Tesi Doctoral

Essays on Time Allocation

A thesis presented

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"It is merely human nature that we overrate the importance of our own types of research and underrate the importance of the types that appeal to others. Perhaps it is not too much to say that we should never do what we are doing, both in science and in other pursuits of life, if we did not do this."

Joseph A. Schumpeter

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Contents

Preface

This thesis studies from the theoretical and empirical points of view the allocation of time by part of rational individuals motivated by technological changes in the economy. It is organized as follows. Drawing upon the labor market viewpoint of Lucas and Rapping (1969), the first two chapters are respectively concerned with the life-cycle allocation of labor effort by part of prime-age males and females, and they seek to ask for the attention over a topic of research that seemed closed from the mid 1980's: the importance of alterations in the price of goods to the intertemporal allocation of market work. The third chapter, by assessing how the distribution of time to different pursuits—market work, child rearing, and recreation—may be affected by a number of technological changes in the economy, aims at making a contribution to the determinants of human fertility in the era following malthusian stagnation. A final section summarizes the main lessons and discusses possible directions for future research.

Although it has always been a significant topic of research in Labor Economics, the economists' increasing awareness of the importance of considering the time allocated to different activities—market work, commuting, child care, etc.—in describing and modeling individual and household behaviour, has motivated both the growing availability of time-use surveys—collected, for instance, in Australia, Canada, the E.U., Japan, New Zealand, and the U.S.—, and the upsurge of a greatly heterogenous literature making descriptive, analytical, and methodological contributions on this issue.[1] These essays are to be framed in this wave of interest.

Regarding the analysis of time, it is fundamental to clarify from the beginning a conceptual and operational issue: the definition of the categories in which the economic agent's time is partitioned. For instance, the category *leisure* (see Wilson [1980]) may be treated either as a portion of one's time or as a quality of experience unconfined to particular times. In this thesis, we conform with the first view, that we may call the *objective view*. To objectively measure how one's time is partitioned, however, it is necessary an *a priori* classification of human activities into particular categories like, say, market work, recreation, household production, and personal care. We proceed the analysis as if these categories of time were firmly established, even though their definition is currently under debate.[2]

A succession of activities in which goods and time are combined to get the highest possible degree of satisfaction, could be an adequate definition of our life from an economic point of view. As a consequence, a change in the price of goods purchased to carry out some activity, could reallocate the distribution of time across the whole set of activities. This is

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1 A milestone of this literature is Juster and Stafford (1985). More recent surveys are Juster and Stafford (1991) and National Research Council (2000). A lot of research effort has been devoted to the documentation of descriptive patterns of individual or group behaviour: see, besides the previous references, Robinson and Godbey (1997), Bittman and Wajcman (2000), and Gronau and Hamermesh (2003), among many others. The investigation of the role of time in behavioural models of market and nonmarket activities has been the object of many other contributions: they range from enhancing the coverage of the social accounting systems (see Landefeld and McCulla [2000]), to a better understanding of transitions from market work to retirement (see Coile [2003]), or even the assessment of how public policies affect individual's well-being (see Del Boca [1997]). Last, but not least, the discussion of conceptual, measurement, and survey dessign issues is another important topic of research: an excellent survey for this literature is National Research Council (2000, Ch. 3).

2 See, for instance, National Research Council (2000, Appendix C) with the *Proposed Coding System for Classifying Uses of Time for the Proposed BLS Survey*.

the starting idea of Chapters 1 and 2. A change in the relative price of some consumption goods might be generated by a change in their relative productive efficiency. Although this feature is not explicitly modeled until Chapter 3, it underlies the first two chapters and unified them with the third one.

In the first chapter, by conceiving leisure time and goods consumed in conjunction with leisure time—recreation goods—as non-separable in the preference ordering of the individual, we extend a standard individualistic model of intertemporal choice to analyze the effect caused by the relative price of recreation goods on the allocation of market time over the life-cycle. For the U.S., individual-level data is combined with price indices of recreation goods at the level of Metropolitan Areas to estimate the elasticity of intertemporal substitution of market time with respect to the price of recreation goods. Its estimated positive sign evidences that prime-age males change the age at which they recreate more readily than they modify the type of recreation activities consumed, what might be due to the existence of habits in the consumption of recreation. Its estimated magnitude brings out another margin of substitution of work effort along time that seems of relevance for business cycle and growth theory.

Based on the model developed in the first chapter, Chapter 2 studies from an empirical point of view the effect exerted by the price of recreation goods on the intensive margin of female labor supply. To consistently estimate the parameters of the labor supply function, an extension of the Wooldridge (1995) estimator controlling for unobserved heterogeneity, selection bias, and measurement error is utilized. The female elasticity of intertemporal substitution of market time with respect to the price of recreation goods is found to be larger, in absolute value, than the male one. Besides, on the contrary than males, females are more readily to modify the sort of recreation activities consumed than to change the age at which they recreate. This noteworthy gender difference in recreational behaviour might be indicating that, on average, women have more options and/or engage in more varied recreation activities than men, an interpretation that would agree with the findings in Robinson and Godbey (1997, Ch. 13) and Coile (2003), for instance.

In the beckerian tradition, the third chapter displays a general equilibrium model of optimal allocation of time in which children are considered consumption goods whose production requires time. We discuss a series of channels of causation through which technological progress in the economy might be determining the allocation of time to different activities and, therefore, affecting the level of fertility. Apart from the usual sort of technological progress considered in models explaining the evolution of human fertility in the post-malthusian era,[3] the model laid out in this chapter emphasizes the roles of the expansion in the variety of recreation goods and of the existence of technological imbalances across sectors of production as new sources of movements in fertility. We study the evolution of the U.S. fertility during the twentieth century in the light of our model, finding that, for a plausible range of parameter values, the price of recreation goods might contribute to the explanation of the surprising recovery in U.S. fertility known as the baby boom.

3 See, for instance, Galor and Weil (2000).

Chapter 1 of my Ph D. thesis is based on the following article:

González Chapela, J. On the price of recreation goods as a determinant of male labor supply. Journal of Labor Economics 2007; 25(4):795-824.

Chapter 1
On the Price of Recreation Goods as a Determinant of Male Labor Supply

1.1 Motivation

This chapter examines whether the price of goods consumed in conjunction with leisure time—henceforth called recreation goods—influences the life-cycle allocation of time devoted to work in the market by part of prime-age males.[4]

The neoclassical economic analysis of time as an *input* in the satisfaction of human necessities started with the works by Mincer (1962) and Becker (1965). From these seminal contributions, the analysis splitted up into different lines of research. Within a static framework of analysis, economists estimated the elasticity of demand of time devoted to consumption purposes—labeled as consumption time—with respect to the price of different aggregates of goods and services, finding, in general, evidence against the hypothesis of contemporaneous separability between time and goods in the preference ordering of the individual.[5] Within a dynamic framework, economists were mainly concerned with the elasticity of intertemporal substitution of market time with respect to the price of leisure time,[6] although Browning, Deaton, and Irish (1985), Mankiw, Rotemberg, and Summers

[4] In addition to the advice received from the people referenced in the acknowledgments, this chapter has also benefited from the comments of Alberto Bisin, Jordi Galí, José Ignacio García, Libertad González, Maia Güell, Adriana Kugler, Kevin T. Reilly, Silvio Rendón, Hernando Zuleta, and seminar participants at Universitat Pompeu Fabra, Universidade de Santiago de Compostela, and Universidad Pablo de Olavide.

[5] See, for instance, Abbot and Ashenfelter (1976) and Browning and Meghir (1991).

[6] See, among many others, the contributions by Heckman (1974a, 1976), Ghez and Becker (1975), MaCurdy

(1985), and Altonji and Ham (1990) studied the issue of intertemporal substitution with respect to both the price of leisure time and the price of goods, finding, however, that the hypothesis of contemporaneous separability between time and goods is usually not rejected.

