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ORIGINAL PAPER

# Joint estimation of intertemporal labor and consumption decisions: evidence from Spanish households headed by working men

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**Abstract**
The aim of this paper is testing the three first-order conditions of an intertemporal optimization model for a representative individual who chooses simultaneously for her level of consumption and leisure, assuming a separable utility function. We estimate these conditions jointly in a system of equations, using a Spanish pseudo-panel data set built by combining the Family Expenditure Survey and the Labor Survey over the period 1987–1997. Our results are in line with previous empirical evidence as regards the elasticity of intertemporal substitution for consumption, as our estimate for this elasticity is between 0.4 and 0.5. Further, we also obtain the first estimate for Spain of the intertemporal elasticity of leisure. This value is above 0.3, and is comparable to other estimates found for other economies.

**Keywords** Euler equation · Instrumental variables · Intertemporal substitution · Panel data

**JEL Classification** C33 · C36 · E21 · E24 · J22

## 1 Introduction

The empirical research on the elasticities of intertemporal substitution for leisure and consumption using the corresponding intertemporal Euler equations has provided disappointing results. On the one hand, the elasticity of intertemporal substitution for leisure using microeconomic data has traditionally produced very low estimates, as compared to the values used for this elasticity in the business cycle

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models (Keane, 2011; Chetty et al., 2011; Chetty, 2012). This discrepancy between the empirical evidence and the parameters considered in many theoretical macroeconomic models is a crucial question in the debate within both literatures and also for policy purposes[1] and has motivated a renewed effort to reconcile both facts (Chang & Kim, 2006; Rogerson & Wallenius, 2009). On the other hand, the estimation of the intertemporal elasticity of consumption have yielded quite poor results using macroeconomic data, and only those estimates using individual data provide positive and statistically significant values (see Hall, 1988; Thimme, 2016).[2]

The elasticity of intertemporal substitution for leisure measures labor supply responses to wage changes, a key determinant for the internal organization of labor within a firm. Similarly, the elasticity of intertemporal substitution for consumption measures consumption responses to the real interest rate and determines the allocation in time of savings and consumption. Both parameters have relevant policy implications, given that they determine the response of leisure, and so working hours, or consumption, to changes in wages and prices, respectively, which might be modified through tax policies such as the VAT, the income tax or the social security contributions.[3] There are different ways to obtain an estimate for these elasticities that vary according to the assumptions adopted in their analytical derivation. In this paper, we will estimate the so-called Frisch elasticities for labor supply and consumption using Spanish microdata. Frisch elasticities are derived using life cycle models under the assumption that the marginal utility of wealth is constant. We consider this is the most accurate approach to analyze the behavior of labor supply and consumption along the life cycle.[4] However, the traditional methodological approaches to estimate these intertemporal conditions (for leisure and/or consumption) ignore that individuals decide jointly (and simultaneously) about their intertemporal labor supply and consumption profiles. This might be due to either the limited results obtained in the first attempts to tackle this issue (see Mankiw et al., 1985, for the US economy, or Cutanda, 2019, for Spain).[5] The joint analysis of labor and consumption decisions for the Spanish economy has been traditionally limited

[1] As Chetty et al. (2011, p 471) point out, “micro estimates of intertemporal substitution (Frisch) elasticities are an order of magnitude smaller than the values needed to explain business cycles fluctuations in aggregate hours by preferences”.

[2] Hall (1988), using aggregate data, was unable to get a statistically significant estimate for this parameter. Further studies, also using aggregate data, obtain similar results as regards the intertemporal elasticity of consumption. Contrarily to these works, those using microeconomic data estimate a positive and statistically significant parameter, although generally below one, what indicates the appropriability of microdata in this respect (Attanasio & Weber, 1993).

[3] However, it is important to note that during the period of analysis, both the budgetary difficulties of the Spanish government made it very difficult to modify some of these taxes (either the VAT or the social security contribution) to incentivize employment.

[4] There are two further approaches to this concept: the Hicksian and the Marshallian elasticities. However, these depend on assuming that either the utility or wealth remain constant when wage is changing, respectively.

[5] However, the joint analysis of the consumption and leisure decisions is more realistic and provides better insights, as shown by recent available evidence (Lepage-Saucier, 2016; Lugilde et al., 2018, for the Spanish case).

by data availability.[6] Thus, previous research has analyzed only one of the two decisions, specially the consumption decision, as Cutanda et al. (2020).[7] In this paper, we try to overcome these drawbacks by jointly estimating the first order intertemporal conditions of the individual optimization program with microeconomic data.[8]

In recent years, the traditional empirical approach for the estimation of the elasticities of intertemporal substitution for leisure and consumption has experienced a new impulse as there are new attempts to estimate them. See for example Blundell et al. (1994), Imai and Keane (2004), or Attanasio et al. (2018), for the estimation of the elasticity of intertemporal substitution for leisure, or Thimme (2016), for the estimation of the elasticity of intertemporal substitution for consumption. Finally, there is also a renewed interest to study the effect of taxes both on consumption and labor supply, with the aim of explaining the different behavior of the U.S. and the European economies (see Silva, 2008).[9]

In this paper, we provide new evidence for the elasticity of intertemporal substitution for leisure and consumption, by analyzing the complete system of intertemporal optimization first-order conditions. We estimate the log-linearized version of the Euler equations for the individual optimization problem. Attanasio and Low (2004) and Alan et al. (2009) demonstrate, using simulation techniques, that the elasticity of intertemporal substitution might be consistently estimated by log-linearized estimation procedures using sufficiently large datasets. We consider that our empirical work lies in this category as we use a long (pseudo) panel with 41 quarters.

