(1-\varepsilon)\psi+\varepsilon}\right)(1-\psi)}{\overline{\eta}_s+\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}+(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\frac{1-\psi}{(1-\varepsilon)\psi+\varepsilon}}} \text{ if } \varepsilon<1 \text{ and } \sigma>1\\
\dfrac{-\varepsilon\left(\frac{\gamma_g}{1-\alpha}\right)+\alpha z^{\alpha-1}-\delta-\rho}{(1-\varepsilon)\psi+\varepsilon} \text{ if } \varepsilon>1 \text{ and } \sigma<1\\
\dfrac{-\left(\gamma_g-\gamma_s\right)(\varepsilon-\sigma)-\sigma\left(\frac{\gamma_g}{1-\alpha}\right)+\alpha z^{\alpha-1}-\delta-\rho}{(1-\varepsilon)\psi+\varepsilon+(\varepsilon-\sigma)(1-\psi)} \text{ if } \varepsilon>1 \text{ and } \sigma>1
\end{cases},
$$

where

$$
\varsigma=\frac{\overline{\eta}_s\left(\gamma_g-\gamma_s\right)+\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\left[\left(\frac{\sigma+\psi(1-\sigma)}{(1-\varepsilon)\psi+\varepsilon}\right)\left(\gamma_g-\gamma_s\right)+\left(\frac{\sigma(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}\right)\frac{\gamma_g}{1-\alpha}+\frac{1-\psi}{(1-\varepsilon)\psi+\varepsilon}(r-\rho)\right]}{\overline{\eta}_s+\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}+(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\frac{1-\psi}{(1-\varepsilon)\psi+\varepsilon}}
$$

and

$$
\omega_{11}^{*}=\begin{cases}
-\alpha \text{ if } \varepsilon<1 \text{ and } \sigma<1\\
\dfrac{-\sigma\alpha-\frac{(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\left(\frac{\sigma(\psi-1)}{(1-\varepsilon)\psi+\varepsilon}\right)\alpha}{\overline{\eta}_s+\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}+(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\frac{1-\psi}{(1-\varepsilon)\psi+\varepsilon}}}{(1-\varepsilon)\psi+\varepsilon+(\varepsilon-\sigma)(1-\psi)+\frac{(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\left(\frac{\sigma+\psi(1-\sigma)}{(1-\varepsilon)\psi+\varepsilon}\right)(1-\psi)}{\overline{\eta}_s+\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}+(1-\varepsilon)\overline{\eta}_l\beta^{\sigma\frac{1-\varepsilon}{1-\sigma}}\frac{1-\psi}{(1-\varepsilon)\psi+\varepsilon}}} \text{ if } \varepsilon<1 \text{ and } \sigma>1\\
\dfrac{-\alpha\varepsilon}{(1-\varepsilon)\psi+\varepsilon} \text{ if } \varepsilon>1 \text{ and } \sigma<1\\
\dfrac{-\sigma\alpha}{(1-\varepsilon)\psi+\varepsilon+(\varepsilon-\sigma)(1-\psi)} \text{ if } \varepsilon>1 \text{ and } \sigma>1
\end{cases}.
$$

We proceed to obtain the long run values of labor and of the transformed variables. We first use (C.25) and the definition of $q$ to obtain

$$
1-l-\bar{l}=\kappa_3^{\frac{\varepsilon-\sigma}{((1-\varepsilon)\psi+\varepsilon)\sigma}}\left(\frac{\psi^{\varepsilon}\overline{\eta}_l w^{1-\sigma}(1-\beta)^{\sigma}}{(1-\alpha)\kappa_1}\right)^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}\left[(q-\overline{v})\,l\right]^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}
$$

and from using (B.6) we obtain

$$
1-l-\bar{l}=\kappa_3^{\frac{\varepsilon-\sigma}{\sigma}\frac{1}{(1-\varepsilon)\psi+\varepsilon}}\left(\frac{w^{1-\sigma}}{1+\overline{\eta}_s p_s^{1-\varepsilon}+\beta^{\sigma}p_s^{1-\sigma}\omega_0}\right)^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}\left[\frac{\overline{\eta}_l(1-\beta)^{\sigma}(q-\overline{v})\,l\psi^{\varepsilon}}{1-\alpha}\right]^{\frac{1}{(1-\varepsilon)\psi+\varepsilon}}.
$$

