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HUMAN CAPITAL AND CONSUMPTION OVER THE LIFE CYCLE: A SYNTHESIS

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ABSTRACT: This paper presents a life cycle model that contains the Becker's (1975) and Heckman's (1976) models as special cases. Contrary to the previous literature, the model can explain the *life cycle hypothesis* and the maximum in the consumption profile without appealing to the rupture of typical neoclassical assumptions and for any value of intertemporary elasticity of substitution. An estimation of the consumption demand for Spanish case shows that current earning is a significant and robust variable explaining the consumption pattern.

KEY-WORDS: consumption profile, human capital, *life cycle hypothesis.*

JEL classification: D11, D12

RESUMEN: El presente documento desarrolla a un modelo de ciclo vital que contiene los modelos de Becker (1975) y Heckman (1976) como casos especiales. Al contrario que la literatura previa, el modelo puede explicar la *hipotesis del ciclo vital*, así como el máximo alcanzado en los perfiles de consumo sir recurrir a la ruptura the los supuestos típicos neoclásicos, y para cualquier valor de la elasticidad intertemporal de substitución. Una estimación de la demanda de consumo para España muestra que los ingresos actuales son una variable significativa y robusta explicando los patrones de consumo.

PALABRAS CLAVE: perfil de consumo, capital humano, *hipótesis del ciclo vital*

Clasificación JEL: D11, D12

1. INTRODUCTION

According to the *life cycle hypothesis* enunciated by Modigliani and Brumberg (1954), consumption and current income are not necessarily related, because individuals prefer a smoothed consumption profile and, therefore, they borrow for present consumption against their future revenues. In each moment, the consumption depends upon the discounted present value of the life cycle total income and not upon current income. However, Thurow (1969) demonstrated the existence of a strong relationship between both variables, and he observed that both, current income and consumption, reach a maximum in the age interval 45-54 years old, by using US data corresponding to the period 1960-61.

To explain this finding Thurow (1969) argues that constraints in the credit market prevent consumers borrow as much as they want to the effective interest rate, that is, there exist liquidity constraints. Nagatani (1972) explained this maximum by recurring to the existence of uncertainty in future income. Both relax a neoclassical standard assumption[1] to obtain their results.

The empirical evidence observed by Thurow was explained by Heckman (1974) and Becker (1975), remaining the typical neoclassical assumptions. Both introduce a wage rate that evolves over the life. The first one assumes that wage is exogenous and evolves itself simply on age, and the second one assumes that this variable is the result of decisions of time allocation, that is, labor supply is endogenous.

In Heckman's (1976) model, consumers have incentives to economize their leisure and to spend in goods, which would explain that consumption reaches a maximum[2]. Because consumption of goods is substitutive of leisure in the utility function, in the sense that a reduction of leisure increases the marginal utility of

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[1] The typical neoclassical assumptions are perfect forecast, perfect competition and complete markets.

[2] This result is demonstrated only for the particular case in which interest rate and discount rate, or rate of impatience, are equalized; otherwise, the existence of a maximum in the consumption profile cannot be assured.

compsumtion in the ages where leisure's price is higher.

In Becker's (1975) model, the demand for compsumtion goods and services that individual carry out in each period, depends directly upon leisure's price in each period[3], that is, consumption depends upon wage rate in each period. The behavior of the wage rate reflects the improvement in labor productivity, and in this model it is explained through human capital accumulation. It has been tested enough that life cycle wage profile reaches a maximum, and it would explain why also the life cycle consumption profile reaches a maximum.

Many empirical studies have tried to clarify which are the key variables that explain the consumption profile. The *life cycle hyphothesis* enunciated by Brumberg and Modigliani (1954) received empirical support in Ando and Modigliani (1963) and Hall and Mishkin (1982). And the Becker's (1975) model received empirical support in Ghez and Becker (1975)[4], where the existence of a strong positive relationship between consumption and current earnings was observed. Nagatani's (1972) hypothesis of uncertainty in future income received empirical support in Flavin (1981) and Runkle (1991), while the existence of liquidity constraints, proposed by Thurow (1969), does not have any strong empirical support, as it is shown in Altonji and Siow (1986), Zeldes (1989)[5] and Runkle (1991). The importance of household's characteristics has already been studied by Blundell, Browning and Meghir (1994) and Attanasio and Browning (1995). These studies support *life cycle hypothesis* and explain the maximum observed in the consumption profile base, mainly upon the behavior of family size and upon the age of its members. Once these variables have been taken into

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[3] It is true if individuals prefers a profile smoothed enough for his/her consumption, that is, when the intertemporary elasticity of substitution of the consumption is low enough.

[4] See Ghez, G. and G. Becker (1975): "The Allocation of Time and Goods over the Life Cycle." Columbia University Press. New York.

[5] This study supports the hypothesis that liquidiy constraints affect population with a low ratio wealth/income, however, the author recognizes that his results are not consistent when variations in the tests and in the procedures of sample selection are carried out.

account, the positive relationship between consumption and current income disappears.

The present paper has a double aim: first, to study in a theoretical framework, the life cycle consumption profile and its possible relationship with current income through wage, explaining the behavior of wages through human capital accumulation, and carrying out an empirical verification of the results obtained in our model for the Spanish case.

As we have mentioned above, the behavior of compsumtion has already been analyzed in many empirical studies. The results obtained in this way contributes to support empirically the *life cycle hypothesis* and the existence of a maximum in the consumption profile, therefore, it would be desirable that a theoretical model that explains the behavior of compsumtion might reproduce both results. The model that we develop here has this quality.

In order to explain the relationship between consumption and current income without breaking the neoclassical assumptions, we introduce decisions of time allocation among leisure, work and training, and we assume wage rate as an endogenous variable. Becker (1975) is a suitable theoretical frame of reference, because it allows that consumption profile take different shapes depending upon the consumption's intertemporary elasticity of substitution, impatience rate and interest rate: it might has a maximum or a minimum, being strictly increasing or decreasing, or stationary, according to the values of these parameters[6]. A limitation of this theoretical framework is that it is only able to reproduce the result of *life cycle hypothesis* if the intertemporary elasticity of substitution coincides with the elasticity of substitution between leisure and consumption of goods into the utility function. Independently of the value of this parameter, Heckman's (1976) model is able to reproduce this result by assuming that human capital acts like Harrod neutral technical progress augmenting leisure in the

[6] This model assumes a perfect credit market, therefore, the interest rate is constant in each period, and because of this, we assume the interest rate like a parameter.

utility function; a limitation of this last model is that it does not allow other consumption profiles.