To jointly estimate the intertemporal labor supply and consumption decisions, implies using a data set with information on both individual consumption and hours worked (that would allow calculating wages). As there is not a microeconomic statistical source with these two basic pieces of information in Spain we will combine two available data sets that provide detailed information for these two variables. In particular, we combine the Spanish Family Expenditure Survey (the *Encuesta Continua de Presupuestos Familiares*, ECPF), that provides information on individual consumption and income, with information on individual labor supply from the Spanish Labor Force Survey (*Encuesta de Población Activa*, EPA). To combine these two data sets, we use pseudo-data panel techniques (Browning et al. 1985). Combining these two microeconomic data sets for Spain makes it possible to empirically analyze the intertemporal substitution of leisure and consumption.

As regards the estimation results, we get estimates both for the elasticity of intertemporal substitution for consumption and leisure in line with the empirical literature (below one in both cases), using a sample of working men. In relation

[6] Recently, a new survey has been launched in Spain (the Families Financial Survey, Encuesta Financiera de las Familias, EFF), which combines statistical information on both labor and consumption variables. However, these data are available every 3 years and the sample overrepresents wealthy households.

[7] Additionally, the main Spanish Labor Force Survey (*Encuesta de Población Activa,* EPA), does not provide information on wages or income, what complicates the empirical analysis of labor supply decisions.

[8] Cutanda (2019) uses aggregate regional data and does not obtain a statistically significant estimate for the elasticity of intertemporal substitution of leisure.

[9] See the influential survey by Keane (2011) on the empirical labor supply research.

to consumption, we obtain an elasticity between 0.4 and 0.5, that is in line with Cutanda et al. (2020).[10] For leisure we also get a statistically significant estimate for the elasticity of intertemporal substitution, above 0.3. We consider this is significant given that Cutanda (2019) obtained a non-significant estimate using Spanish regional data. Our results are comparable to the estimates obtained for other economies (Altonji, 1986; Blundell et al., 2016; MaCurdy, 1981). Further, this is a relevant result given the controversy in the values traditionally used for this parameter in business cycle macroeconomic models.[11] One of the reasons explaining the relatively lower aggregate elasticity for intertemporal substitution in Spain might be related to the high persistence of the unemployment rate and the high rate of temporary workers.[12]

The contribution of this paper is threefold. First, we add evidence to the intratemporal separability between consumption and leisure, as we estimate the two decisions jointly in a system. Considering this system, that combines the intra and intertemporal equations, involves assuming that the individual's decisions on consumption and leisure are taken jointly. We consider that this evidence is key given that the standard tests of intratemporal separability between consumption and leisure are excess of sensitivity tests, considered weak tests for this hypothesis. Moreover, our estimates allow also detecting differences with respect to the results of the traditional approach in the literature, consisting of estimating the intertemporal decision as single equations. Second, we provide the first estimate of the elasticity of intertemporal substitution for leisure for Spain. The estimate we obtain is statistically significant and in line with the values estimated for other countries. And, finally, our estimate is based in microdata. This is quite relevant, provided that in previous works, the main reason behind not being capable to estimate this parameter was the availability of appropriate statistical data.

The rest of the paper is organized as follows. In Sect. 2, we develop the theoretical model and discuss the main aspects related to the model. In Sect. 3, we present the data used and how we build the pseudo-panel data set. In Sect. 4, we report the results and in Sect. 5 we conclude.

[10] Our estimates for the elasticity of intertemporal substitution for consumption are larger than their estimates, what might be related to the fact that we use more homogeneous cohorts, and we have a more appropriate definition of expenditure to analyze the intertemporal elasticity of consumption.

[11] Our estimate for the Frisch elasticity is within the range of MaCurdy (1981) estimates (0.1–0.45) and Altonji (1986) estimates (0.08–0.54), which vary depending on the specification or the set of instruments used. Keane (2011) surveys 12 influential studies and reports an average estimate of 0.83 with a median estimate of 0.17, although these numbers are upward biased due to, at least, a clear outlier. More importantly, Chetty et al. (2013) conclude, from an exhaustive meta-analysis of fifteen empirical studies, that the mean extensive margin for the intertemporal elasticity of leisure is around 0.25.

[12] In the period we analyze, the Spanish unemployment and temporary average rates reached 17.19% and 30.17%, respectively. There is a broad consensus about the dual behavior of the Spanish job market, what is usually explained by the high rate of temporary workers, which reached values above 30% before the last crisis (see Dolado et al., 2002). It is expected that temporal workers restrict their intertemporal substitution of leisure, what might explain, at least partially, the lower estimated we obtain.

## 2 The intertemporal model and the empirical specifications

In our theoretical approach we follow MaCurdy (1981, 1983) who develops a basic life-cycle model of intertemporal labor supply. In this framework, it is assumed that individuals choose in each period consumption and leisure to maximize their expected life cycle utility function:

$$\max_{C_t,L_t} U = E_t \sum_{i=0}^{T-1} \beta^i u\left(C_{t+i}, L_{t+i}\right) \tag{1}$$

where $C_t$ and $L_t$, are non-durable consumption and leisure, respectively. In this model, the utility function $U$ is assumed to be intertemporally separable, and $u(.)$ corresponds to the utility in a specific period, assumed to be increasing and concave in its arguments. $E_t$ is the mathematical expectations operator conditional on the information set available in period $t$ and $\beta$ is the discount rate. This maximization is subject to the usual budget constraint:

$$A_{t+j+1} = R_t\left[A_{t+j} + W_{t+j}N_{t+j} - P_{t+j}C_{t+j}\right] \tag{2}$$

where $A_t$ is the individual's financial non-human wealth; $R_t$ is the nominal interest factor, or gross interest rate, $R_t = 1 + r_t$, where $r_t$ is the nominal interest rate;[13] $W_t$ is the wage per hour and $N_t$ is the number of hours an individual works in $t$; $C_t$ is the individual real consumption in period $t$; and, $P_t$ is the nominal price of a unit of $C_t$. $W_t$ as well as $P_t$ are assumed to be exogenous. We also assume, as usual, no legacies ($A_T = 0$), and perfect capital markets.