In our opinion, the conclusion from dynamic models needs and merits to be re-examined. It needs to be re-examined because previous work has focused on the influence of changes in the price of an *aggregate* of goods and services on market time. Nevertheless, there is compelling evidence that changes in the price of different groups of commodities generate opposing effects regarding the allocation of time: Abbot and Ashenfelter (1976) report that housing, transportation, and other services tend to be complementary—in a Slustky sense—with non-market time, while durables tend to be substitutes. As a consequence, the fact that the price aggregate is not influencing the life-cycle allocation of work effort might be hidden significant and offsetting responses with respect to particular categories of goods. Furthermore, regarding the allocation of time, alterations in the price of some goods could be more important than alterations in the price of others: Gronau and Hamermesh (2003) show that what they call "leisure" is the activity, apart from "sleep", in which more time is combined with every dollar spent in goods consumed as the activity takes place, which suggests that recreation goods could be an important determinant of the allocation of time.

The conclusion from dynamic models merits to be re-examined since the existence of a causal link between the price of goods and the intensive margin of labor supply would be of undoubted relevance. If economic agents allocate work effort over the life-cycle in

(1981), Altonji (1986), Mulligan (1995), and Ham and Reilly (2002). Blundell and MaCurdy (1999) provide a summary of this extensive literature.

response to the level of prices of, say, recreation goods, it would create cyclical movements in the output of an economy that, depending on their frequency, would be important for business cycle or growth theory.

This chapter presents, firstly, an individualistic life-cycle theoretical model within which to understand how the price of recreation goods affects the intensive margin of labor supply. Regarding the previous life-cycle literature, the main feature of this model consists in the assumption of contemporaneous non-separability between leisure time and recreation goods in the preference ordering of the individual. The sign and magnitude of the effect identified in the theoretical model is then estimated by combining individual-level data for the population of prime-age males suministered by the University of Michigan Panel Study of Income Dynamics and price indices of recreation goods for 27 U.S. Metropolitan Areas. The identification of the effect is based on the time series and cross-sectional exogenous variation provided by the different evolution across Metropolitan Areas of the price indices. The econometric methodology utilized consists in a generalized method of moments estimation procedure applied over different specifications of the structural equation.

The estimated elasticity of intertemporal substitution of market time with respect to the price of recreation goods centers at 0.15. Such a magnitude implies that, for a prime-age male working two thousand hours a year, a reduction of 15% in the price of recreation goods—something that occurred in the U.S. economy between 1976 and 1981—,[7] will cause a reduction of 45 hours in the number of annual hours of market work.

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[7] This reduction occurred with respect to the prices of food plus beverages, housing, and transportation.

The chapter proceeds as follows. The next section presents the theoretical model and discusses its main predictions regarding the intertemporal allocation of time. Section 1.3 comments on the data utilized in the empirical exercise. The description of the econometric methodology pursued to consistently estimate the elasticities identified in the theoretical part is postponed until Section 1.4. Section 1.5 presents the main results, with the final section highlighting the main conclusions of this chapter.

1.2 Theoretical Model

A household—indexed by i—is assumed to be made up of one adult person, whose well-being depends on the consumption of recreation goods (X), leisure time (L),[8] and a composite commodity representing other consumption goods (C^{*}). The economic agent knows with certainty the duration of the lifetime, his type of preferences, and all relevant prices needed to efficiently allocate the endowments of wealth—if any—and time.[9] The lifetime preference ordering is assumed to be strongly separable over periods of time—indexed by t—, while within-period preferences are represented by the twice differentiable, strictly concave utility function[10]

$$U_i\left(C_{it}^{*}, X_{it}, L_{it}\right) = \frac{C_{it}^{*1-\frac{1}{\theta}} - 1}{1-\frac{1}{\theta}} + \psi_{it}\left[\frac{1}{1-\frac{1}{\gamma}}\left(X_{it}^{1-\frac{1}{\rho}} + \alpha_{it} L_{it}^{1-\frac{1}{\rho}}\right)^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}}\right].$$

8 In this chapter, leisure time and non-market time are treated as synonymous. This comparison is justified in Appendix 1.C.

9 The assumption of perfect foresight is not crucial and simplifies the model. Nevertheless, for comprehensive purposes, both the theoretical model under uncertainty and the estimation of the intertemporal labor supply function derived from it are discussed in Appendix 1.B.

10 The features of this preference representation are extensively described, for instance, in Auerbach and Kotlikoff (1987).

In this specification of the felicity function, recreation goods and leisure time are conceived as inputs to the enjoyment of recreation, which is assumed, in turn, additively separable from other consumption goods. The parameters θ, γ, and ρ are assumed to be strictly positive and constant across individuals. "θ" represents the elasticity at which expenditures in other consumption goods are intertemporally substituted. More importantly regarding subsequent analysis, the parameter γ stands for the elasticity of intertemporal substitution of the whole recreation activity, while ρ measures the elasticity of contemporaneous substitution between recreation goods and leisure time in the production of recreation.

Individual heterogeneity in labor supply behaviour is introduced into the model by means of the time varying variables ψ_{it} and α_{it}. The former measures the relative importance given by each economic agent to the enjoyment of recreation along the lifetime, while the latter captures the relative importance of leisure time in the production of recreation. Thus, consumers may differ in the amount of recreation they feel as necessary and/or the way in which it is produced—e.g., from time intensive activities like reading a voluminous novel to goods intensive ones like dancing and drinking in the fashion club.

The economic agent starts his life with an amount of real wealth given by A_0, and with the ability to get the command over market goods—C^* and X—through work in the market. Every period he disposes of one unit of time that is devoted to market activities or to the enjoyment of recreation activities.[11] If the consumer offers labor services to the market,

[11] In this thesis the utilization of people's time is analyzed integrally, that is, paying attention to "...how time is allocated into separate activities over some relatively long time interval" (Hamermesh [1996]). Thus, for instance, we do not care about the duration of the spells making up of leisure time. There is evidence, however, that people engage in different recreation activities depending on the duration of the spell of leisure time available (see Robinson and Godbey [1997]). If these recreation activities were not perfect substitutes, a modification of the utility function would be required (see Hanoch [1980] and Reilly [1994]).

these are rewarded at a real rate given by W^*, and assumed exogenous to the individual. To purchase one unit of C^*, one unit of real resources is needed, while to purchase one unit of X, P units are necessary. Resources can be freely transferred across periods of time at a real rate of interest given by r. Thus, the intertemporal budget constraint for individual i expressed in terms of other consumption goods may be written as:

$$\sum_{t=0}^{T} R_t \left(C_{it}^* + P_{it} X_{it} + W_{it}^* L_{it} \right) = \sum_{t=0}^{T} R_t W_{it}^* + A_{i0},$$

where $R_t \equiv \frac{1}{(1+r_0)(1+r_1)...(1+r_{t-1})}$ discounts period t real resources to the beginning of the planning horizon. This constraint says that "full wealth" is spent in the purchases of market goods and—through foregone earnings—leisure time.[12]

The consumer's problem can be formally stated as:[13]

$$\max \sum_{t=0}^{T} \frac{1}{(1+\delta)^t} \left(\frac{C_{it}^{*1-\frac{1}{\theta}} - 1}{1-\frac{1}{\theta}} + \psi_{it} \left[\frac{1}{1-\frac{1}{\gamma}} \left(X_{it}^{1-\frac{1}{\rho}} + \alpha_{it} L_{it}^{1-\frac{1}{\rho}} \right)^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} \right] \right) \tag{1.1}$$

subject to

$$\sum_{t=0}^{T} R_t \left(C_{it}^* + P_{it} X_{it} + W_{it}^* L_{it} \right) = \sum_{t=0}^{T} R_t W_{it}^* + A_{i0}, \tag{1.2}$$

$$C_{it}^*, X_{it}, L_{it} \geq 0, \quad t = 0, ..., T, \tag{1.3}$$

[12] The i subindex in P_{it} indicates the existence of cross-sectional variation in the price of recreation goods. It is a matter of fact that this variable has evolved differently across U.S. Metropolitan Areas—see Figure 1.4 below. While the extent of the market for recreation goods needs not to be individual-specific, we shall maintain the i subindex for notational clarity.