From using (D.1) and (D.3), we obtain

$$
\frac{\left(1-l-\bar{l}\right)^{(1-\varepsilon)\psi+\varepsilon}}{l}=\left(\beta^{\sigma}\left(\frac{\psi p_s\left(1-\bar{l}-l\right)^{(\psi-1)}}{w}\right)^{1-\sigma}+(1-\beta)^{\sigma}\right)^{\frac{\varepsilon-\sigma}{\sigma-1}}\left(\frac{w^{1-\varepsilon}\left[\frac{\overline{\eta}_l(1-\beta)^{\sigma}(q-\overline{v})\psi^{\varepsilon}}{1-\alpha}\right]}{1+\overline{\eta}_s p_s^{1-\varepsilon}\frac{1}{x}}\right)
$$

which can be rewritten as

$$
\frac{\left(1-l-\bar{l}\right)^{(1-\sigma)\psi+\sigma}}{l}=\frac{p_s^{\sigma-\varepsilon}\left(\beta^{\sigma}+\left(\frac{\psi p_s\left(1-\bar{l}-l\right)^{(\psi-1)}}{w}\right)^{\sigma-1}(1-\beta)^{\sigma}\right)^{\frac{\varepsilon-\sigma}{\sigma-1}}w^{1-\sigma}\left[\frac{\overline{\eta}_l(1-\beta)^{\sigma}(q-\overline{v})\psi^{\sigma}}{1-\alpha}\right]}{1+\overline{\eta}_s p_s^{1-\varepsilon}+\beta^{\sigma}p_s^{1-\varepsilon}\overline{\eta}_l\left[\beta^{\sigma}+\left(\frac{\psi p_s\left(1-\bar{l}-l\right)^{(\psi-1)}}{w}\right)^{\sigma-1}(1-\beta)^{\sigma}\right]^{\frac{\varepsilon-\sigma}{\sigma-1}}}.
$$

From using the last two expressions, it can be shown that $l^* = 0$ if $\sigma < 1$ and $\varepsilon < 1$. Otherwise, $l^* = 1 - \bar{l}$. These are the long run values obtained in Proposition 3.4.

In order to obtain the long run values of the transformed variables, we use the system of differential equations (3.8), (3.9) and (3.10). We only consider the case $l^* = 0$, as it is the only case consistent with empirical evidence. We use (3.8) and (3.9) to obtain the long run value of $z^*$ and of $q^*$. Using (3.10), we show that in the long run $\dot{\overline{v}} < 0$, which implies that $\overline{v}^* = 0$.

The results in Proposition 3.5 regarding the long run employment shares are obtained from using (3.5) and the long run values of $\overline{v}$ and $\kappa_1$.

## E. Working and leisure hours and recreational services

In this section we discuss data sources and we explain the procedures that we follow to obtain the shares of total time devoted to work and leisure and the share of value added in the service sector explained by recreational services.

### E.1. Labor supply and leisure

**Market working hours**

We report the share of working hours on total available time in Figure 4. To obtain this share, we first need to compute average weekly working hours per employed person in the period 1947-2010. We use two data sets. The first one is the Census Data Population Survey (CPS). This survey provides information on average weekly working hours reported by the population above 16 years for the period 1947-1998 in an annual basis.[5] The second data set is provided by Aguiar and Hurst (2007) and Aguiar, Hurst, and Karabarbounis (2013). We will refer to them as AH. These authors link five major time-use surveys that all together provide the trends in the allocation of time in the period 1965 to 2010. Based on these surveys, AH provides information on average weekly working hours, leisure, home production, personal care, and child care for the years 1965, 1975, 1985, 1993, 2003, and 2010. The following table shows the average market working hours per week obtained by AH.[6]