After defining a value function $V$, which represents the maximum utility expected by an individual in $t+1$, from consumption and leisure, according to the Bellman's optimality principle, the optimization problem is equivalent to the following expression,

$$V\left(A_t\right) = \max_{C_t,L_t} \left\{U\left(C_t, L_t\right) + \beta E_t V\left(A_{t+1}\right)\right\} \tag{3}$$

from where we get,

$$V'\left(A_t\right) = R_t \beta E_t V'\left(A_{t+1}\right) \tag{4}$$

that allows obtaining the following first order conditions,

$$\frac{W_t}{P_t}\frac{\partial u/\partial C_t}{\partial u/\partial L_t} = 1 \tag{5}$$

$$E_t \beta \frac{\partial u/\partial C_{t+1}}{\partial u/\partial C_t}\frac{P_t R_t}{P_{t+1}} = 1 \tag{6}$$

[13] We generically name $R_t$ as the interest rate.

$$E_t\beta\frac{\partial u/\partial L_{t+1}}{\partial u/\partial L_t}\frac{W_tR_t}{W_{t+1}}=1 \tag{7}$$

In an optimum, the fulfilment of these equations implies that individuals cannot increase their utility changing their consumption, or leisure, or both, given the values of the exogenous variables. It is important to note that, if (5) holds exactly in the data, one of the two remaining equations would be redundant (i.e., replacing (5) in (6), or in (7), we can obtain the other).

To derive the testable expressions, we need to specify a utility function. We follow MaCurdy (1983) and Mankiw et al. (1985), who propose a generalization of the CRRA utility function, widely applied in the empirical analysis of consumption, to incorporate leisure as an additional argument.[14] From this function, and given that we aim at testing the model with individual data, we add the effect of demographic variables (the vector $\theta_t$) using an exponential term, as follows:

$$u\left(C_t,L_t\right)=\frac{1}{1-\gamma}\left[\frac{C_t^{1-\alpha}-1}{1-\alpha}+d\frac{L_t^{1-\phi}-1}{1-\phi}\right]^{1-\gamma}e^{\lambda\theta t} \tag{8}$$

where $\gamma$, $\alpha$, $\phi$, λ and $d$ are all parameters to be estimated. Note that this utility function becomes additively separable in consumption and leisure when $\gamma=0$, which is the case traditionally considered in the empirical analysis of consumption (Zeldes, 1989). In expression (8), $1/\alpha$ is the elasticity of intertemporal substitution for consumption and $1/\phi$ is the elasticity of intertemporal substitution for leisure.

From the utility function (8), to obtain the empirical testable expressions, we take logs in the first order conditions and impose intratemporal separability between consumption and leisure. These expressions will be estimated using (cohort) data. Our empirical approach is different to Mankiw et al. (1985), as they use nonlinear estimators with aggregate U.S. data. After taking logs, we rewrite these equations adding an individual subscript and applying the rational expectations assumption in the usual way:

$$ln\left(C_{it}\right)=k_{os}+k_{1s}ln\left(L_t\right)+k_{2s}ln\left(\frac{W_t}{P_t}\right) \tag{9}$$

$$\Delta ln\left(C_{it+1}\right)=k_{oc}+k_{1c}ln\left(\frac{P_{it}R_t}{P_{it+1}}\right)+k_{2c}\Delta\theta_{it+1}+\varepsilon_{ict+1} \tag{10}$$

$$\Delta ln\left(L_{it+1}\right)=k_{ol}+k_{1l}ln\left(\frac{W_{it}R_t}{W_{it+1}}\right)+k_{2l}\Delta\theta_{it+1}+\varepsilon_{ilt+1} \tag{11}$$

[14] More recently, Bredemeir et al. (2019) apply a modified version of this utility function to the joint analysis of intertemporal consumption and leisure.

where $\varepsilon_{ict+1}$ and $\varepsilon_{ilt+1}$ are two error terms independent of all variables dated in $t$ or before. It is important noting, first, that our empirical model is static given that the dependent variables in Eqs. (10) and (11) are the growth rates of consumption and leisure, respectively (see Zeldes, 1989; Runkle, 1991). Further, all time invariant demographic variables vanish as the vector of demographic variables ($\theta_{it}$) enters in the specification in first differences. And, second, that the reduced form expressions for these coefficients are:

$$k_{os} = -\frac{1}{\alpha} lnd \quad k_{1s} = \frac{\phi}{\alpha}$$

$$k_{oc} = \frac{1}{\alpha} ln\beta \quad k_{2s} = k_{1c} = k_{2c} = \frac{1}{\alpha} \tag{12}$$

$$k_{ol} = \frac{1}{\phi} ln\beta \quad k_{1l} = k_{2l} = \frac{1}{\phi}$$

We will estimate both a system of two equations (Eqs. 10 and 11), and a system of three equations (Eqs. 9–11). The system of two intertemporal equations relate variables dated both in $t$ and in $t+1$, that are more appropriate to analyze intertemporal behavior. In the system of three equations we add the Eq. (9), that relates only variables dated in time $t$. Adding the intratemporal equation will allow checking whether the results obtained in the two-equation system change. Further, the estimation proposed will also let to detect intratemporal non separabilities between consumption and leisure.