Our theoretical framework synthesizes the results of these two models and is able to reproduce them for any value of the intertemporary elasticity of substitution. Nevertheless, our model presents a novelty respect to Becker's (1975) model that refers to the role of human capital in the utility function, and how it affects to consumption profile over the life cycle. In this sense, the theoretical and empirical study carried out by Michael (1973) observed that human capital affects individual preferences.

Individual utility depends upon leisure, consumption of goods and services, and human capital. This last one may play three possible roles in the utility function: first, as a variable with own entity respect to goods and leisure and, therefore, individual obtains more utility if he/she possesses more human capital. Second, as a variable augmenting time for leisure, and therefore, individual's utility depends upon consumption of goods and upon time in units of efficiency devoted to leisure[7] or leisure's value. And third, it does not affect individual utility and it only depends upon leisure in natural units and upon consumption. These three alternatives affect to life cycle consumption profile. We obtain a maximum in consumption profile if the intertemporary elasticity of substitution is smaller than one[8] and leisure has more weight than human capital in the utility function, or when exactly the opposite happens.

Notice that it is possible to obtain this result even when intertemporary elasticity of substitution is higher than the elasticity of substitution within each period among leisure, consumption of goods and human capital, because the individual prefers training rather than leisure. Investment in human capital takes place to early ages because the cost in terms of given up retributions is lower and the period of time to obtain the returns of the investment is higher, therefore the

[7] As in Heckman's (1976) model.

individual will devote more time to his training when he/she is younger and he/she postpone his/her consumption. We obtain a consumption profile strictly increasing if intertemporary elasticity of substitution is unitary and/or human capital acts augmenting leisure time in the utility function, therefore, we achieve *life cycle hypothesis* result for any value of this elasticity.

In order to check whether we can accept the existence of a maximum in the consumption profile without appealing to the rupture of typical neoclassical assumptions, or to the behavior of household's characteristics, we have carried out an empirical test of the results derived from our model. This empirical test shows a significant and robust relationship between consumption and current earnings. Family's characteristics are significant, but do not eliminate the excess of sensibility of the consumption respect to earnings.

Following the aims and assumptions mentioned above, the paper is structured as follows. Section 2 developes the model. Section 3 studies the life cycle profiles and levels of investment in human capital. Section 4 analyzes leisure, consumption and earnings profiles. Section 5 shows the empirical analysis. And finally, section 6 collects a summary and the main conclusions.

2. THE THEORETICAL MODEL

In this section we analyze the allocation of time and goods along the life upon four activities: leisure, production of human capital, production of goods and consumption of goods and services.

Theoretical models that do not take into account leisure in the utility function, and do not allow wage variations along time, are unable to explain the maximum in the life cycle consumption profile without appealing to the rupture of neoclassical assumptions. Heckman (1974) and Becker (1975) consider leisure and a wage rate that evolves along life. The first one assumes that temporal wage

[8] Due to the form of our utility function, that is, a Coob-Douglas nested in a CES.

trajectory is exogenous and depends, simply, upon age[9], however, the second one explains the wage trajectory through human capital accumulation.

We have taken as theoretical framework of reference Becker (1995), because we think that it is the most complete, since it considers leisure, takes wage rate as an endogenous variable and allows different consumption profiles. Our model allows that human capital has non-market benefits, that is, it affects directly to the utility index[10]. Our theoretical framework contains the Becker's (1975) model, where human capital is not an argument of the utility function, and Heckman's (1976) model, where human capital acts like Harrod´s neutral technical progress increasing time devoted to leisure in the utility function, as particular cases.

Following our theoretical framework, it is also possible to analyze the case where leisure and human capital have different weights in the utility function. We think that this treatment is also reasonable, since although it is true that individuals invest in human capital to improve their productive capacity, and hence to obtain higher earnings, it is also true that human capital level could be a variable that creates utility *per se*, because contributes to obtain social prestige.

We represent preferences by an utility function as in Becker (1975), where the main argument is an index or consumption function, C_t, which depends upon three arguments; goods and services devoted to consumption, X_t, time devoted to leisure or time devoted to consumption, L_t, and human capital level, H_t. We may understand that "consumption", C_t, is produced at home using these three inputs. Our subject to be studied is not the consumption index, C_t, despite that consumption of goods and services, X_t, along life and how is affected by human

[9] Although in Heckman (1974) it is assumed an exogenous wage evolution, the author clarifies that the same predictions are obtained through a more general model that explains wage evolution through human capital accumulation.

[10] As we have mentioned above, this focus is analyzed in a theoretical and empirical framework in Michael (1973). We will concetrate ourselves in how human capital accumulation affects to consumption profile.

capital accumulation. Therefore, we define a general production function for "consumption" as:

$$C_t = f_t\,(X_t, L_t, H_t) \qquad (1)$$

As far as f_t, for analytical simplicity we assume stability over time, $f_t = f$. This assumption will not affect our analysis[11].

We use a CES as instantaneous utility function in the consumption index, and a Cobb-Douglas to characterize the "consumption" production function. Then, we propose the following instantaneous utility

$$U_t = \begin{cases} \dfrac{(X_t^{\alpha} L_t^{\beta} H_t^{\gamma})^{1-\sigma} - 1}{1-\sigma}, & \text{if } \sigma \neq 1 \\ \alpha \text{Ln} X_t + \beta \text{Ln} L_t + \gamma \text{Ln} H_t, & \text{if } \sigma = 1 \end{cases} \qquad 0 < \alpha, \beta, \gamma < 1 \qquad (2)$$

Notice that the intertemporary "consumption" elasticity of substitution of "consumption", C_t, might take any value, even constant. However, elasticity of substitution among consumption of goods and services, leisure and human capital at a concrete age is constant and unitary. To take this concrete functional form is quite restrictive, since the degree of substitution among the last three arguments of the "consumption" production function could not be so high. We have taken this functional form for analytic simplicity. The generalization of this production function to a CES does not vary the results.

Production of human capital is characterized by a function that depends upon time devoted to training, S_t, and upon human capital. It takes decreasing returns in S_t, which means that successive increments of time devoted to invest in human capital improve the individual productivity less and less. Human capital is

[11] Becker (1975) carries out this analysis by introducing the assumption that "consumption" production function is modified with age, assuming that individuals lose part of their capacity

then a “productivity factor”, therefore, we can write the production function of human capital as:

$$I_t = H_t S_t^{\theta},\ 0 < \theta < 1 \tag{3}$$

where I_t is the gross investment in capital human.