**Table 5. Average market working hours per week**

| | 1965 | 1975 | 1985 | 1993 | 2003 | 2010 |
|---|---|---|---|---|---|---|
| Hours | 35.98 | 33.79 | 32.67 | 33.22 | 31.71 | 30.54 |

Source: Aguiar and Hurts (2007) and Aguiar, Hurst, and Karabarbounis (2013)

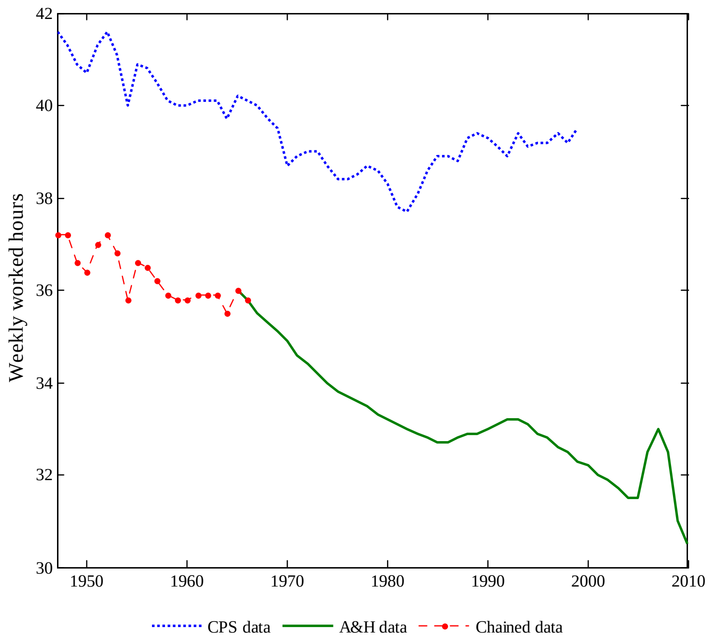
To obtain the market working hours from 1947 to 2010 reported in Figure 4, we first interpolate linearly working hours between the initial and final years reported in

[5] Sundstrom, William A. , "Average weekly hours worked in nonagricultural industries, by age, sex, and race: 1948–1999." Table Ba4597-4607 in Historical Statistics of the United States, Earliest Times to the Present: Millennial Edition, edited by Susan B. Carter, Scott Sigmund Gartner, Michael R. Haines, Alan L. Olmstead, Richard Sutch, and Gavin Wright. New York: Cambridge University Press, 2006.

[6] This data is adjusted for changing demographics. As AH claim, "this is important given the changes in the age distribution, fertility, family structure, and educational attainment that occurred during this time period". AH also report the effect of changing demographics on the evolution of the unconditional mean in the time use.

the previous table in order to obtain the amount of hours worked in the market in the period 1965-2010. We then chain the CPS to AH data to obtain market working hours for the period prior to 1965. We joint together both data sets by rescaling the reported working hours in CPS to make its value in 1965 equal to the reported hours in AH. The following figure plots the trend in market working hours reported in CPS, AH and the chained time series.[7]

**Figure 11. Average market working hours**




**Leisure**

We compute the amount of hours devoted to leisure by using the weekly leisure hours reported by AH. Aguiar and Hurts (2007) show four different measures of leisure based on the type of activities related with non-working time. The first measure of leisure, denoted Leisure 1, is composed of average weekly hours devoted to sports, exercise, socialize, travel, reading, hobbies, tv, radio, entertainment, and other leisure activities. The second measure, denoted Leisure 2, is composed of Leisure 1 plus the average weekly hours devoted to sleep, eating and personal care. The third measure, Leisure 3, is composed of Leisure 2 and the average weekly hours devoted to child care. Finally, Leisure 4 is computed as the residual between the total available weekly time (168 hrs) and working hours (market and non-market).