From above, it is important highlighting that if the utility function is intratemporally separable in consumption and leisure, i.e., $\gamma=0$, $k_{1c}$ in (10) is the intertemporal elasticity of substitution for consumption and $k_{1l}$ in (11) is the intertemporal elasticity of substitution for leisure. Further, when estimating the complete system of equations, it is required to consider the restrictions between parameters imposed by Eqs. (12).[15] Only the elasticities of intertemporal substitution are exactly identified estimating the model, being these the parameters of interest in this study. It is important to state that almost all previous empirical research is based on the estimation of each equation considered in isolation, and not the full system of equations. Thus, the studies have ignored the restrictions across the equations in estimating the elasticities of intertemporal substitution for leisure or consumption, what might explain the disparity in the estimation results. We aim at verifying the consequences of accounting for these restrictions by jointly estimating the complete system of intertemporal equations using individual data.

[15] In particular, $k_{2s}=k_{1c}$, and $k_{1s}=k_{1c}/k_{1l}$.

Therefore, our empirical analysis, based on expressions (9), (10) and (11), is dependent on separability assumptions.[16] When utility is assumed to be intratemporally non-separable, the static intratemporal equation does not change in a significant way with respect to the expression (9), but the expressions for the Euler conditions, expressions (10) and (11), will both depend on consumption and leisure in $t$ and $t+1$.

To empirically test our model implies the fulfilment of the three above first order conditions. Thus, we need to assume no violations of the canonical model of intertemporal choice, such as, for example, liquidity constraints in the consumption equation, or involuntary unemployment in that of the labor supply.[17]

As we have stated above, the empirical strategy we will follow would imply estimating first a system of the two intertemporal conditions (for consumption and leisure) jointly. Second, we will incorporate the intratemporal condition in a three-equation system. Mankiw et al. (1985) stress that despite the properties of the static intratemporal equation, it is very unlikely that this equation holds exactly in the data. This indicates the importance to consider all the information provided by the three Euler conditions. Therefore, it seems sensible to jointly estimate the three equations. However, given that one of the equations is redundant, we can jointly estimate only two equations instead of estimating the complete system, and retrieve all the relevant parameters with only these two equations.[18]

In this paper, we will estimate Frisch elasticities for consumption and labor supply (see Frisch, 1959; Ayanian, 1969). A Frisch demand relates the quantity demanded to the marginal utility of income. The Frisch elasticities are considered the relevant ones in an intertemporal setting, given that the link between periods is the reciprocal of the marginal utility of lifetime wealth,[19] whereas the Hicksian and Marshallian elasticities are more appropriate for a static framework.[20] Hicks elasticity provides a lower bound for Frisch elasticity (Chetty, 2012) and, as Marshall

[16] It is important to underline that much of the empirical analyses of aggregate consumption, based on the expression (10), also assume separability, and, as emphasized by Mankiw et al. (1985), this weakness is aggravated by the fact that the aggregate analyses ignore the information provided by the expression (9). In this respect, Carrasco et al. (2004) find evidence of no intertemporal separabilities in Spanish intertemporal consumption behaviour.

[17] This would imply discarding households where the head is unemployed, what would have implications for the empirical sample used. There might be other individuals suffering (potentially) from liquidity constraints, such as young individuals with low income. To avoid this problem, we also discard individuals younger than 23 years in 1987. On the effect of borrowing constraints in the elasticity of intertemporal substitution of leisure, see Domeij and Flodén (2006) and Bredemeier et al. (2019).

[18] Mankiw et al. (1985) jointly estimate the three equations with aggregate data, rejecting systematically the test of over identifying restrictions. Cutanda (2019) also tests the three equations system with regional Spanish data without obtaining a statistically significant value for the intertemporal elasticity of substitution for leisure.

[19] Therefore, Frisch demands depend on observable within period variables and the marginal utility of wealth as the only variable outside the current period.

[20] These elasticities have been widely analyzed in studies researching the effect of changes in taxes on labor supply, both in a static (Eklöf and Sacklén 2000; Bloomquist et al. 2001) or in a dynamic context (Aaronson & French, 2009; Blundell & Walker, 1986; Ziliak and Kniesner 2005). See Browning et al. (1985) for the analytical relationship between them.

elasticity, can be retrieved from the static intratemporal equation, while retrieving Frisch elasticity requires to use the Euler conditions. In this sense, Attanasio et al. (2018) obtain the Frisch elasticity for labor supply from an estimation of the static intratemporal equation (similar to Eq. 9). However, Mankiw et al. (1985) established the difference between short and long run elasticities in an intertemporal setting. Our approach is similar to this last work. Keane (2011) provides a complete and updated survey of the results obtained in the literature for these different elasticities.

Further, in the analysis of the effect of wage changes on labor supply, it is important to distinguish between the intensive and extensive margins (Rogerson & Wallenius, 2009). The first refers to the change in hours worked in response to a wage change, while the second refers to changes in labor market participation. To face this issue, the common practice is to use sampling selection procedures to obtain a sample of individuals who a priori will not drop from the labor market (i.e., males in certain ages, who are head of their household and always work). We follow this approach, as explicitly considering the participation decision would be a troublesome issue in the empirical analysis (for example to analyze intertemporal female labor supply). There are very few studies addressing this issue, especially in the context of pseudo-panel data, and it has been addressed in its full complexity quite recently (Attanasio et al., 2018). Further, Blundell et al. (2018) consider a family labor supply approach that evaluates household decisions on leisure and working time for both spouses in the presence of children. Analyzing female labor participation is out of the scope of this paper, as this is a much more complex empirical exercise that we leave for future work.