[13] If the prices of market goods and leisure time are strictly positive during the whole planning horizon, the existence of a solution to this optimization problem is guaranteed, as it is claimed in Proposition 3.D.1 of Mas-Colell, Whinston, and Green (1995). The necessary first order conditions for an optimum are also sufficient by the strict concavity of the felicity function.

and

$$A_{iT+1} \geq 0, \tag{1.4}$$

where $\delta > 0$ stands for the rate of time preference and A_{i0} is given.

Assuming an interior optimum,[14] the optimality conditions are characterized by the budget constraint in Eq. (1.2) and the next set of first order conditions:

$$\begin{aligned} \frac{1}{(1+\delta)^t} C_{it}^{*\frac{-1}{\theta}} &= \lambda_i R_t, & (1.5) \\ \frac{1}{(1+\delta)^t} \psi_{it} \Omega_{it} X_{it}^{\frac{-1}{\rho}} &= \lambda_i R_t P_{it}, & (1.6) \\ \frac{1}{(1+\delta)^t} \psi_{it} \Omega_{it} \alpha_{it} L_{it}^{\frac{-1}{\rho}} &= \lambda_i R_t W_{it}^{*}, & (1.7) \end{aligned}$$

where

$$\Omega_{it} = \left(X_{it}^{1-\frac{1}{\rho}} + \alpha_{it} L_{it}^{1-\frac{1}{\rho}} \right)^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}} \tag{1.8}$$

and λ_i is the marginal utility of wealth of individual i.

The first order conditions in Eqs. (1.6) and (1.7) provide a contemporaneous equilibrium relationship between leisure time and recreation goods:

$$L_{it} = \left(\frac{W_{it}^{*}}{P_{it} \alpha_{it}} \right)^{-\rho} X_{it}. \tag{1.9}$$

Substituting Eq. (1.9) into Eq. (1.6), and since the unit of time available every period has to be splitted up into work in the market (N^{*}) and leisure time, we finally get the next expression for the intertemporal labor supply function:

14 Since this chapter is concerned with the behaviour of prime-age males, this assumption seems no more controversial than previous ones.

$$N_{it}^{*}=1-\psi_{it}^{\gamma}\left(\frac{W_{it}^{*}}{\alpha_{it}}\right)^{-\rho}\left(P_{it}^{1-\rho}+\alpha_{it}^{\rho}W_{it}^{*1-\rho}\right)^{\frac{\rho-\gamma}{1-\rho}}\left(\lambda_{i}\left(1+\delta\right)^{t}R_{t}\right)^{-\gamma}. \tag{1.10}$$

It says that the current amount of hours worked in the market is chosen by considering prices and tastes in all time periods, although past and future prices and tastes influence current hours only through λ_i.

The partial derivatives of Eq. (1.10) with respect to current prices provide the elasticities of intertemporal substitution (EIS) of market time with respect to the price of leisure time and with respect to the price of recreation goods. The algebraic expressions for both elasticities are:

$$\left.\frac{W_{it}^{*}}{N_{it}^{*}}\frac{\partial N_{it}^{*}}{\partial W_{it}^{*}}\right|_{\lambda\, const}=\frac{(1-N_{it}^{*})}{N_{it}^{*}}\left(\zeta_{it}\gamma+\left(1-\zeta_{it}\right)\rho\right)\;>0 \tag{1.11}$$

and

$$\left.\frac{P_{it}}{N_{it}^{*}}\frac{\partial N_{it}^{*}}{\partial P_{it}}\right|_{\lambda\, const}=\frac{(1-N_{it}^{*})}{N_{it}^{*}}\left(\left(1-\zeta_{it}\right)\left(\gamma-\rho\right)\right)\gtrless 0, \tag{1.12}$$

where

$$\zeta_{it}=\frac{\alpha_{it}^{\rho}W_{it}^{*1-\rho}}{P_{it}^{1-\rho}+\alpha_{it}^{\rho}W_{it}^{*1-\rho}}\in(0,1) \tag{1.13}$$

is—roughly—the share of the cost of leisure time in the total cost of recreation.

As is well known in the literature,[15] the EIS of market time with respect to the price of leisure time is positive, meaning that in those periods in which the wage rate is relatively high the rational consumer will increase his market time. Two margins of substitution contribute to this effect: on one hand, the individual will reduce the amount of recreation

[15] See, for instance, Ghez and Becker (1975) and Kotlikoff, Smetters, and Walliser (2001).

consumed because one of its inputs is relatively more expensive; on the other hand, he will consume recreation activities more intensive in recreation goods, freeing up time that is devoted to market activities. In the partial derivative given by expression (1.11), the former margin of substitution is represented by γ, the rate at which recreation may be intertemporally substituted; the latter margin is captured by ρ, the rate at which leisure time and recreation goods may be contemporaneously substituted in the production of recreation.

The overall sign of the EIS of market time with respect to the price of recreation goods can not be determined *a priori*. In those periods in which the price of recreation goods is relatively high, the individual will reduce the amount of recreation consumed since, again, one of its inputs is relatively more expensive. For the same reason, however, the economic agent will have an incentive to rise the time intensity of the recreation activities consumed, reducing, as a consequence, the time available to be supplied to the market. In the partial derivative given by (1.12), both margins of substitution are captured—respectively—by the parameters present at the expression $(\gamma - \rho)$. It exists the theoretical possibility that the price of recreation goods was not influencing labor supply: this would happen either when γ and ρ were equal, or when ζ_{it} was very close to one; that is, either when both margins of substitution were of the same magnitude, or when the enjoyment of recreation required expenditures per unit of goods considered as negligible in comparison with expenditures per unit of time. Hence, assuming an interior solution, the contemporaneous separability between leisure time and recreation goods will be rejected when $\gamma \neq \rho$ and $\zeta_{it} < 1$.

Regarding the relationship between the values of both elasticities, we may establish the next two claims. Firstly, if the EIS of market time with respect to the price of recreation goods is negative, then it must be lower, in absolute value, than the EIS of market time with respect to the price of leisure time. Secondly, if the EIS of market time with respect to the price of recreation goods is positive, it is larger than the elasticity with respect to the price of leisure time if and only if $\zeta < 1/2$ and $\gamma > \frac{2(1-\zeta)}{(1-2\zeta)}\rho$.[16] The validity of the proposed theoretical model shall be further evaluated by verifying the fulfillment of these claims in the section discussing the empirical results.

Unfortunately, the lack of an estimate for ζ prevent us to assess the value of the behavioural parameters γ and ρ. Nevertheless, if the value of the ratio of market time to leisure time could be known from the sample on which we estimate the elasticities, it would be possible to obtain an estimate of γ and to offer an upper or lower bound for the plausible range of values of ρ. To see this, notice that the expression for the EIS of market time with respect to the price of recreation goods given in (1.12) may be rewritten as

$$\frac{(1-N_{it}^{*})}{N_{it}^{*}}\gamma - \frac{(1-N_{it}^{*})}{N_{it}^{*}}\left(\zeta_{it}\gamma + (1-\zeta_{it})\,\rho\right). \tag{1.14}$$

Therefore, γ equals to the sum of both EIS multiplied by the ratio of market time to leisure time. Once we know γ, the sign of (1.12) will indicate a limit in the range of possible values of ρ.

[16] The proofs of both claims follow the same lines. If $\rho > \gamma$, the absolute value of the EIS of market time with respect to the price of recreation goods is $\frac{(1-N_{it}^{*})}{N_{it}^{*}}\left((1-\zeta_{it})(\rho-\gamma)\right)$. To be greater than $\frac{(1-N_{it}^{*})}{N_{it}^{*}}\left(\zeta_{it}\gamma + (1-\zeta_{it})\,\rho\right)$, it should happen that $\gamma < 0$, what makes no sense. If $\rho < \gamma$, the absolute value of the EIS of market time with respect to the price of recreation goods is $\frac{(1-N_{it}^{*})}{N_{it}^{*}}\left((1-\zeta_{it})(\gamma-\rho)\right)$. It is greater than $\frac{(1-N_{it}^{*})}{N_{it}^{*}}\left(\zeta_{it}\gamma + (1-\zeta_{it})\,\rho\right)$ when and only when $\zeta < 1/2$ and $\gamma > \frac{2(1-\zeta)}{(1-2\zeta)}\rho$.