We assume that human capital depreciates itself, due to physical and technological causes, at each age to a constant and positive rate δ, therefore, its law of motion can be expressed as:

$$\dot{H}_t = H_t S_t^{\theta} - \delta H_t,\ 0 < \delta < 1 \tag{4}$$

where $H_t = dH_t/d_t$ is the net investment in human capital.

The individual has a unit of time in each period, and so, in each instant the following time constraint is applied:

$$L_t + S_t + W_t = 1 \tag{5}$$

where W_t is the time devoted to work.

The individual’s budget constraintt says that, saving plus consumption of goods and services should be equal to total income at each age, and the last one is equal to labor income, or earnings, plus financial income, that is:

$$\dot{A}_t = rA_t + wH_t(1 - L_t - S_t) - pX_t \tag{6}$$

where $A_t = dA_t/d_t$ is the saving, rA_t is the financial income and the remaining expression, without consumption of goods and services, which we denote by G_t, represents the labor income or earnings. We assume a perfect credit market, since the interest rate, r, is constant. The wage rate per unit of labor efficiency, w, is constant, and also consumption goods and services price, p. That is, individual

to “produce consumption” as they get older.

maximizes his/her total utility along his life, and its longitude, T, is known by the individual, discounted to a constant and positive rate ρ, subject to constraints (3), (4) and (5) and given the initial levels of wealth, A_0, and human capital, H_0. Concretely:

$$
\begin{aligned}
&\underset{X_t, L_t, S_t}{\text{Max}} \int_0^T e^{-\rho t} \frac{(X_t^{\alpha} L_t^{\beta} H_t^{\gamma})^{1-\sigma} - 1}{1-\sigma} dt \\
&\text{s.a:} \qquad \dot{A}_t = rA_t + wH_t(1 - L_t - S_t) - pX_t \\
&\qquad\qquad \dot{H}_t = H_t S_t^{\theta} - \delta H_t \\
&\qquad\qquad A_0, H_0 \text{ given; } A_0 \geq 0,\ H_0 > 0
\end{aligned}
$$

It is a standard problem of dynamic optimization with temporal finite horizon, which control variables are X_t, L_t and S_t, and their state variables are A_t and H_t. In order to solve it, we make the following Hamiltonian function:

$$
\begin{aligned}
M(X_t, L_t, S_t, A_t, H_t, \lambda_t, \mu_t, t) = {}& e^{-\rho t} \frac{(X_t^{\alpha} L_t^{\beta} H_t^{\gamma})^{1-\sigma} - 1}{1-\sigma} + \\
& + \lambda_t\left(rA_t + wH_t(1 - L_t - S_t) - pX_t\right) + \\
& + \mu_t\left(H_t S_t^{\theta} - \delta H_t\right)
\end{aligned} \qquad (7)
$$

where λ_t and μ_t are the co-state variables or shadow prices of wealth and human capital, respectively. The first-order conditions of the problem and the two transversality conditions are:

$$e^{-\rho t} C_t^{-\sigma} \alpha X_t^{\alpha-1} L_t^{\beta} H_t^{\gamma} - \lambda_t p = 0 \qquad (8)$$

$$e^{-\rho t} C_t^{-\sigma} \beta X_t^{\alpha} L_t^{\beta-1} H_t^{\gamma} - \lambda_t w H_t = 0 \qquad (9)$$

$$-\lambda_t w H_t + \mu_t H_t \theta S_t^{\theta-1} = 0 \qquad (10)$$

$$\dot{\lambda}_t = -r\lambda_t \qquad (11)$$

$$\dot{\mu}_t = -e^{-\rho t} C_t^{-\sigma} \gamma X_t^{\alpha} L_t^{\beta} H_t^{\gamma-1} - \lambda_t w(1 - L_t - S_t) - \mu_t S_t^{\theta} + \mu_t \delta \tag{12}$$

$$\lambda_T A_T = 0 \tag{13}$$

$$\mu_T H_T = 0 \tag{14}$$

We do the same than in Heckman (1976) in the elimination of corner solutions. We can understand the absence of corner solutions in two ways: first, to define the period of schooling at the beginning of life cycle, when labor supply is low and demand for human capital is high. And the retirement stage at the end of the life, when labor supply is low and the demand for training is almost null. Second, to consider that the model only characterizes the stage of the life where the individual is incorporated in the labor market. This assumption simplifies the technical level in our model, and does not remove us from the main subject of this paper[12].

The shadow price of wealth is equal to marginal value of wealth and falls exponentially with age. The transversality condition indicates that wealth should be null at the end of life. The shadow price or marginal value of human capital should eliminate itself at the end of life, according to the associated transversality condition.

Defining relative shadow prices ratio as $g_t = \mu_t / \lambda_t$, we may write its law of motion by considering expressions (9), (10), (11) and (12):

$$\dot{g}_t = (r + \delta) g_t - w \frac{1-\theta}{\theta} \left(\frac{\theta}{w} g_t \right)^{\frac{1}{1-\theta}} - w \left(1 - \left(\frac{\beta - \gamma}{\beta} \right) L_t \right) \tag{15}$$

The variable defined in (15) represents time devoted to investment in human capital, therefore, expression (10) may be rewritten as:

[12] Blinder and Weiss (1976) developed a model that takes special emphasis in corner solutions, defining four stages in lifetime: school, work and learning in the work, work and retirement. Their analysis does not include consumption behavior, that is our main target.

$$S_t = \left(\frac{\theta}{w} g_t \right)^{\frac{1}{1-\theta}} \qquad (10b)$$

Notice that because $\mu_T = 0$ and $g_T = 0$ should be complete, that is, at the end of the life, investment in training is null, because human capital loses its value.

Dividing expressions (8) and (9), we obtain that leisure-consumption ratio is an inverse function of human capital:

$$\frac{L_t}{X_t} = \frac{\beta p}{\alpha w H_t} \qquad (16)$$

This result implies the fulfillment, in each period, of the usual equality condition of marginal utilities pondered by prices. If real wage is relatively low, individuals have incentives to consume less goods and services respect to leisure, on the other hand, if it is relatively high, individual will consume more respect to leisure.