As regards Eqs. (10) and (11), we will treat the variables $k_{ioc}$ and $k_{iol}$ as individual fixed effects, given that these terms include the unobservable discount rate, that might be potentially correlated with the regressors. This is not the case for $k_{os}$ in (9). For this reason, we will apply robust estimation techniques to account for this correlation. In particular, we apply the two-step generalized method of moments (GMM) to avoid this problem. Further, in these two specifications we will include a constant term, that could be interpreted as the *autonomous* discount rate, common to all the individuals in the economy. Finally, in the empirical analysis, we will test for the goodness of fit with a Hansen's test of overidentifying restrictions and for residuals second order autocorrelation.[21]

Finally, both expenditure and income might be (potentially) affected by measurement error. However, given the time span we have available (41 quarters) we consider that the intertemporal elasticities of substitution are consistently estimated (Attanasio & Low, 2004). Further, the usual procedure to obtain data on wages (when this variable is not available in the data set) is dividing income by hours worked, what might be another source of measurement error (Altonji, 1986). Thus,

[21] We have estimated the model using the *gmm* Stata command. This does not provide the first stage estimation results and the under identification and weak identification tests. The main reason to use it, instead of the *xtivreg2* command, is that we estimate the complete system of intertemporal equations. Nevertheless, to check that our results are not affected by a weakness instruments problem, we have verified that the fixed-effects estimates obtained by using the *xtivreg2* command are quite similar to the reported results, and are not affected by this problem.

to prevent measurement error problems we follow Griliches and Hausman (1986), and avoid using as instruments current values of income, expenditure, interest rates, hours, wages or any variable directly related to household's income level, such as the number of income earners in the household. However, we assume that the error term is first-order auto-correlated, what implies that we can use the second or further lags of these variables as instruments. As regards the demographic variables, we will consider them as exogenous, what allows using them directly (or lagged) as instruments.

## 3 The data

The aim of this research is to estimate the first order intertemporal conditions of a consumption-leisure optimization program with Spanish cohort data. For this purpose, one would need a statistical source with information both on individual consumption and hours worked (or wages). The main survey with panel information on consumption for Spain is the Family Expenditure Survey (*Encuesta Continua de Presupuestos Familiares*, ECPF). However, this data set does not have information on hours worked or wages. The only information on labor supply is whether any member in the household works more or less than one third of the usual weekly working hours. These data provide information on households' income, classified in different categories depending on the different sources of income. Information on income is aggregated at the household level and there is not detailed information about which member of the household earns that income.[22] As regards labor supply, we have the Spanish Labor Survey (*Encuesta de Población Activa*, EPA). This survey is not a panel data set, as one cannot track individuals across time. As this is a labor data survey, it does not provide information on individual consumption, income or wages.

To combine the information available from both statistical sources, we build the same pseudo-panel, using the age of the head of the household, in both surveys. Once we have the pseudo-panel in the consumption (ECPF) and labor (EPA) surveys, we merge both data sets. To build the pseudo-panel, we select in both surveys only those households with a male (not retired) being the only member receiving labor income. We discard households whose head is unemployed or self-employed. By applying this selection criteria, we guarantee that we can merge the labor income declared by these males in the ECPF with the hours declared (by the same males) in the EPA.[23] These two surveys have quarterly periodicity. As the first period is the first quarter of 1987 and the last one is the first quarter of 1997, we have 41 points

[22] Although it is possible to identify individual's income across appropriate sample selection, the problem we have to face is the loss of observations. The most obvious selection would be the sample of households composed only by one labor income earner.

[23] Lugilde et al. (2018) also discuss the lack of Spanish data for the jointly analysis of consumption and labor supply of the household.

in data.[24] The pseudo-panel we have constructed is composed by eight households of 5-year bands for the head of the household, being the minimum and maximum ages 18 and 57, respectively. However, in the empirical analysis we will only use six cohorts of 5 years bands for the age of the head of the household, being the minimum and maximum ages 23 and 52, inclusive, in 1987 (34 and 63, respectively in 1997).[25]

As regards the variables in both data sets, given that the definition and scope of the household's variables is standard in the ECPF, we have taken the variables directly from the survey. For wages, we follow the standard procedure in the literature and divide employees' income from the ECPF by the hours worked by employees in the EPA.

In the analysis of the response of labor supply to wage changes there are different approaches in the literature. First, there are obvious differences in the analysis of male or female labor supply; and, second, the analysis in an intertemporal setting is also different from the analysis in a static one. In our case, given the statistical sources available in Spain, and the period considered, we cannot analyze female labor supply as this would imply reducing quite importantly our sample.[26] Further, the fact that the ECPF only collects household's income implies that we should, in principle, consider household's labor supply in a similar manner to Blundell and Walker (1986). However, given the available sample sizes in the ECPF, it is possible to select only those households where the head of the household is a non-self-employed male and his wife or any other household member is not working;[27] we have also discarded all households whose head declares to be unemployed or retired. Thus, with this fairly adjusted profile, we consider we are able to examine the Spanish male labor supply, which sounds sensible given the limited female participation in the labor market during the analyzed period.[28]

[24] It is important to notice that our period includes the 1992 recession that occurred between two long expansionary phases for the Spanish economy.

[25] We have applied all the usual filters in this kind of studies. In this sense, we have discarded households with no data in expenses, income, hours of work or any other sensible variables, both in the ECPF or EPA. Also, following the usual practice, in the ECPF we have withdrawn all households with income in the first and last percentile of the distribution.

[26] It is important to recall that the period considered in our analysis is characterized by a very low rate of women participation in the Spanish labor market, for different historical reasons. This, combined with the fact that we use pseudo-panel data techniques that require a relatively high sample size (to reduce the impact of measurement error problems in the cohorts), makes the analysis of Spanish female labor supply unfeasible for these years.