[7] From visual inspections, it is clear that CPS overestimates the number of working hours compared with those reported by AH. According to Abraham et al. (1998), this discrepancy in working hours is due to the period in which the surveys are carried out. In the case of the CPS data, by design, the weeks in which they carried out the data collection avoids major holiday periods, periods in which average working hours tend to be lower. This implies an overestimation of working hours. By controlling for differences in the weeks that surveys are carried out, reported working hours tend to be similar between the time-use surveys and CPS. Due to CPS overestimate working hours and daily data is presumed to provide a higher reliable measure of how individuals allocate time, we choose AH dataset as a basis for our calculations.

In our model, individuals enjoy their leisure time together with the consumption of recreational services. As a consequence, the appropriate measure of leisure in our analysis is Leisure 1. The table below reports the data on this measure of leisure. We interpolate linearly these data to obtain a complete time series for the period 1965-2010.

**Table 6. Average hours per week devoted to leisure**

| | 1965 | 1975 | 1985 | 1993 | 2003 | 2010 |
|---|---|---|---|---|---|---|
| Hours | 30.77 | 33.24 | 34.78 | 37.47 | 35.33 | 36.92 |

Source: Leisure 1 reported in Aguiar and Hurts (2007) and Aguiar, Hurst, and Karabarbounis (2013).

In order to obtain a measure of hours devoted to leisure prior to 1965 consistent with Leisure 1, we assume that any increase (or decrease) in market working hours from 1947 to 1964 is equivalent to a decrease (or increase) in the time devoted to leisure. That is, we assume that there is a mirror effect between working and leisure hours. This assumption has the important implication that time devoted to personal care, child care, and home production remains constant. This is consistent with available evidence for the period after 1965, which shows that weekly hours devoted to these tasks have remained robustly constant. The following table shows the average weekly hours devoted to these activities reported in AH.[8] Beyond the decrease in the average hours in 1993, the figures for these 4 decades is roughly the same, which allows us to assume that this pattern remains prior to 1965. Based on this assumption, we compute the time series of weekly leisure hours using the average working hours for the period 1947-1964 to extend the time series reported in AH.

**Table 7. Average hours per week devoted to:**
**personal and child care and home production**

| | 1965 | 1975 | 1985 | 1993 | 2003 | 2010 |
|---|---|---|---|---|---|---|
| Hours | 101.25 | 100.97 | 100.55 | 97.31 | 100.96 | 100.54 |

Source: Based on Aguiar and Hurts (2007).

Note that both market working hours and leisure hours are not reported directly in the main text. Instead, these time series are reported as shares of total available time. In what follows, we show the procedure to obtain these shares.

**Rescaling total available time**

We first rescale the total time available as follows

$$T_s = T - (P + H + C) \equiv l + w,$$

where $T_s$ is the re-scaled available time, $T$ is the total available time in a week (168hrs), $P$ is time spend on personal care, $H$ is time devoted to home production,[9] $C$ is time spend on child care, $l$ are the hours devoted to leisure and $w$ are the hours devoted

[8] To obtain data in Table 7, we calculate the difference between total time in a week (168 hrs) and total time devote to market working hours, reported in Table 5, and hours devoted to Leisure 1.

[9] Home production also includes time devoted to educated children, self-medication and community services.

to work. Then, the shares of leisure and working hours on total available time are, respectively,

$$s_l = \frac{l}{T_s}, \quad s_w = \frac{w}{T_s}.$$

Finally, we use the Hodrick-Prescott filter to remove business cycle changes. In this way, we obtain the smooth time series that capture the long run trends that we report in Figures 1 and 2.

### E.2. Recreational Services

In this appendix we compute the share of value added in the service sector generated in recreational activities. To this end, we use information from input-output tables (IO) available for the period 1947-2010.[10] Using IO tables allows us to compute the added value of those industries that provide services that are consumed during leisure time.