Reordering terms in (8), (9) and (16) we obtain that leisure and consumption of goods and services, are functions that depends upon age and human capital:

$$L_t = \left(\frac{\alpha}{p\lambda_0} \right)^{\frac{1}{\varepsilon}} e^{\frac{r-\rho}{\varepsilon}t} \left(\frac{\beta p}{\alpha w} \right)^{\frac{1+(\sigma-1)\alpha}{\varepsilon}} H_t^{-\frac{1+(\sigma-1)(\alpha+\gamma)}{\varepsilon}} \qquad (17)$$

$$X_t = \left(\frac{\alpha}{p\lambda_0} \right)^{\frac{1}{\varepsilon}} e^{\frac{r-\rho}{\varepsilon}t} \left(\frac{\alpha w}{\beta p} \right)^{\frac{1+(\sigma-1)\beta}{\varepsilon}} H_t^{\frac{(\sigma-1)(\beta-\gamma)}{\varepsilon}} \qquad (18)$$

where $\varepsilon = 1 + (\sigma-1)(\alpha+\beta)$.

Leisure is an inverse function of its price[13]. Five parameters are key in order to determine the life cycle profile of X_t: interest rate, r, discount rate, ρ, inverse of

[13] It would be possible the extreme case where $1+(\sigma - 1)(\alpha+ \gamma) < 0$. It would implies that leisure is an increasing function respect to human capital. To avoid it, we take values of α and γ small enough. We can do exactly the same with expression ε. Although empirical studies obtain estimators for the parameter σ equal or higher than one, we do not discard the

intertemporary elasticity of substitution, σ, and the weights of leisure and human capital in the utility function, β and γ, respectively. The casuistry for consumption according to relationships among the values of these parameters will be analyzed attentively later on. The shape of leisure, consumption of goods and services, and earnings profiles depend upon human capital, therefore, the following step must be to study the behavior of the investment in human capital and level behavior along the lifetime.

3. INVESTMENT IN HUMAN CAPITAL AND LEVEL

To know life cycle profiles of investment in human capital and level, the behavior of relative shadow prices, denoted by g_t, is crucial. On the contrary to Ben-Porath's (1967) and Heckman's (1976) models, the variable g_t depends upon H_o. In these models, accumulation of human capital depends upon the investment done by individuals, and upon depreciation of human capital. However, the behavior of g_t is independent from the level in human capital, which implies that two individuals having the same initial level in human capital invest exactly the same.

The estimates of earnings functions realized by Mincer (1974) and Díaz Serrano *et al.* (1998) observed that educational level is a key variable explaining earnings differentials, while earnings differences due to labor experience between workers belonging to different educational levels are not significant. If we assume that our model has only into account, human capital accumulation through *learning by doing*, the unique consistent case with this empirical evidence would be one where human capital is leisure augmenting in the utility function, because it would implies that the behavior of g_t is independent from H_0, assuming it as the individual educational level. On the other hand, if we assume that the model also includes a period of formal education at the beginning of life, we could accept that investment in human capital depends upon H_0.

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theoretical possibility that this could take lower values than one to obtain a richer analysis.

Combining expressions (4), (15) and (16), we make the following two-differential equations system, which allow us the join determination of relative shadow prices, equation (15), and temporal leisure trajectories:

$$\frac{\dot{L}_t}{L_t} = \frac{r-\rho}{\varepsilon} - \frac{1+(\sigma-1)(\alpha+\gamma)}{\varepsilon}\left(\left(\frac{\theta}{w}g_t\right)^{\frac{\theta}{1-\theta}} - \delta\right) \qquad (19)$$

where g_t is as in (15). This equational system allows us to make a phases' diagram in the space (g_t, L_t). We distinguish four cases according to the relationship between the weights of leisure and human capital in the utility function, β and γ, respectively, which affect to the phase's line defined by g_t=0.

Case 1: b = g

In this case, human capital acts like the Harrod´s neutral technical progress augmenting leisure in the utility function, as in Heckman's (1976) model.

Expression (15) does not depend upon leisure, but it is a nonlinear differential equation respect to g_t. Therefore, we cannot obtain the trajectory of this variable, and then, we must base ourselves in expression (19) to make a phases' diagram that relates the trajectories of relative shadow prices and leisure, jointly.

In order to check how many values of g_t cancel $F(g_t)$, we define the following auxiliary function:

$$F(g_t) = (r+\delta)g_t - w\frac{1-\theta}{\theta}\left(\frac{\theta}{w}g_t\right)^{\frac{1}{1-\theta}} - w \qquad (20)$$

It is easy to check that $F(g_t)$ has a maximum and takes a negative value, therefore, there is no positive value of g_t that cancels expression (20), that is, no phase's line exists. This analysis indicates that g_t falls strictly and L_t falls for high values of g_t, reaches a minimum, and hence increases until the end of life, as it is shown in Figure 1:

FIGURE 1

Case 2: b¹ **0,** g**= 0**

Human capital is not an argument of the utility function, that is, it does not have non-market benefits, as in Becker's (1975) model. In this case the phase's line defined by g_t=0 is:

$$L_t = 1 - \left(\frac{r+\delta}{w} g_t - \frac{1-\theta}{\theta} \left(\frac{\theta}{w} g_t \right)^{\frac{1}{1-\theta}} \right) \qquad (21)$$

The previous expression has a minimum for the following value of g_t:

$$\frac{r+\delta}{w} \tilde{g}_t - \frac{1}{\theta} \left(\frac{\theta}{w} \tilde{g}_t \right)^{\frac{1}{1-\theta}} = 0 \qquad (22)$$

Evaluating (21) in the critical point, we check that $\tilde{L}_t = 1 - \tilde{S}_t$, which implies $\tilde{W}_t = 0$. Higher values than $\tilde{L}_t$ imply W_t<0, and smaller values imply W_t>0. Therefore, as in the previous case, we can assure that the behavior of the variables is qualitatively the same, such as it is shown in Figure 2.

FIGURE 2

Case 3: b > g

Leisure weights up more than human capital in the utility function, therefore, human capital is a variable with own entity respect to consumption and leisure. This case is similar to the last one, but the phase's line defined by g_t=0 reaches a minimum in $\tilde{L}_t = \frac{\beta - \gamma}{\beta}(1 - \tilde{S}_t)$. Evaluating this phase's line in the minimum, we check that $\tilde{W}_t < 0$. Therefore, the optimal trajectory is qualitatively the same than in the previous cases, as it is shown in Figure 3:

FIGURE 3

Case 4: b < g

Human capital is a variable with own entity in the utility function, but utility-human capital elasticity is smaller than utility-leisure elasticity. In this case, relative shadow prices decrease strictly as individual ages, and hence we obtain the same qualitatively optimal trajectory than in the previous cases.