Finally, notice that, by making use of the first order condition in Eq. (1.5), the intertemporal labor supply function in Eq. (1.10) could be alternatively written as

$$N_{it}^{*} = 1 - \psi_{it}^{\gamma} \left(\frac{W_{it}^{*}}{\alpha_{it}} \right)^{-\rho} \left(P_{it}^{1-\rho} + \alpha_{it}^{\rho} W_{it}^{*1-\rho} \right)^{\frac{\rho-\gamma}{1-\rho}} C_{it}^{*\frac{\gamma}{\theta}}. \tag{1.15}$$

The insight under this specification is that, since current expenditures in other consumption goods are chosen taking into account prices and tastes in all time periods, C^{*} would have the same role as λ in Eq. (1.10). The estimation of this alternative structural equation was pioneered by Altonji (1986), who proxied C^{*} with data on food expenditures, and it has been more recently pursued by Ham and Reilly (2002), for instance. Jointly with the specification in Eq. (1.10), the intertemporal labor supply function in Eq. (1.15) will be estimated in the empirical part of this chapter.

1.3 Data

Two sets of data are combined in order to estimate the elasticities of intertemporal substitution (EIS) just discussed: individual-level panel data supplied by the University of Michigan Panel Study of Income Dynamics (PSID), and price indices of different groups of commodities supplied by the U.S. Bureau of Labor Statistics (BLS).[17]

The BLS has long made available indices of prices for the aggregate of consumption goods and services—the Consumer Price Index (CPI)—and for specific categories of goods and services included in that aggregate. For the purpose of this and the next chapter, a price

[17] Some of the data used in this analysis are derived from Sensitive Data Files of the Panel Study of Income Dynamics, obtained under special contractual arrangements designed to protect the anonymity of respondents. These data are **not** available from the authors. Persons interested in obtaining PSID Sensitive Data Files should contact through the Internet at **PSIDHelp@isr.umich.edu**

index capturing the evolution in the price of commodities consumed in conjunction with leisure time could be utilized to estimate the EIS of market time with respect to the price of recreation goods. Indeed, as part of the CPI-All Urban Consumers, the BLS has been publishing the evolution of the price of a category of goods labeled as "Entertainment", which includes the items appearing in Figure 1.1.[18] Moreover, the series for this index are available for the U.S. as a whole and for the 27 Metropolitan Areas displayed in Figure 1.2.[19]

FIGURE 1.1

"ENTERTAINMENT" ITEM STRUCTURE

- **Entertainment**
  - **Entertainment Commodities**
    - **Reading materials**
      - **Newspapers**
      - **Magazines, periodicals and books**
    - **Sporting goods and equipment**
      - **Sport vehicles, including bicycles**
      - **Other sporting goods**
    - **Toys, hobbies and other entertainment**
      - **Toys, hobbies and music equipment**
      - **Photographic supplies and equipment**
      - **Pet supplies and expense**
  - **Entertainment Services**
    - **Club memberships**
    - **Fees for participant sports, excl. club memberships**
    - **Admissions**
    - **Fees for lessons or instructions**
    - **Other entertainment services**

SOURCE.— U.S. Bureau of Labor Statistics. CPI-All Urban Consumers.

[18] The proportion of consumer expenditures absorbed for this category of goods in the U.S. during the eighties and part of the nineties was around 7% (see Nelson [2001]).

[19] A Metropolitan Area is defined by the U.S. Office of Management and Budget as an area containing a recognized population nucleus and adjacent communities that have a high degree of integration with that nucleus.

FIGURE 1.2

U.S. METROPOLITAN AREAS WITH AVAILABLE "ENTERTAINMENT" PRICE INDEX

NORTHEAST:	**NORTHCENTRAL:**
New York-Northern N.J.-Long Island	**Chicago-Gary-Lake County**
Philadelphia-Wilmington-Trenton	**Detroit-Ann Arbor**
Boston-Lawrence-Salem-Lowell-Brockton	**St. Louis-East St. Louis**
Pittsburgh-Beaver Valley	**Cleveland-Akron-Lorain**
Buffalo-Niagara Falls	**Minneapolis-St. Paul**
	Milwaukee
	Cincinnati-Hamilton
	Kansas City
SOUTH:	**WEST:**
Washington, DC	**Los Angeles-Anaheim-Riverside**
Dallas-Fort Worth	**San Francisco-Oakland-San Jose**
Baltimore	**Seattle-Tacoma**
Houston-Galveston-Brazoria	**San Diego**
Atlanta	**Portland-Vancouver**
Miami-Ft. Lauderdale	**Honolulu**
	Anchorage
	Denver-Boulder

SOURCE.— U.S. Bureau of Labor Statistics. The names of these Metropolitan Areas correspond to those established by the U.S. Office of Management and Budget on June 6th, 1990.

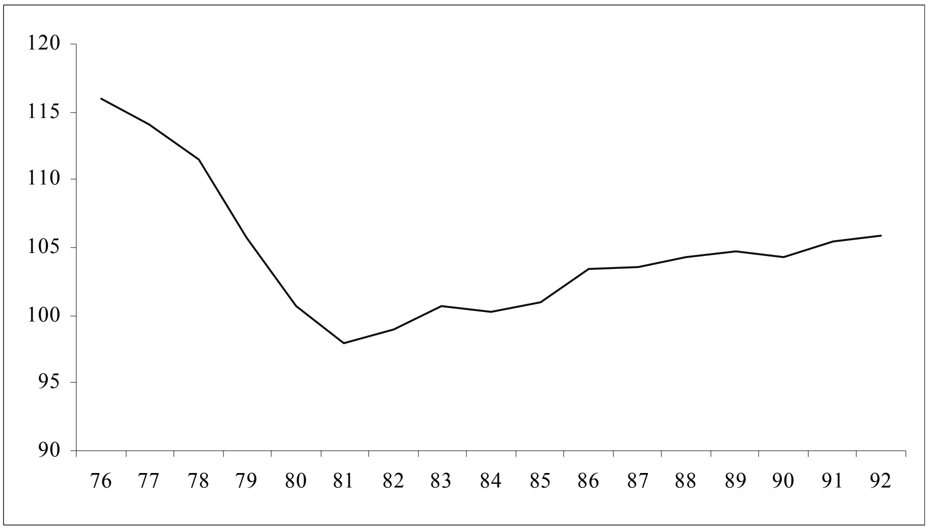
Furthermore, the BLS also publishes at the level of Metropolitan Areas price indices for other groups of items like, for instance, "Food+Beverages", "Housing", and "Transportation". In order to get an index for the price of recreation goods in terms of other consumption goods specific to each Metropolitan Area, the price index corresponding to entertainment goods and services is divided by a weighted average of the indices for food plus beverages, housing, and transportation, where the weights are given by average consumer expenditures on these three groups of items.[20] To estimate the structural equation

[20] The data on average expenditures comes from the U.S. Consumer Expenditure Survey, Two-Year Report Tables. They may be downloaded at www.bls.gov/cex/csxmsa.htm. We have utilized the weights for 1986-1987. Food plus beverages, housing, and transportation absorb approximately two thirds ot total consumer

derived from Eq. (1.15), however, the "Entertainment" price index was divided by the index of food plus beverages alone, since C^* will be proxied by the food expenditures variable available in the PSID.

FIGURE 1.3

PRICE OF RECREATION GOODS
U.S. (1982-84=100)



SOURCE.— U.S. Bureau of Labor Statistics, CPI-All Urban Consumers. The index for the price of recreation goods depicted here is constructed by dividing the "Entertainment" category of the CPI by a weighted average of "Food plus Beverages", "Housing", and "Transportation".