[27] Also, and for similar reasons, Lugilde et al. (2018) restrict their sample to households where the reference person is an employee, although they do not impose any requirement on the labor status of the partner. However, we are aware of the relevance of the household perspective for labor decisions (Duguet and Simonnet 2007; Apps and Rees 2010; and more recently, Blundell et al. 2016 and 2018).

[28] The average size of the sample of households whose head is a labor income woman in the period is 74. We have also tried other samples. For example, we have selected married couples where both members are working, in an attempt to analyze household's labor supply, however this is not viable due to the downfall in the average cohort size (the average number of individuals in the ECPF cohorts drops between 40 and 50%). In a second attempt, we also checked the possibility of including self-employed males in our sample. But we abandoned this option, as the gain associated with the increase in the average size of the cohorts did not compensate the problems we had to face due to the lack of sample homogeneity.

Table 1 presents the average size of the number of individuals in the two pseudo-panels constructed in our study. The numbers we get are within the usual figures in this literature, especially in the reduced pseudo-panel (cohorts 2–7). We had to apply a quite strict sample selection criteria to assure that we properly calculate the wages we use in our empirical approach.[29]

In what follows we describe the variables we use in estimation (see Table 4 in the Appendix for a description of these variables). Consumption is measured as the sum of total non-durable expenditures (expenditures in food, beverages and tobacco; petrol, fuels and lubricants; heating, lighting and water distribution; transport services and mail and communications). The nominal wage has been obtained dividing the head of the household's quarterly labor income, obtained from the ECPF, by the effective hours declared in the EPA. The quarterly leisure hours have been computed by subtracting the effective hours worked from the total number of available hours. The number of available hours is calculated as the number of days in the quarter multiplied by 16 h. And the effective hours worked are the weekly effective hours declared in the EPA multiplied by 12.

As for the price index, we calculate a Stone price index for each cohort in the sample using the expenditure categories considered. We use a nominal interest rate for the Spanish bank deposits, following Cutanda et al. (2020). Although the nominal interest rate does not change across cohorts, the real interest rate does as we have variability in the cohort price index.

Finally, we have estimated the model using the Generalized Method of Moments and we instrument all variables that potentially might suffer from endogeneity problems or by measurement error, using at least their second lag. Further, in all the specifications estimated, we provide the results for the Hansen's test of overidentifying restrictions and we have tested for the second order autocorrelation using the Cumby and Huizinga test, given that the estimator might produce first order autocorrelation of the residuals.[30]

## 4 Empirical results

In this section we present the estimation results for the different specifications discussed above. We start providing the results attained from the joint estimation of the two intertemporal specifications (using a system of two equations), and the two intertemporal specifications together with the intratemporal specification (using a system of three equations).

[29] This selection issue is quite standard in this literature. For example, the sample used in MaCurdy (1983) has 121 individuals, and in Blundell and Walker (1986) it amounts to 1378 individuals. These sample numbers could suggest to tackle some sort of the sample selection correction. However, Keane (2011, p 977) points out that it is common in this literature "to ignore selection on the grounds that the large majority on adult non-retired do participate in the labor market", differently to what happens in the female labor supply literature.

[30] We would like to note that our results do not change when we estimate the model demeaning the data to eliminate the fixed effects. These results are available upon request.

**Table 1** Average number of individuals within each age cohort

| N. of Cohort | Age of head of house. in 1987 | Age of head of house. in 1997 | ECPF | EPA |
|---|---|---|---|---|
| 1 | 18–22 | 29–33 | 41 | 622 |
| 2 | 23–27 | 34–38 | 94 | 1373 |
| 3 | 28–32 | 39–43 | 118 | 1876 |
| 4 | 33–37 | 44–48 | 126 | 1988 |
| 5 | 38–42 | 49–53 | 116 | 2133 |
| 6 | 43–47 | 54–58 | 82 | 1868 |
| 7 | 48–52 | 59–63 | 58 | 1622 |
| 8 | 53–57 | 64–68 | 47 | 1288 |
| Mean 1–8 | | | 85 | 1596 |
| Mean 2–7 | | | 99 | 1810 |

1. In the ECPF we select only households whose head is a man and has income as employee (i.e., we discard all households whose head declares to be self-employed, unemployed or pensioner), and whose wife does not have an income as employee or as self-employed. In the EPA we select male households whose head declares to be an employee and whose wife declares not to be

2. Our estimation sample is composed by cohorts 2–7, that are framed in the table

We start with the discussion of the results obtained in the two intertemporal conditions (for consumption and leisure) system, see Table 2.[31] As stated above, one of the equations in our model is redundant. Then, as we are primarily interested in intertemporal allocation we leave out the intratemporal equation. We report two sets of results: one with a set of education level variables (column 2) and one without these variables (column 1). As regards the intertemporal elasticities estimated, we obtain an elasticity of intertemporal substitution for consumption (*EISC*) about 0.579 (and statistically significant) in the specification with the educational variables (column 2). This estimate is pretty similar to that obtained by Cutanda et al. (2020) estimating the intertemporal Euler equation for leisure separately for Spain. Further, it is interesting noting that our result is in accordance with the empirical results obtained for the *EISC* for different economies with individual data, in particular for the U.S. and the U.K. (Thimme, 2016).

As regards the estimate for the elasticity of intertemporal substitution for leisure (*EISL*), we get estimates bigger than 0.3 (and statistically significant) in both cases. This result suggests that individual data are better fitted than aggregate data to estimate the *EISL*, given that Cutanda (2019) estimated a non-reliable parameter for the *EISL*, using Spanish regional data.[32] The constants for the intertemporal conditions of consumption and leisure are not statistically significant, except in the

[31] In Table 2, the Hansen tests reported refer to the whole system, not to a single equation.