We conclude that, given an initial human capital, H_0, and a final null value for relative shadow prices, g_T, along the optimal trajectory, g_t falls strictly and L_t has a minimum in all cases. Therefore, the time devoted to training falls strictly with age, and human capital profile is strictly concave and has a maximum due to depreciation, as it is shown in Figures 4 and 5:

FIGURES 4 AND 5

Our model reproduces the typical results in the literature upon human capital accumulation over the life cycle. Time devoted to invest in human capital decreases with age for two reasons: first, the time until the end of life falls while individual ages, and hence also actual value of future returns falls. Second, investment costs in human capital increases with age because renounced retributions are increasing.

4. LEISURE, CONSUMPTION AND EARNINGS PROFILES

Now, we can analyze leisure, consumption and earnings profiles, because we know human capital life cycle profile.

As we have mentioned in section 2, leisure is an inverse function of human capital and, therefore, if this last one has a maximum, the time devoted to leisure will has a minimum, although not necessarily at the same age. If the interest rate is equal to the discount rate, leisure has a minimum at the same age where human capital reaches a maximum. If the interest rate exceeds discount rate, the minimum of leisure arises at an earlier age than the maximum of human capital, because a higher interest rate implies higher financial income and, therefore, the individual can stop sacrificing his/her leisure before than in the previous case. The opposite happens if the discount rate exceeds interest rate. This result coincides with Becker (1975). The casuistry is picked up in Table A and illustrated in Figure 6.

Table A. Behavior of leisure

$R = \rho$	$t_L = t_H$
$R > \rho$	$t_L < t_H$
$R < \rho$	$t_L > t_H$

t_L: age where leisure reaches a minimum

t_H: age where human capital reaches a maximum

FIGURE 6

The consumption profile depends upon the values taken by the parameters σ, ρ, r, β, and γ. All possible cases are summarized in Table B and illustrated in Figures 7a, 7b and 7c. Consumption may be a constant, and strictly increasing or decreasing function upon age, to reach a maximum or a minimum depending not only upon the values of intertemporary elasticity of substitution, interest rate and impatience rate, as in Becker (1975), but also on relative weight of leisure respect to human capital in the utility function.

If $\sigma=1$ and/or $\beta=\gamma$, the consumption does not depend upon human capital. When $\beta=\gamma$, we obtain Heckman's (1976) case, since the utility function includes consumption and time in units of efficiency devoted to leisure as arguments. If $r=\rho$, consumption is constant at each age; if $r>\rho$, it is stricly increasing, because the individual has incentives to postpone his/her consumption and to save, obtaining by this way larger financial income respect to the previous case; the opposite happens if $r<\rho$.

The consumption profile could has a maximum if $\sigma>1$ and $\beta>\gamma$, or if $\sigma<1$ and $\beta<\gamma$, which implies that consumption and leisure are substitutive one of each other, in the sense that the consumption is directly related with leisure's price. Contrary to Becker's (1975) results, despite that individuals prefers a smoothed consumption along his/her life, that is, $\sigma<1$, the profile of this variable could reach a maximum if human capital has a weight higher than leisure in the utility function. In this case, when the individual is younger prefers to accumulate more human capital, due to the reasons argued in the previous section, and then postpones his/her consumption.

It would be possible that the consumption profile had a minimum if $\sigma>1$ and $\beta<\gamma$, or if $\sigma<1$ and $\beta>\gamma$, it implies that leisure and consumption of goods are complementary one of each other, in the sense that demand for goods is an inverse function upon leisure's price. Although consumers prefer a smoothed consumption profile, it could reaches a minimum if human capital has a weight higher than leisure in the utility function.

If $r=\rho$, consumption reaches the maximum at the same age than human capital. If $r>\rho$ the maximum arises after than human capital, because the financial income is larger than in the previous case. If $r<\rho$, the maximum arises before than human capital. Exactly the opposite happens if consumption has a minimum.

The cases that seem to be empirically reasonable are those that imply a consumption-human capital elasticity, E_{XH}, null or positive, and a value of interest rate that exceeds impatience rate. As it is shown in Figure 7a, a null value of E_{XH} implies a consumption profile without critical points, besides if $r>\rho$ we obtain a profile as in the *life cycle hypothesis*. Figure 7b shows the three possible consumption profiles when this elasticity is positive and, therefore, the consumption depends upon wage at each age. In absence of uncertainty in future income, to explain the maximum observed in consumption profile through a positive relationship between consumption of goods and services and wage seems to be reasonable. A negative elasticity is unlikely, because estimations of consumption profile in the empirical studies do not show the existence of a minimum in any case.

Table B. Behavior of consumption

$\sigma = 1$	$r = \rho$	$\dot{X}_t = 0$
Y/o	$r > \rho$	$\dot{X}_t > 0$
$\beta = \gamma$	$r < \rho$	$\dot{X}_t < 0$
$\sigma > 1, \beta > \gamma$	$r = \rho$	$t_M = t_H$
O	$r > \rho$	$t_M > t_H$
$\sigma < 1, \beta < \gamma$	$r < \rho$	$t_M < t_H$
$\sigma > 1, \beta < \gamma$	$r = \rho$	$t_m = t_H$
O	$r > \rho$	$t_m < t_H$
$\sigma < 1, \beta > \gamma$	$r < \rho$	$t_m > t_H$

t_M: maximum for X_t
t_m: minimum for X_t

As it is shown in Figure 8, labor income profile is strictly concave and has a maximum. This result is contrasted enough by many empirical studies. If r=ρ and r<ρ, earnings reach a maximum after than human capital (see Table C). If r>ρ, earnings could reach the maximum at an earlier age than human capital, because the financial income is greater.

Table C. Behavior of labor income

$R = \rho$	$t_G > t_H$
$R > \rho$	$t_G > t_L$
$R < \rho$	$t_G > t_H$

t_G: maximum for G_t

5. AN EMPIRICAL ANALYSIS FOR SPAIN

Following the theoretical model developed in the first part of the paper, consumption demand could depends or not upon human capital, that is, could respond or not to wage period by period, and it is not necessary to introduce uncertainty in future income or imperfections in the credit market, as in Becker (1975). In this section, we check the results derived from our theoretical model, using data for the Spanish economy corresponding to the period 1990-91. Our aim is to verify if consumption and current earnings have a significant and robust relationship, once some variables as family characteristics or geographical factors have been taken into account, using for it a sample where all possible distorting elements are purged, as uncertainty in future income.

5.1. Description of the sample and variables

To carry out the econometric analysis we use the *family budget survey* (Encuesta de Presupuestos Familiares) for 1990 (EPF/90), from where we have taken yearly consumption and yearly earnings, besides other household characteristics. The EPF/90 is made to 21155 households around Spain. Nevertheless, in order to eliminate any distorting element for our estimates, we have discarded some households following some reasonable criteria.