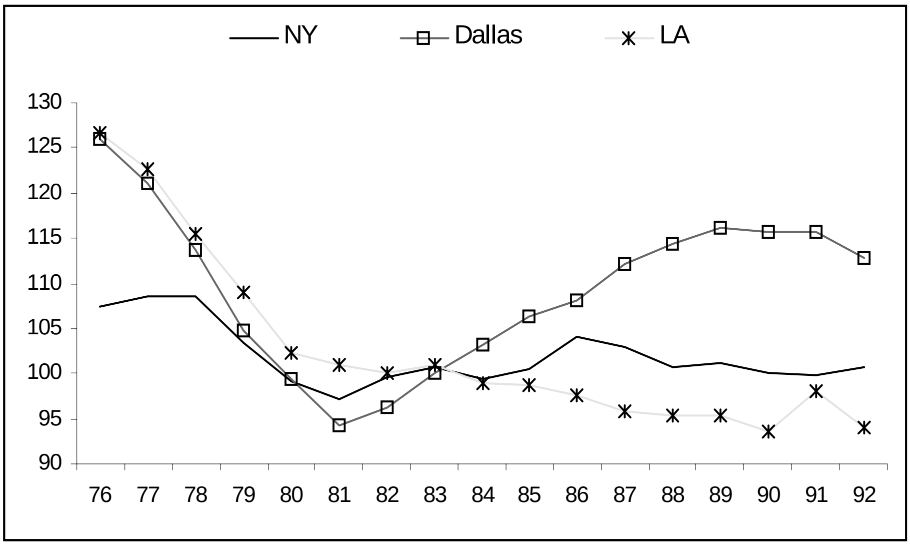
Figures 1.3 and 1.4 show the evolution of the price of recreation goods in the U.S. and in selected Metropolitan Areas during the sample period 1976-1992. For the U.S. as a whole, the evolution was U-shaped, although this profile is not shared by all the Metropolitan Areas, generating, as a consequence, cross-sectional variation in the level of the price of recreation goods that, jointly with the time series one, will be exploited in the econometric

expenditures.

exercise that follows to identify the EIS of market time with respect to the price of recreation goods. Regarding the reasons explaining the U-shaped pattern for the whole U.S., Figure 1.5 shows that the downward part of the U responded to the unusual increase in the price of energy and raw materials that took place in the late seventies: transportation and housing—which includes expenditures in fuel oil—registered significant price increases. The upward trend is, however, more difficult to explain, although the Postmodernist school of economic thought would point to the commodification of leisure as the driving force of this steady growth.[21]

FIGURE 1.4

PRICE OF RECREATION GOODS
SELECTED U.S. METROPOLITAN AREAS
(1982-84=100)

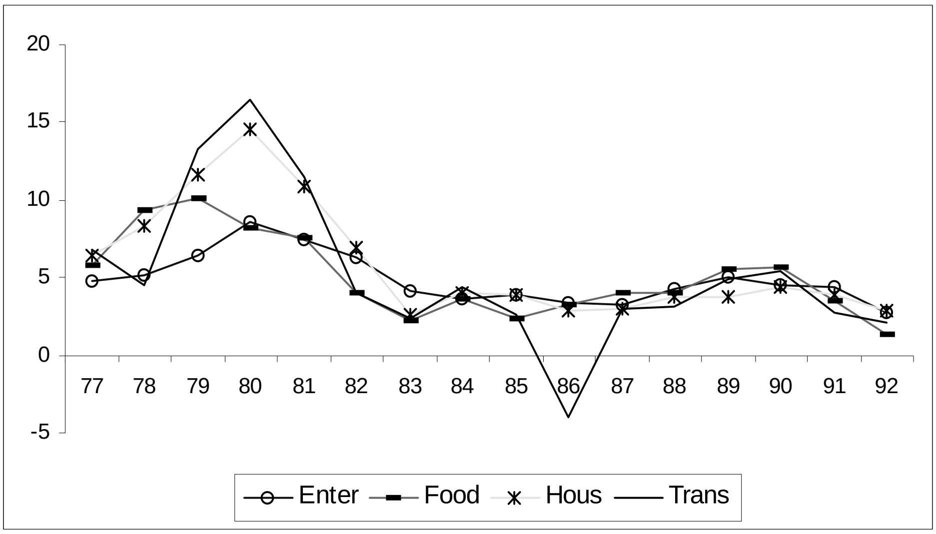


SOURCE.— U.S. Bureau of Labor Statistics, CPI-All Urban Consumers. The indices for the price of recreation goods depicted here are constructed by dividing the "Entertainment" category of the CPI by a weighted average of "Food plus Beverages", "Housing", and "Transportation". The selected Metropolitan Areas are referred to by the name of their central city.

[21] See Benhabib and Bisin (2002) for a survey of the Postmodernist literature.

FIGURE 1.5

GROWTH RATES IN PERCENTAGE TERMS
SELECTED U.S.-CPI COMPONENTS



SOURCE.— U.S. Bureau of Labor Statistics, CPI-All Urban Consumers.

The PSID is a longitudinal, representative database of the U.S. population which, starting in 1968, has been collecting information regarding demographic and economic events of the individuals being surveyed. In particular, individuals are asked a series of questions in order to ascertain the total time devoted to work in the market during the calendar year previous to the year of the interview. Thus, annual market hours is calculated as the sum of hours worked in the main job, in the secondary job/s, and in overtime, while the annual hours worked in each of these three components is obtained as the product of weeks worked during the previous year times usual number of hours worked per week.[22]

[22] The exact wording of the questions is:
"*How many weeks did you actually work on your main job/ secondary job/ overtime in* [previous year]?"
"*And, on the average, how many hours a week did you work on your main job/ secondary job/ overtime in* [previous year]?"

Besides, in the PSID there are available two measures for the price of leisure time. The first measure, henceforth denoted as W, is calculated as real annual earnings divided by annual hours of market work. The second, henceforth denoted as ϖ, is based on the response to a direct question about the straight-time hourly wage, which is asked of those workers who are paid on an hourly basis.

The sample selection criteria applied on the combined dataset, draw partially upon those utilized by Altonji (1986). We must add, however, a geographic selection criterion, since only observations of individuals residing in Metropolitan Areas with the necessary price indices are included in the analysis.[23] As a difference with the study of Altonji, however, observations of unmarried males and of non-whites are kept as part of the sample. The cost in terms of both representativeness and efficiency of considering only white males being married to the same woman and residing in a Metropolitan Area with the required price indices during the entire sample period is too high: only 246 men surveyed by the PSID would meet these requirements. Instead, this study uses observations from 3,742 males, each contributing to the sample with an average of six observations. Table 1.1 offers a set of descriptive statistics for the sample object of analysis.

[23] Appendix 1.A outlines the sample selection process and discusses the existence of sample selection biases.

TABLE 1.1

DESCRIPTIVE STATISTICS

Individuals: 3,742
Average obs. per individual: 6.0

Variable	Obs.	Mean	Std. Dev.	Min	Max
Hours	22,316	2,140	590.1	2	4,845
I^P_{jt}	22,316	105.4	8.329	88.19	141.2
W_{it}	22,316	13.18	9.000	1.047	359.7
ϖ_{it}	8,877	10.13	9.354	0.771	724.7
C_{it}	18,808	4,602	2,219	77.34	29,469
Age	22,316	37.80	9.604	25	60
Education	22,316	13.21	2.856	0	17
Experience	22,316	19.60	10.37	3	55
No. Children	22,316	1.216	1.300	0	10
Family size	22,316	3.343	1.652	1	18
Nonwhite	22,316	0.366	0.482	0	1
Married	22,316	0.835	0.371	0	1
Bad health	22,316	0.076	0.266	0	1

NOTE.— *Hours*: Annual hours worked in the main job, secondary job/s, and overtime. I^P_{jt}: Index of the price of recreation goods in terms of other consumption goods in Metropolitan Area *j* and period *t*; base period 1982-84=100. W_{it}: First measure of the price of leisure time for individual *i* in period *t*, obtained as annual earnings in 1982-84 dollars divided by annual hours worked. ϖ_{it}: Second measure of the price of leisure time: straight-time hourly wage in 1982-84 dollars, asked of those workers who are paid on an hourly basis. C_{it}: Annual food expenditures at home and in restaurants in 1982-84 dollars. *Education*: Highest grade finished; a code 17 indicates some post-graduate work. *Experience*: Years of labor market experience, calculated as age minus years of schooling minus five. *No. Children*: Number of persons in the family unit under 18 years old. *Nonwhite*, *Married*, and *Bad health*: binary indicators taking on value 1 when the individual declares to be non-white, is legally married or permanently cohabiting, or has any physical or nervous condition that limits the type of work or the amount of work he can do, respectively.