In an ideal world, for the calculation of added value of recreational services, we would link every leisure activity to a commodity in the IO tables and, in turn, each commodity with a particular industry. In that hypothetical case, the sum of added values generated by industries corresponds to the added value of the recreational services sector. However, changes in the industrial classification during the period and lack for information in higher detailed industrial level for some years do not allow us to apply directly this strategy. To deal with these issues, we use the Bridge Tables published by the Bureau of Economic Analysis (BEA). The Bridge Tables provide the IO commodity codes that connect personal consumption estimates from the input-output accounts to the consumption categories (PCE) used by the National Income and Product Accounts (NIPA). We use these codes to identify recreational industries in the IO tables.[11] This procedure allows us to identify the industrial classification for industries that provide recreational services even in periods when reclassification of industries take place. Given the IO codes, we follow the methodology proposed in Herrendorf et al (2013) to compute the added value of recreational services.

**Table 8. SIC classification and IO code for Recreational Services (1967)**

| Leisure activities | PCE code | IO codes | SIC |
|---|---|---|---|
| Civic | 9918 | 770500 | 84, 86, 8921 |
| Sports & exercise | 9830, 9900 | 760200 | 84 |
| Entertainment, and hobbies | 9820, 9910 | 760200 | 79 |
| Socializing | 9918 | 720300 | 723, 724 |
| Travel | 9400 | 720100 | 70, 81 |
| Tv, radio, movies | 9500, 9600, 9810 | 760100 | 78 |

[10] Bureau of Economic Analysis (BEA) publishes IO tables for the years 1947, 1958, 1963, 1967, 1972 1977, 1982, 1987, 1992, 1998. After 1998, IO tables are published annually from 1999 to 2010 . To download IO table prior to 1977, see http://www.bea.gov/industry/io_benchmark.htm . For the years after 1977, IO tables are available in http://www.bea.gov/industry/io_histsic.htm

[11] Those that provide services consumed during leisure time.

The previous table shows this procedure. Using PCE category codes, we assign a code to each of the activities that characterize our measure of leisure. For instance, sports and exercise activities, which cover all activities related to attend sport events and travel related to sports, are coded by 9830 and 9900 in the PCE classification in 1967. Based on the Bridge Table, the sub-industries that provide this kind of services are coded 760200 and classified into the sector 84 according to the Standard Industrial Classification (SIC) at that time. Using the IO table published by BEA in 1967, we can compute the added value of this sub-industry as well as the share of this sub-industry in the aggregate sector (84) that it belongs to. Following the same procedure for the others activities, we can compute the added value for all sub-industries. We then aggregate all added values from these industries to obtain the added value for the recreational services sector in 1967. We repeat the procedure described here for all the IO tables with high detail disaggregate industry levels.[12]

When the IO tables only provide data for more aggregate industrial level, i.e. two digits level, we compute the added value of recreational industries by using the computed weights of each sub-industry for years with detailed information. In order to reduce substantially any potential over or subestimation of real weights of sub-industries in the recreational sector, we use the computed weights of the closest years from which we have available detailed IO tables.[13] Once we have computed the added value of the recreational sector, we then linearly interpolate between the years for which IO tables are available.

To obtain the share of value added in the service sector explained by the recreational sector that we report in Figure 5, we use the time series of added value personal consumption expenditure calculated by Herrendorf, Valentiny and Rogerson (2013). They calculate the added value of agricultural, industrial goods and services generated by personal consumption, which excludes government and transportation costs. Thus, we calculate the ratio between the added value of recreational services and the added value of the service sector generated by personal consumption to obtain the share reported in the paper. We use the Hodrick-Prescott filter to eliminate any variation in data due to business cycles.

[12]IO tables with two-digit detail are those tables published in 1947 and 1958.

[13]Overestimation may be due to changes in the composition of demand for new leisure activities. For example, the introduction of the VCR in the 80's substantially changes the demand for cinema tickets. Using the computed weight of the cinema industry in added valued of recreational sector in the 60s to compute added value of cinema industry in the 90s overestimates the weight of this sector in the recreational sector.