As we have mentioned in previous sections, uncertainty in future income ought to be considered in the analysis, since many empirical works has shown that this factor affects seriously to consumption profile in the life cycle. Because EPF/90 does not include any information neither type of contract nor hours worked, it is impossible to make an efficient index that collects in an appropriate way uncertainty in future earnings. Due to this lack of information, we have eliminated from the sample all those households where uncertainty in earnings is likely to appears, and therefore to affect dramatically the consumption decisions.

In order avoid the uncertainty, and hence excessive dispersion in earnings[14], first we have selected households where the unique earner is male and salaried, then self-employees have been kept out[15]. Finally, we only haveincluded households where the household head is aged between 25 and 65[16]. The previous exclusions provide us a homogeneous subsample composed by 5954 households.

We have considered the definition of consumption given in the EPF/ 90 as an appropriate variable, since this survey does not consider spending in housing as consumption. Spending in housing is the most distorting, since the stronger investments in this sense are given when the individual is younger. Moreover, at younger ages this type of spending takes out a very important part of the individuals' budget. Contrary to many empirical studies, we have decided to keep consumption of durable goods, since it can be acquired at any age and it should not suposse an excessive part of the budget, as it is shown in the survey. Therefore, we think that to eliminate durable goods from consumption could create distortions in the consumption patterns. Despite that we have also considered the definition of salaried earnings given in the EPF/90, which refers to net yearly salaries, it has been necessary to transform them to gross yearly salaries. Therefore, our model relates yearly consumption upon gross yearly

[14] As it show in many empirical studies, the participation of woman in the labor market is intermittent along life cycle, the female work is also more precarious and has a lower remuneration than male work. See e.g. Rodríguez, Vera and Moreno (1995) for some empirical evidence in Spain.

[15] Generally, self-employees are quite heterogeneous among them, therefore, to include them in the sample could be an additional source of variability in earnings.

[16] Workers younger than 25 years old have a higher uncertainty in their future income, because at these ages labor contracts are very often temporary and precarious, as it is possible to check in the Active Population Survey for 1990 (EPA/90). Therefore, as in the previous case it is an aditional source of variability in earnings.

wages.

Following Ghez and Becker (1975), we take as the main factor of influence upon households consumption the yearly earnings, since these authors observed a strong relationship between consumption and earnings. For the Spanish case this relationship seems to be also feasible, since labor income and consumption profiles have a very similar behavior, reaching both variables a maximum in the same age interval, from 45 to 54 years old. Indeed, as it is shown in Figure 9, taking the age period from 35 to 65 years old, we check that consumption-earnings ratio is almost constant.

We also consider in the functional relationship a polynomial function of consumption upon individual's age. Moreover, age structure of households have been also taken into account, we denominate this as *demographic effects*. It would be reasonable to expect that these *demographic effects* may influence in a significant way the household consumption pattern, as Blundell, Browning and Meghir (1994) and Attanasio and Browning (1995) observed. In our analysis, the two variables upon the household composition characteristics are the number of members older than 18 years old, and the number of members younger than 18 years old.

Finally, the possible existence of *geographical effects* are also considered. In this sense, we control if consumption pattern differs significantly between geographical regions in Spain. To do this we use a set of dummy variables which take 1 if a household belongs to a certain region, and 0 otherwise.

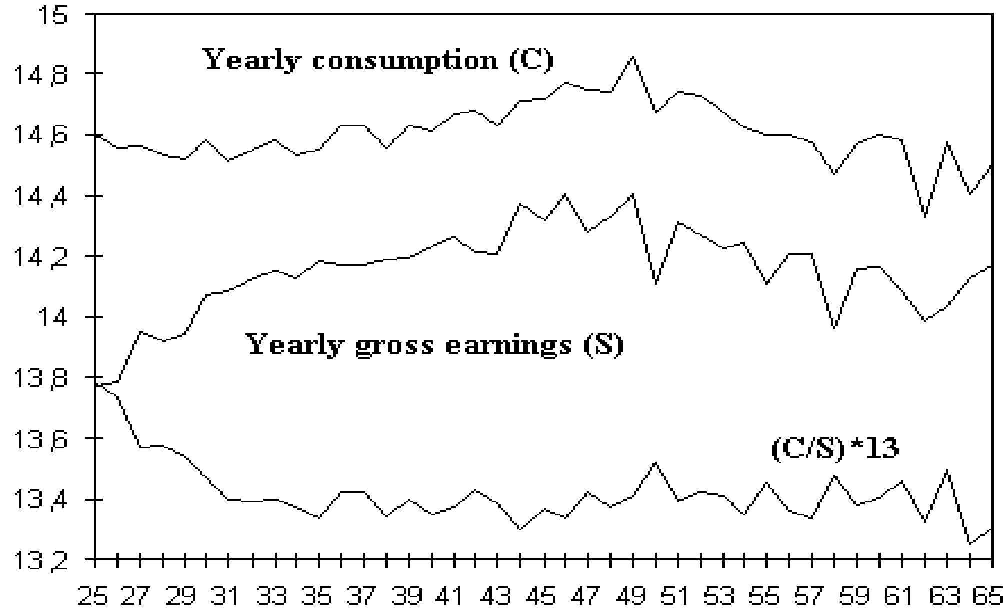

Fig. 9

5.2. The econometric model

In order to test the importance of the factors described above, we propose the following functional linear relationship

$$\log c_i = \alpha + \beta \log y_i + \Gamma X_i + \Lambda Z_i + u_i \qquad (23)$$

where c_i is the yearly consumption of household *i*, y_i are the gross yearly earnings of household *i*, X_i is a polynomial age function of the household head *i*, Z_i is a set of variables that collects *demographic* and *geographical effects* of household *i*, u_i is a random error term, and α, β, Γ, and Λ are parameters to be estimated.

In expression (23), now we have to determine what age polynomial function is more appropriate. Although in many empirical studies[17] has been observed that second degree polynomial function upon age is appropriated, in our case an age cubic function has been better.

5.3. Estimation methodology

To estimate equation (23), we use two different econometric methods. The first one based upon average effects (OLS), and the second one based upon the quantile regression, which estimates the parameters along the quantiles of the conditional log-consumption distribution.

The average effects estimation method, according to the assumptions upon the behavior of the random error term u_i, that is an homoscedastic structure[18], is based upon ordinary least squares (OLS) estimates. On the contrary, when such a behavior in the random error term is not given, it is necessary to look for an alternative estimation method. In life cycle models, it is usual that the basic assumptions for OLS estimates are violated, as for instance homoscedasticity.