1.4 Econometric Methodology

This section, that draws heavily upon the classic paper by Altonji (1986), discusses how to consistently estimate the elasticities of intertemporal substitution of market time with respect to the price of leisure time and the price of recreation goods. The starting points are the structural equations given in expressions (1.10) and (1.15), predicted by the theoretical model as governing the intertemporal allocation of work effort. Following a conventional terminology,[24] the estimating equation derived from Eq. (1.10) is labeled as the Euler equation for labor supply, while if Eq. (1.15) is the structural equation initially considered, the estimating equation is labeled as the Marginal Rate of Substitution equation. Both approaches are pursued in this section.

1.4.1 Euler Equation for Labor Supply

Specification

Since our interest lies in the estimation of elasticities, we take a log-linear approximation to the intertemporal labor supply function in Eq. (1.10) around the individual equilibrium. The result of the log-linearization is formally expressed as:

$$\begin{aligned} \ln N_{it}^{*} &= \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln W_{it}^{*} + \beta_3 \ln \psi_{it} + \beta_4 \ln \alpha_{it} \\ &\quad + \beta_5 \left(\textstyle\sum_{\kappa=0}^{t-1} (\delta - r_{\kappa}) \right) + \beta_5 \ln \lambda_i, \end{aligned} \tag{1.16}$$

where we made use of the approximations $\ln(1+\delta) \approx \delta$ and $\ln(1+r_t) \approx r_t$. The population parameters β_1 and β_2 are the elasticities of intertemporal substitution (EIS) of market time with respect to the price of recreation goods and the price of leisure time, respectively. Since Eq. (1.10) was obtained under the assumption of an interior solution, the population under inquiry will be the population of prime-age males.[25] From now on, it is assumed that a longitudinal random sample drawn from this population is available.

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24 See, among others, Altonji and Ham (1990) and Ham and Reilly (2002).

25 Indeed, what is studied is the population of prime-age male workers, although given the high participation rates displayed by the demographic group of prime-age males (see Goldin [2000]), it is assumed that both populations roughly display the same behaviour.

Each taste-shifter variable (ψ and α) is approximated by a log-linear function of observed characteristics of the worker, an individual specific term reflecting time-invariant preferences, and a residual term:

$$\ln \psi_{it} = \mathbf{y}'_{it}\boldsymbol{\phi}^{\psi} + y_i^{\psi} + \xi_{it}^{\psi}, \tag{1.17}$$

$$\ln \alpha_{it} = \mathbf{y}'_{it}\boldsymbol{\phi}^{\alpha} + y_i^{\alpha} + \xi_{it}^{\alpha}. \tag{1.18}$$

The vector $\mathbf{y}$ contains time-varying individual variables like age, health status, marital status, family size, and number of children in the family unit. Even though it could be an interesting exercise in itself, we do not disentangle the specific effect they exert on the taste for recreation and on the taste for time intensive recreation activities. It is assumed that $E(\xi_{it}^{\psi}) = E(\xi_{it}^{\alpha}) = 0$, and that the natural logarithm of annual hours of market work is mean independent of $\boldsymbol{\xi}^{\psi}$ and $\boldsymbol{\xi}^{\alpha}$ after having controlled for the observed covariates and the individual heterogeneity.

A time trend specific to each Metropolitan Area is included among the explanatory variables in order to control for spatial differences between the subjective and market discount rates. Notice that it is almost inherent to the existence of cross-sectional variation in the *relative* price of recreation goods the presence of this sort of variation in the price of other consumption goods, therefore modifying the real interest rate across Metropolitan Areas.

As discussed, among others, by Altonji (1986), Juster and Stafford (1991), and Bound, Brown, and Mathiowetz (2000), some answers collected in surveys like the PSID are subject to recall biases, specially those obtained to questions in which individuals are asked about past labor market outcomes. As a consequence, it is assumed in what follows that we have imperfect measures for annual hours of market work and for the price of leisure time, with the corresponding measurement errors following a multiplicative model in which the true measure is uncorrelated with the error term:

$$\ln N_{it} = \ln N_{it}^{*} + e_{it}^{N}, \tag{1.19}$$

$$\ln W_{it} = \ln W_{it}^{*} + e_{it}^{W}, \tag{1.20}$$

$$\ln \varpi_{it} = \ln W_{it}^{*} + e_{it}^{\varpi}. \tag{1.21}$$

As pointed out in the previous section, the first measure of the price of leisure time, W, is constructed as real annual earnings divided by annual hours of market work. As a consequence, the errors of measurement e^N and e^W are quite likely correlated: if labor earnings were objectively reported, overestimations of the amount of hours worked would lead to underestimations of the price of leisure time and vice versa, causing a negative bias in the estimate of β_2. The second measure of the price of leisure time, ϖ, is the direct response to a question about the straight-time hourly wage, which is asked of those workers who are paid on an hourly basis. Since ϖ is obtained from a question separate from those used to construct N and W, it is expected that e^{ϖ} is uncorrelated with e^N and e^W, and we shall assess the validity of this assumption when discussing the empirical results.

The price of recreation goods poses some interesting problems when trying to consistently estimate the effect it exerts over the allocation of time. Firstly, P_{it} is an unobserved variable and, to approximate it, we make use of price indices of recreation goods at the level of Metropolitan Areas. Formally:

$$\ln P_{it} = \tau \ln P_{jt} + e^{P}_{it}, \tag{1.22}$$

where j ($j = 1, .., 27$) denotes the Metropolitan Area of residence of individual i. As explained by Deaton (1997), in cases like this the measurement error is orthogonal to the error-ridden proxy, and it would seem that we had eluded the attenuation bias. Geronimus, Bound, and Neidert (1996), however, point to the fact that an aggregate variable is usually imperfectly correlated with the microvariable that it is representing, creating an *errors-in-variables bias* that tends to exert a downward bias on the coefficient of the aggregate proxy. Besides, Geronimus *et al.* (1996) also remark that the aggregate variable may itself be correlated with the residual in the microlevel equation, generating what they call an *aggregation bias*. This sort of endogeneity might arise because of simultaneity bias: the level of prices of recreation goods could be affected by the aggregate number of hours of leisure time in each Metropolitan Area. In a sense, the amount of hours of leisure time indicates the extent of the market for recreation which, in its turn, determines the division of labor, that is, the variety of recreation activities offered. This spatial variety of recreation activities could be affecting the evolution of the price of a constant basket of recreation goods measured across Metropolitan Areas by means of price indices.

Secondly, P stands for the *level* of the price of recreation goods but, in principle, we have only available *relative variations* in this level captured by means of price indices.[26] Nonetheless, by taking logarithms on the price indices and adding Metropolitan Area of residence dummies to the right hand side of the structural equations, this problem may be overcome. Notice that:

$$I_{jt}^{P} \equiv \frac{I_{jt}^{X}}{I_{jt}^{C^*}} \equiv \frac{\frac{P_{jt}^{X}}{P_{j0}^{X}}}{\frac{P_{jt}^{C^*}}{P_{j0}^{C^*}}}, \tag{1.23}$$

where I_{jt}^{P} denotes the level of the index of the price of recreation goods in terms of other consumption goods in Metropolitan Area j and period t, I_{jt}^{X} stands for the level of the index of the entertainment component of the CPI, and $I_{jt}^{C^*}$ expresses the level of the index of the groups of commodities included in C^*.[27] By definition, every price index is constructed as the ratio of the level of prices in period t over the level of prices in the base period, indicated with the subindex $_0$. Taking natural logarithms on both sides of the previous identity, we get:

$$\ln I_{jt}^{P} \equiv \left(\ln P_{jt}^{X} - \ln P_{jt}^{C^*}\right) - \left(\ln P_{j0}^{X} - \ln P_{j0}^{C^*}\right) \equiv \ln P_{jt} - \ln P_{j0.} \tag{1.24}$$

Therefore, when we take the log of a price index included among the explanatory variables, what we are measuring is the contemporaneous effect exerted by the price level on the dependent variable plus a time-constant effect representing the influence of the base period

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26 As it is well known, the indices are, for instance, a hundred in the base year, without necessarily implying that the prices of recreation goods across Metropolitan Areas are the same too.