[32] Similarly to Mankiw et al. (1985) for the U.S., Cutanda (2019) obtained a very unstable estimate with the wrong sign.

**Table 2** Intertemporal consumption and leisure system

$$\Delta ln\left(C_{it+1}\right) = k_{oc} + k_{1c}ln\left(\frac{P_{it}R_t}{P_{it+1}}\right) + k_{2c}\Delta\theta_{it+1} + \varepsilon_{ict+1}$$

$$\Delta ln\left(L_{it+1}\right) = k_{ol} + k_{1l}ln\left(\frac{W_{it}R_t}{W_{it+1}}\right) + k_{2l}\Delta\theta_{it+1} + \varepsilon_{ilt+1}$$

| | (1) | (2) |
|---|---|---|
| Constant consumption ($k_{oc}$) | – 0.081 (0.091) | – 0.164 (0.107) |
| EISC ($k_{1c}$) | 0.483 (0.735) | 0.579* (0.284) |
| Constant leisure ($k_{ol}$) | – 0.059* (0.020) | – 0.133 (0.096) |
| EISL ($k_{1l}$) | 0.314*** (0.096) | 0.332*** (0.088) |
| Age head | 2.561*** (0.728) | 2.205*** (0.530) |
| Age head squared | – 0.029*** (0.008) | – 0.025*** (0.006) |
| Number of members | – 0.820*** (0.273) | – 0.656*** (0.194) |
| Number of adults | 0.097*** (0.021) | 0.091*** (0.020) |
| Pre-school and/or primary education | – | 0.970** (0.409) |
| High School | – | – 0.146 (0.147) |
| College | – | 0.427 (0.348) |
| N. observations | 228 | 228 |
| Test overidentifying restriction | | |
| Hansen's J Chi2(1) | 3.399 | 6.348 |
| *p*-value | 0.846 | 0.785 |
| Cumby-Huizinga test for 2º order correlation | 0.267 | 9.079 |
| EQ 1 p-value | 0.605 | 0.002 |
| EQ 2 p-value | 0.238 | 8.486 |
| | 0.626 | 0.002 |

Notes for Tables 1 and 2: 1. For estimation of both systems of equations, we instrument specification (1) by the second and third rate of the interest rate and the rest of covariates, and in the case of specification (2) we use the same set substituting the interest rate by the real interest rate obtained with wage inflation

intertemporal condition of leisure in the specification without the education level variables. In relation to the demographic variables, we get that all are statistically significant. We obtain the variables *Age of the head* and *Number of adults* have a positive impact, whereas *Age of the head squared* and the *Number of members in the household* have a negative impact. With respect to the education level dummies, we get that only one of them is statistically significant, and with a positive sign.

In relation to the fit of the model, we obtain quite satisfactory significance levels for the Hansen tests (over 75%). However, as there is not a formal test for the second order autocorrelation of the residuals for the entire system, we have applied the test to each equation separately, obtaining that in the specification without the educational variables we do not face a problem of second order correlation, but we do in the extended specification.

In a second exercise, we estimate the elasticities obtained using a system of three equations, imposing all the restrictions between parameters of the model. These results are presented in Table 3 and are directly comparable with those reported in Table 2 (a system with the two intertemporal equations). In the estimation of the

**Table 3** Intertemporal consumption, leisure and intratemporal equations system

$\Delta ln\left(C_{it+1}\right) = k_{oc} + k_{1c}ln\left(\frac{P_{it}R_t}{P_{it+1}}\right) + k_{2c}\Delta\theta_{it+1} + \varepsilon_{ict+1}$

$\Delta ln\left(L_{it+1}\right) = k_{ol} + k_{1l}ln\left(\frac{W_{it}R_t}{W_{it+1}}\right) + k_{2l}\Delta\theta_{it+1} + \varepsilon_{ilt+1}$

$ln\left(C_{it}\right) = k_{os} + k_{1s}ln\left(L_t\right) + k_{2s}ln\left(\frac{W_t}{P_t}\right)$

| | (1) | (2) |
|---|---|---|
| Constant consumption ($k_{oc}$) | – 0.129*** (0.018) | – 0.213* (0.094) |
| EISC ($k_{1c}$) | 0.885*** (0.074) | 0.877*** (0.071) |
| Constant leisure ($k_{ol}$) | – 0.060*** (0.019) | – 0.150 (0.095) |
| EISL ($k_{1l}$) | 0.328*** (0.091) | 0.370*** (0.086) |
| Constant ($k_{os}$) | – 15.749*** (5.166) | – 15.603*** (5.151) |
| Log leisure | 3.124*** (0.758) | 3.106*** (0.755) |
| Age head | 2.452*** (0.691) | 2.149*** (0.529) |
| Age head squared | – 0.028*** (0.008) | – 0.025*** (0.006) |
| Number of members | – 0.801*** (0.259) | – 0.635*** (0.193) |
| Number of adults | 0.092*** (0.020) | 0.082*** (0.019) |
| Pre-school and/or primary education | – | 0.978*** (0.406) |
| High School | – | – 0.126 (0.146) |
| College | – | 0.468 (0.342) |
| N. observations | 228 | 228 |
| Test overidentifying restriction | | |
| Hansen's J Chi2(1) | 8.379 | 11.048 |
| *p*-value | 0.679 | 0.682 |
| Cumby-Huizinga test for 2° order correlation | 0.242 | 8.877 |
| EQ 1 p-value | 0.622 | 0.003 |
| EQ 2 p-value | 0.252<br>0.615 | 8.774<br>0.003 |
| EQ 3 p-value | 21.650<br>0.000 | 22.008<br>0.000 |

three-equation system we do not include as a covariate the logarithm of the real wage of the intratemporal condition, as by definition, this parameter is equal to the parameter of the logarithm of the real interest rate in the intertemporal condition for consumption. The estimated *EISC* in the three-equation system are higher than the estimates we get in the two-equation system. Now, we get a parameter for the *EISC* about 0.89, whereas this estimate is about 0.5 in the intertemporal equation for consumption in the two equations system (see Table 2). Further, we get that the constant for the intertemporal consumption equation in the three-equation system is larger and statistically significant. As regards the intertemporal equation for leisure, we get very similar values for the *EISL* in both sets of estimates. Finally, the Hansen test performs quite well and the second order autocorrelation test provides good results for the two intertemporal equations (in those specifications in which we do not include the education variables).