Table 1 reports the variance of log-consumption according to different birth cohorts, where it is possible to observe that log-consumption has an increasing variance across birth cohorts. In order to check the absence of homoscedasticity, we use a test to verify that effectively variances across birth cohort are statistically different, thus as the White's test[19], which is a more consistent way to test the null hypothesis of homoscedasticity constancy. The chi-square statistics obtained in the tests are 171 and 52 respectively, which implies that the hypothesis of homoscedasticity does not hold, therefore in order to obtain efficient average effects estimates we use weighted least squares (WLS) estimation. The diagonal matrix containing the weights for WLS estimation of equation (23) is constructed with the variances reported in table 1, therefore we estimate the following weighted linear regression

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[17] See e.g. Attanasio and Browning (1995).

[18] Following these assumptions, the term u_i behaves as:

$$u_i \cong N(0, \sigma_i^2)$$
$$\sigma_i^2 = E(u_i^2) \qquad \sigma_1^2 = \sigma_2^2 = \ldots = \sigma_N^2$$
$$\sigma_{ij} = E(u_i u_j) = 0 \qquad \forall i \neq j$$

[19] See White (1980).

$$\frac{\log c_{ij}}{\sqrt{\mathrm{var}(\log c_{ij})}} = \frac{1}{\sqrt{\mathrm{var}(\log c_{ij})}}\left[\alpha + \beta \log y_{ij} + \Gamma X_{ij} + \Lambda Z_{ij} + u_{ij}\right] \qquad (24)$$

where the subscript *j* represents every birth cohort group.

On the other hand, as it has been suggested in many empirical studies, an estimation method based upon least squares misses relevant aspects of the endogenous variable distribution. By using quantile regression we can observe if the consumption-wage elasticity is the same or it is changing across all quantiles of the conditional log consumption distribution. The quantile regression method was introduced by Koenker an Basset (1978), and it may be taken as a simple minimization problem. Lets suppose a linear log-consumption function

$$\log c_i = \beta X_i + u_i \qquad (25)$$

with c_i the observed consumption for *i=1, 2, ..., N* households, X_i a set of exogenous variables for the same households, $\beta \in \Re^k$ an unknown parameters' vector, and u_i an unobserved random error term. Following Koenker and Basset (1978), the θth regression quantile, 0<θ<1, is defined as a solution of

$$\min_{\beta \in \Re^k}\left[\sum_{i \in \{i:\log C_i \geq \beta X_i\}} \theta |\log C_i - \beta X_i| + \sum_{i \in \{i:\log C_i \geq \beta X_i\}} (1-\theta)|\log C_i - \beta X_i| \right] \qquad (26)$$

and with the θth quantile of the conditional distribution of the log consumption given X, expressed as

$$Q_{\log C}(\theta|X) = \inf\{\log C | F_i(\log C|X) \geq \theta\} = \beta_\theta X_i \qquad (26)$$

with $F_i(\log C|X)$ the conditional distribution of the log wage upon a vector X.

The estimation procedure for the parameters in (26) is based upon the least absolute deviation (LAD) method. In order to capture the non-homoscedastic structure in the random error term dectected previously, to estimate the standard errors of parameters in (26) we use a method based upon bootstrap resampling of the variances and covariances matrix of the estimated parameters. Moreover, the bootstrap method provide us a high efficient estimated parameters.

5.4. Estimation results

Table 2 reports the results obtained by WLS estimation. Polynomial age function has been significant, thus as variables upon the household's composition, which are number of adults (aged upper 18), and number of non-adults (aged lower 18) controlling by this way the *demographic effects*, have been significant, revealing the importance of the household's composition expalining consumption over the life cycle. The fact that the value of consumption-earnings elasticity is practically unaltered from the simplest specification (model 1) to the model including all *demographic and geographical effects* (model 4) is remarkable. This results reveals that, although the household's composition is important explaining the household's consumption pattern, its explanatory power is not strong enough to change the value of consumption-earnings elasticity, exactly the opposite that other authors has found, since once family composition is included income losses relevance in the households' consumption, as it was observed in Attanasio and Brownin (1995).

Model 4 in table 1 incorporates the *geographical effects*, captured through dummy variables, one for each Autonomic Region. As the rest of effects considered, they have been significant. This last result is especially interesting for two reasons: first, the fact that all dummy variables are significant confirms that consumption pattern changes according to geographical location of the households. Second, this last inclusion of variables confirms that consumption-earnings elasticity is very robust, since the variation in this parameter after including the group of 17 regional dummies is almost null Therefore, although geographical effects, like demographic, are quite significant, once more the consumption-wage elasticity remains itself practically unaltered, which enforces the strong relationship between earnings and consumption argued and defended in this paper.

Table 3 reports the results obtained by quantile regression estimation. From these results we may obtain an interesting conclusions; first, once more the high significance of the consumption-wage elasticity across all quantiles in the log-consumption distribution, enforces the relationship consumption-wages. And second, since the consumption-wage elasticity is decreasing as we go up across the quantiles, that is, marginal propensity to consume is decreasing with income. It is due to in the lower quantiles of the consumption distribution, households spend a higher fraction of the wage in consumption, because a lower level of consumption has associated a lower level of earnings, and *vice versa*. Therefore, the amount of money spent in consumption by households in the lower quantiles of the consumption distribution are smaller than in the upper quartiles, however it represents a higher fraction of their earnings.

6. CONCLUSIONS

Many empirical studies have shown that conventional theory of consumption over the life cycle is not supported by the data, since the life cycle consumption profile has a maximum, instead to be strictly increasing. So, our main goal has been to construct a theoretical frame able to reproduce the results of life cycle models which do not appeal to the rupture of typical neoclassical assumptions, taking special attention upon the relationship between consumption of goods and services and investment in human capital along lifetime.

Our model reproduces the typical investment in human capital and level, leisure and earnings profiles in the literature. As far as the consumption profile, we obtain a quite wide casuistry. Our results collects Becker’s (1975) and Heckman’s (1976) findings. However, contrary to Becker’s (1975) model, our model reproduces the result of the *life cycle hypothesis* and the maximum in consumption profile for any value of the intertemporary elasticity of substitution by allowing human capital to be an argument in the utility function. And contrary to Heckman's (1976) model, our model allows to consumption profile to have a maximum.