27 Food plus beverages, housing, and transportation in the Euler equation for labor supply, and food plus beverages alone in the Marginal Rate of Substitution equation.

prices utilized to construct the index. In our empirical application, this time-constant effect is controlled for by means of Metropolitan Area of residence dummies.

Taking into account all these considerations, we get an estimating Euler equation for the natural logarithm of annual hours of market time of the form

$$\ln N_{it} = \beta_0 + dMA_{it} + \bar{\beta}_1 \ln P_{jt} + \beta_2 \ln W_{it} + \mathbf{y}'_{it}\boldsymbol{\phi} + \beta_5 t + c_i + e_{it}, \tag{1.25}$$

where $\bar{\beta}_1 \equiv \beta_1 \tau,\ \boldsymbol{\phi} \equiv \left(\boldsymbol{\phi}^{\psi}\beta_3 + \boldsymbol{\phi}^{\alpha}\beta_4\right),\ c_i \equiv \left(\beta_5 \ln \lambda_i + \beta_3 y_i^{\psi} + \beta_4 y_i^{\alpha}\right),\ e_{it} \equiv \left(\beta_3 \xi_{it}^{\psi} + \beta_4 \xi_{it}^{\alpha} + e_{it}^{N} + \beta_1 e_{it}^{P} - \beta_2 e_{it}^{W}\right)$, and dMA_{it} stands for the set of Metropolitan Area dummies.

Estimation Method

To get consistent estimates of the main parameters in Eq. (1.25) we must, at a minimum, get rid of the unobserved heterogeneity, since the marginal utility of wealth is correlated with prices and tastes in all time periods. Thus, by taking a fixed effects (FE) transformation of the data, the estimating equation becomes

$$\ln \ddot{N}_{it} = d\ddot{M}A_{it} + \bar{\beta}_1 \ln \ddot{P}_{jt} + \beta_2 \ln \ddot{W}_{it} + \ddot{\mathbf{y}}'_{it}\boldsymbol{\phi} + \beta_5 \ddot{t} + \ddot{e}_{it}, \tag{1.26}$$

where $\ln \ddot{N}_{it} \equiv \ln N_{it} - \left(T_i^{-1} \sum_{t=1}^{T_i} \ln N_{it}\right)$, $\ln \ddot{P}_{jt} \equiv \ln P_{jt} - \left(T_{i,i\in j}^{-1} \sum_{t=1}^{T_{i,i\in j}} \ln P_{jt}\right)$, and so on, with T_i denoting the number of observations available for the randomly sampled ith individual.[28]

[28] Our panel dataset is unbalanced because of sample attrition and the sample selection criteria discussed in Appendix 1.A. Lillard and Panis (1998) found evidence of significant selectivity in attrition behaviour in the PSID, although Ziliak and Kniesner (1998) showed that nonrandom attrition is of little concern when estimating intertemporal labor supply equations because the effect of attrition is absorbed into fixed effects. Appendix 1.A also discusses the selection biases introduced by the sample selection criteria.

Here, $\ln \ddot{P}_{jt}$ is possibly endogenous because of the simultaneity bias discussed above. In order to avoid this sort of bias, the conveniently demeaned population of each Metropolitan Area in each time period is added to Eq. (1.26) in the hope to proxy for the size of the market for recreation. Notice, however, that we can not get rid of the errors-in-variables bias unless $\ln P_{jt}$ is perfectly correlated with $\ln P_{it}$, and, as a consequence, we shall get a consistent estimate of $\bar{\beta}_1$, but not of β_1. Nonetheless, if the economic agent's relevant market for recreation goods approaches the Metropolitan Area in which he resides, this bias should not be too significant.[29]

On the other hand, $\ln \ddot{W}_{it}$ is endogenous in Eq. (1.26) because of the correlation with the measurement error terms $\ddot{e}_{it}^{W}$ and $\ddot{e}_{it}^{N}$ included in $\ddot{e}_{it}$. In order to consistently estimate β_2, we instrument the demeaned price of leisure time with two different variables: firstly, a measure of experience in the labor market conveniently demeaned and, secondly, the demeaned straight-time hourly wage of those workers paid on an hourly scheme.[30] It could be questioned the exclusion restriction on labor market experience, since the decision to participate in the labor market could be related with unobserved tastes of the individual affecting the amount of hours worked. Nevertheless, time invariant tastes have been differenced away, and some time-varying taste controls are included among the explanatory variables in Eq. (1.26). Besides, Mroz (1987) does not reject the exogeneity of experience after controlling for self-selection into the labor force, a minor problem in the population

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[29] Things would be easier if we disposed of a valid instrument for the price of recreation goods. Nevertheless, the autocorrelated structure of the error term prevent us from using lags or leads of this variable as instruments. Moreover, we lack a valid excluded instrument.

[30] Altonji (1986) criticizes MaCurdy (1981) for having used education and age as instruments of short term variations in wages. His criticism is shared in this thesis.

under study. As discussed previously, if the measurement error of the second measure of the price of leisure time was independent of e^N and e^W, it would convert the straight-time hourly wage in a valid instrument for the price of leisure time.

We estimate Eq. (1.26) by a two-step feasible generalized method of moments (GMM) procedure. The assumption of random sampling in the cross-section dimension, converts the covariance matrix of the full vector of errors in a block-diagonal matrix. Besides, the autocorrelated structure of the demeaned idiosyncratic error requires intra-cluster covariance matrices of unrestricted form.

1.4.2 Marginal Rate of Substitution Equation for Labor Supply

Specification

Taking a log-linear approximation to Eq. (1.15) around the individual equilibrium, assuming that the functional forms for taste-shifters and the measures of hours and prices given in the previous subsection are appropriate, and assuming that expenditures in other consumption goods are mismeasured with the measurement error following, again, the multiplicative classical model

$$\ln C_{it} = \ln C^*_{it} + e^C_{it}, \tag{1.27}$$

the Marginal Rate of Substitution estimating equation would be:

$$\ln N_{it} = \beta_0 + dMA_{it} + \bar{\beta}_1 \ln P_{jt} + \beta_2 \ln W_{it} + \beta_6 \ln C_{it} + \mathbf{y}'_{it}\boldsymbol{\phi} + a_i + b_{it}, \tag{1.28}$$

where $a_i \equiv \left(\beta_3 y_i^{\psi} + \beta_4 y_i^{\alpha}\right)$, $b_{it} \equiv \left(\beta_3 \xi_{it}^{\psi} + \beta_4 \xi_{it}^{\alpha} + e_{it}^{N} + \beta_1 e_{it}^{P} - \beta_2 e_{it}^{W} - \beta_6 e_{it}^{C}\right)$, and $\bar{\beta}_1$ and ϕ were defined previously.

Estimation Method

The specification given in Eq. (1.28) is estimated by making use of the annual food expenditures variable available in the PSID.[31] The unobserved heterogeneity will be proxied by means of time-invariant characteristics of the worker like race and years of schooling completed. We again seek to reduce the size of the simultaneity bias associated with the price of recreation goods by controlling for the population of each Metropolitan Area in each time period. On the other hand, the price of leisure time and the expenditures in other consumption goods are endogenous in Eq. (1.28) because of the measurement error terms included in the idiosyncratic error. Although the specification in levels of this estimating equation and the longitudinal nature of the dataset at hand, could lead us to think in the estimators suggested by Arellano and Bond (1991) or Arellano and Bover (1995) as suitable ones, the autocorrelated structure of the idiosyncratic error precludes us to utilize estimators based on lags or leads of the explanatory variables.[32] We should rely therefore on excluded instruments.