## 5 Conclusion

In this paper we have estimated the first order conditions of an intertemporal optimization labor supply-consumption model jointly using a system of (two and three) equations, with the aim of estimating the two elasticities of intertemporal substitution (for consumption and leisure). The elasticity of intertemporal substitution for leisure is a key parameter for the internal organization of labor within a firm as it measures labor supply responses to wage changes. Analogously, the elasticity of intertemporal substitution for consumption measures consumption responses to the real interest rate and determines the allocation in time of saving and consumption.

To empirically estimate these two elasticities, we use a Spanish cohort data set constructed by combining the information of two different statistical sources, the ECPF and the EPA, as there is not any statistical source with complete individual information on consumption and labor. The results we obtain for the Spanish elasticity of intertemporal substitution for consumption, that we estimate about 0.4/0.5, are in line with previous empirical available evidence. Further, we get an estimate for the elasticity of intertemporal substitution of leisure above 0.3, which is similar to values estimated in other countries with similar samples (households where the head is a man who is always working). These results ratify that there is scope to modify the Spanish consumption and employment behavior by changing the relative intertemporal prices and wages through fiscal policy, confirming the results in Silva (2008).

Our results show that to empirically estimate these structural parameters is quite troublesome and complex. This is so as even assuming a standard separable utility function, the estimation of the intratemporal (static) first order condition usually produces different estimates to those obtained in the intertemporal first order condition for consumption. This should not be surprising, as the elasticity of intertemporal substitution for consumption reflects the behavior of consumption across time, whereas the static condition captures the joint labor supply-consumption decision in a single period. Therefore, we estimate the elasticities of intertemporal substitution for consumption and leisure jointly in two equation system and together with the intratemporal (static) condition, in a system of three equations imposing all the restrictions between parameters of the model.

Summing up, our results indicate, first, that combining the intertemporal conditions for consumption and leisure in a system of two equations and estimating them jointly, allows attaining more reliable estimates for both intertemporal elasticities. Second, we find that the intertemporal elasticity of leisure we estimate for the Spanish economy is in line with the values obtained for other economies with microeconomic data. Further, this estimate is supported by the calibrated value used in business cycle models for the Spanish economy. See, among others, Boscá et al. (2010), who use 0.5 as the calibrated value and Sánchez-Romero et al. (2018), who use calibrated values between 0.218 and 0.442, depending on the level of education. Third, our estimate for the intertemporal elasticity of consumption is also in line with the values obtained for other economies and in previous works for the Spanish economy. Finally, our results suggest the superiority of using individual data to jointly estimate the system of intertemporal conditions, as compared to previous attempts to estimate them with aggregate data.

We also consider that our estimates might have relevant policy implications. Provided that the intertemporal elasticities of substitution measure the response of either consumption or leisure to the real interest rate, our estimates might help policy makers in designing a taxing policy that changes the gross nominal interest rate by modifying the nominal wage or consumption prices. Thus, according to our results, a one percent change in the real interest rate will produce a reaction around 0.5% (0.3/0.4%) in the rate of growth of consumption (leisure, or working hours).

Our work has also some limitations. The results we provide are based on important assumptions, especially those needed to build the required sample by combining two different statistical sources. Further, we had to limit our sample to households with working men and with only one-man income earner, in order to get a sufficiently homogenous sample. This implied excluding from the analysis important groups of the population, such are unemployed or retired, for which our model would not be appropriate.

Finally, we would like to highlight that the results we obtain pose interesting questions that need to be clarified in future empirical research. The different results obtained in the estimation of the two-equation system, as compared with those obtained in the three-equation system, reinforce this conclusion. While the two intertemporal conditions system produce similar estimates for the elasticity of intertemporal substitution for leisure, in the three-equation system we obtain a different estimate for the elasticity of consumption. This points to the need to jointly estimate both types of elasticities accounting also for the intratemporal condition.

## Appendix

See Table 4.

**Table 4** Variables used in the analysis

| | |
|---|---|
| $C_{it}$ | Non-durable consumption |
| $N_{it}$ | Worked hours |
| $L_{it}$ | Leisure hours |
| $W_{it}$ | Wage per hour |
| $W_{it}N_{it}$ | Labor income |
| $P_{it}$ | Nominal price of a unit of $C_{it}$ |
| $R_{t=}1+r_t$ | Nominal interest rate |
| $\theta_{it}$ | This is a vector of demographic variables. In particular, we include the number of members of the household, the number of adults of the household (individuals 14 years old or older), and a set of educational dummies (pre-school and/or elementary education; high school; and, college). The omitted educational category is middle school |

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**Availability of data and material** All the data used in this study are publicly available in the following page webs of Spanish public entities: https://www.ine.es/, for the ECPF and the EPA. https://www.bde.es/bde/es/, for the interest rate used.

**Declarations**

**Conflicts of interest/Competing interests** The authors declare that they have no conflict of interest.

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