The results derived from the empirical test of our model has corroborated the existence of a significant and robust relationship between consumption and the current earnings for the Spanish case, against the forecasts of the *life cycle hypothesis*. These test based upon the econometric estimates shows that household's size and the age of its components affect significatively to the consumption profile, but they do not rest significance to earnings. Therefore, it would be interesting to construct a theoretical frame that incorporates decisions on number of children, what leaves proposed for future research.

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Table 1
Description of age cohorts

Birth cohort	Sample Size	Average of log-consumption	Variance of log-consumption
1960-1965	922	14.5586	0.2596
1955-1959	1074	14.5486	0.2433
1950-1954	1024	14.6136	0.2594
1945-1949	1019	14.6813	0.2604
1940-1944	761	14.7601	0.2799
1935-1939	498	14.6739	0.3252
1930-1934	462	14.5606	0.3611
1925-1929	194	14.4779	0.3854
1925-1965	5954	14.6202	0.5313

TABLE 2
WLS estimates of equation (23)
(t-statistics in brackets)

	Model 1	Model 2	Model 3	Model 4
Constant	9.5729	12.5688	10.4605	10.5811
	(73.20)	(27.29)	(22.12)	(22.43)
Log(wage)	0.3563	0.3538	0.3555	0.3368
	(38.64)	(37.80)	(39.65)	(37.20)
Age		-0.2281	-0.0983	-0.1069
		(-6.89)	(-2.93)	(-3.24)
Age^2		0.0056	0.0023	0.0025
		(7.14)	(2.92)	(3.19)
Age^3		$-0.4\cdot10^{-4}$	$-0.2\cdot10^{-4}$	$-0.2\cdot10^{-4}$
		(-7.31)	(-2.92)	(-3.15)
Demographic				
Age≥18			0.1581	0.1617
			(21.93)	(22.56)
Age<18			0.0625	0.0703
			(10.96)	(12.36)
Geographical				
Andalucia				0.2223
				(4.07)
Aragón				0.2275
				(3.85)
Asturias				0.4062
				(6.31)
Baleares				0.3424
				(4.93)
Canarias				0.1163
				(1.93)

Cantabria	0.2627 (3.91)
Castilla-Mancha	0.2330 (4.23)
Castilla-León	0.2069 (3.64)
Cataluña	0.3909 (6.83)
C. Valenciana	0.2469 (4.36)
Extremadura	0.1243 (2.07)
Galicia	0.2336 (4.12)
Madrid	0.4804 (8.06)
Murcia	0.2292 (3.59)
Navarra	0.4149 (6.25)
País Vasco	0.3119 (5.47)
Rioja	0.2473 (3.67)

TABLE 3
Quantile regression estimates of equation (23)
(t-statistics in brackets)

	0.1	0.25	0.5	0.75	0.9
Constant	7.5457	8.8105	9.6635	11.9430	11.7563
	(6.76)	(18.64)	(14.32)	(18.64)	(18.29)
Log(wage)	0.4606	0.4097	0.3577	0.3144	0.2776
	(13.89)	(24.78)	(27.04)	(22.09)	(19.73)
Age	-0.0670	-0.0835	-0.0627	-0.1557	-0.0879
	(-0.95)	(-2.36)	(-1.49)	(-3.08)	(-2.01)
Age^2	0.0017	0.0019	0.0014	0.0036	0.0019
	(1.03)	(2.46)	(1.51)	(3.04)	(1.84)
Age^3	$-0.1\cdot10^{-4}$	$-0.1\cdot10^{-4}$	$-0.1\cdot10^{-4}$	$-0.3\cdot10^{-4}$	$-0.1\cdot10^{-4}$
	(-1.11)	(-2.55)	(-1.54)	(-3.00)	(-1.69)
Demographic					
Age≥18	0.1607	0.1658	0.1620	0.1509	0.1451
	(10.97)	(19.32)	(16.69)	(13.65)	(13.13)
Age<18	0.0993	0.0805	0.0589	0.0634	0.0428
	(7.79)	(11.64)	(7.65)	(8.28)	(4.83)
Geographical					
Andalucia	0.3232	0.3136	0.2321	0.1408	0.2819
	(4.07)	(3.61)	(4.67)	(2.03)	(2.59)
Aragón	0.3363	0.3521	0.2601	0.1374	0.2443
	(3.83)	(4.25)	(4.55)	(1.99)	(2.19)
Asturias	0.4976	0.5426	0.4238	0.3129	0.3780
	(4.92)	(5.42)	(6.55)	(3.86)	(3.44)
Baleares	0.3562	0.4050	0.3624	0.2894	0.4763
	(2.92)	(3.84)	(5.59)	(2.97)	(3.49)
Canarias	0.1744	0.1426	0.1702	0.0988	0.2469
	(1.94)	(1.44)	(3.17)	(1.22)	(1.96)

Cantabria	0.3354 (3.59)	0.3431 (3.64)	0.2778 (3.41)	0.1692 (1.53)	0.3850 (3.37)
Castilla-Mancha	0.3143 (4.11)	0.3215 (3.79)	0.2478 (4.71)	0.1585 (2.50)	0.3122 (2.91)
Castilla-León	0.3035 (3.39)	0.3015 (3.44)	0.2229 (3.63)	0.1565 (2.14)	0.3271 (2.89)
Cataluña	0.4486 (5.29)	0.4642 (5.21)	0.3893 (6.58)	0.3286 (4.64)	0.5245 (4.63)
C. Valenciana	0.2759 (3.23)	0.3236 (3.56)	0.2841 (5.72)	0.1935 (2.70)	0.3214 (3.01)
Extremadura	0.2019 (2.17)	0.2175 (2.58)	0.1807 (3.06)	0.0884 (1.22)	0.2670 (2.32)
Galicia	0.3580 (3.74)	0.3287 (3.87)	0.2558 (4.50)	0.1378 (2.12)	0.3051 (3.00)
Madrid	0.6159 (6.23)	0.5574 (6.19)	0.4888 (8.26)	0.3945 (6.17)	0.5153 (4.15)
Murcia	0.3868 (3.55)	0.3205 (3.42)	0.2259 (3.92)	0.1322 (1.59)	0.3377 (2.74)
Navarra	0.4668 (4.90)	0.5029 (4.85)	0.4102 (6.47)	0.3425 (4.13)	0.4936 (4.40)
País Vasco	0.4326 (5.41)	0.4169 (4.79)	0.3247 (5.89)	0.2482 (3.45)	0.3488 (3.30)
Rioja	0.3992 (3.67)	0.3316 (3.72)	0.2197 (3.67)	0.1269 (1.62)	0.3123 (2.58)