We follow Altonji (1986) and instrument both variables with an individual-specific permanent component of the wage, plus another time-varying individual variable capturing deviations around this profile. The permanent component of the wage in Altonji (1986) was

[31] This measure is the sum of food expenditures at home and in restaurants. Even though the survey questions refer only to *food* expenditures, it is quite likely that reported food expenditures include expenditures in beverages.

[32] The estimated AR(1) coefficient amounts to 0.46, robust standard error 0.02.

obtained by means of a regression of the straight-time hourly wage of those workers paid hourly, ϖ, on dummy variables for each individual and other controls.[33] We attempt the same strategy here but, alternatively, given that years of schooling will reveal as redundant in the conditional expectation for hours worked in the market, we also proxy this permanent component of the wage with the education of each worker. The time-varying variable that captures deviations around the long-run profile of earnings will be, as in Altonji (1986), the straight-time hourly wage itself. Both kind of variables affect C_{it} through their effect on λ_i.

As with the previous specification, the estimation method will consist in a two-step feasible GMM procedure. The covariance matrix of the idiosyncratic errors has the same structure as explained above.

1.5 Results

This section discusses the main results obtained after having estimated the structural Eqs. (1.26) and (1.28) by the methods proposed above, giving special attention to the estimate of the elasticity of intertemporal substitution (EIS) of market time with respect to the price of recreation goods. The common set of time-varying taste controls included in both specifications is made up of the age of the individual—in years—and its square, the marital status—*Married* takes on value 1 when the worker is legally married or permanently cohabiting—, the number of children in the family unit younger than 18 years old and its square, the

[33] More precisely, the straight-time hourly wage is regressed on individual, time, and Metropolitan area of residence dummies, a binary indicator of health status, and human capital controls such as labor market experience squared and the interaction of experience and education.

family size, a binary indicator of health status—*Bad health* takes on value 1 when the worker has any physical or nervous condition that limits the type of work or the amount of work he can do—, and the natural logarithm of the population of each Metropolitan Area in each time period.[34] When the labor market experience of each individual is utilized to instrument the price of leisure time, it is raised to the square to avoid a perfect collinearity with age and the intercept, since labor market experience is calculated as age minus years of schooling minus five. Notice that time dummies are not included among the explanatory variables because Metropolitan Area and time dummies alone are able to explain 62 per cent of the total variation in the price of recreation goods, leaving, as a consequence, little variation to be exploited in the estimation of its effect on annual hours worked. Since Metropolitan Area dummies must be included,[35] we control for tastes for work by means of the relatively rich specification of taste-shifters considered in Eqs. (1.26) and (1.28).

1.5.1 Euler Equation for Labor Supply

We now turn to the empirical results. Table 1.2 presents the results of estimating the demeaned specification of the Euler equation for labor supply given in Eq. (1.26). To control for potential differences between the subjective and market discount rates, all regressions shown in Table 1.2 include a time trend specific to each Metropolitan Area among the explanatory variables.

[34] U.S. local area population data is suministered by the Bureau of Economic Analysis. The data can be downloaded at www.bea.gov/bea/regional/data.htm

[35] See the discussion in the previous section.

TABLE 1.2

EULER EQUATION FOR LABOR SUPPLY

(Dependent Variable = $\ddot{\ln N}_{it}$)

	(1)	(2)	(3)	(4)
$\ddot{LnP}_{jt}$	0.2781***	0.1213*	0.1832**	0.1851***
	(0.0652)	(0.0735)	(0.0717)	(0.0715)
$\ddot{LnW}_{it}$	-0.1370***	0.1814*	0.2414***	0.2415***
	(0.0184)	(0.0990)	(0.0701)	(0.0701)
$\ddot{Age}$	0.0228**	0.0106	0.0042	0.0037
	(0.0092)	(0.0106)	(0.0114)	(0.0113)
$\ddot{Age}^2$	-0.0003***	-0.0002*	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$\ddot{\text{Married}}$	0.0183	0.0254	0.0129	0.0129
	(0.0166)	(0.0173)	(0.0226)	(0.0226)
$\ddot{\text{No. Children}}$	0.0107	0.0079	-0.0124	-0.0128
	(0.0104)	(0.0112)	(0.0145)	(0.0144)
$(\ddot{\text{No. Children}})^2$	-0.0025	-0.0018	0.0029	0.0030
	(0.0021)	(0.0021)	(0.0024)	(0.0024)
$\ddot{\text{Family size}}$	0.0091	0.0003	0.0062	0.0063
	(0.0068)	(0.0071)	(0.0083)	(0.0083)
$\ddot{\text{Bad health}}$	-0.0804***	-0.0672***	-0.0548***	-0.0547***
	(0.0168)	(0.0170)	(0.0193)	(0.0193)
$\ddot{\text{LnPopulation}}$	-0.3983*	-0.6087**	-0.5737*	-0.5576*
	(0.2279)	(0.2417)	(0.3114)	(0.3086)
Observations	22,316	22,316	8,877	8,877

NOTE.— Two dots over a variable indicate that it has been previously demeaned. All regressions include Metropolitan Area (MA) dummies and a time trend specific to each MA. $\ln W_{it}$ demeaned is instrumented with: labor market experience squared in Column (2), the straight-time hourly wage of those workers paid hourly in Column (3), and both variables in Column (4). Heteroskedasticity and autocorrelation within panels robust standard errors in parentheses. Standard errors **corrected** for the presence of generated regressors and for the lost of degrees of freedom caused by the fixed effects transformation. * significant at 10%; ** significant at 5%; *** significant at 1%

For comparative reasons, the first column of Table 1.2 exhibits the results of a simple Pooled OLS estimation of Eq. (1.26). Although the unobserved heterogeneity has been differenced away, the sign of the estimated EIS of market time with respect to the price of leisure time evidences that this variable is being affected by the correlation with the measurement errors indicated above. Thus, in columns 2 to 4 we attempt several instrumental variables strategies in order to avoid this latter kind of bias. In Column 2 the price of leisure time is instrumented with labor market experience, while in Column 3 it is instrumented with the straight-time hourly wage of those workers paid on an hourly basis, ϖ. In order to assess the validity of the instruments by performing a test of overidentifying restrictions, in Column 4 we simultaneously instrument the price of leisure time with both the labor market experience and ϖ.

The EIS of market time with respect to the price of recreation goods is invariably estimated to be positive, evidencing that a prime-age male puts more market effort during the years in which the price of recreation goods is relatively high. This behaviour reflects that the elasticity at which recreation is substituted across periods of time, γ, is larger than the elasticity at which leisure time and recreation goods are contemporaneously substituted, ρ. That is, prime-age males anticipate or delay the enjoyment of recreation more readily than they change the kind of recreation activities consumed, a feature that could be explained by the presence of habits in the recreation activities usually engaged in. The magnitude of this elasticity varies from column to column depending on sample size and the magnitude of the estimated EIS with respect to the price of leisure time, but we could say that the range of more reliable estimates centers at 0.15. Such a magnitude implies that a prime-age male working two thousand hours a year will work 3 hours more when faced with a one per cent increase in the price of recreation goods. To gauge the size of this effect, notice that the price of recreation goods in terms of other consumption goods dropped in the U.S. around 15 per cent between 1976 and 1981, suggesting that a prime-age male would have reduced, on average, 45 hours his annual hours of market work in 1981 with regard to the amount worked in 1976. The statistical significance of the EIS of market time with respect to the price of recreation goods reveals the price of recreation goods as a significant determinant of the intertemporal allocation of work effort, rejecting, as a consequence, the contemporaneous separability between leisure time and recreation goods postulated in most of the life-cycle models.

Regarding the other estimated coefficients, we observe a wage effect that is similar to those previously obtained by MaCurdy (1981), Altonji (1986), and Ham and Reilly (2002), among others. To assess the validity of the instruments for the price of leisure time, we computed the value of the J statistic of Hansen (1982) after the regression given in Column 4: 0.22—p-value 0.64—, not rejecting, therefore, the exogeneity of labor market experience and the straight-time hourly wage as instruments of the price of leisure time. We do not see significant demographic effects, with the exception of the binary indicator of health status: on average, a disabled prime-age male works 6 per cent less hours in the market than a healthy male. Interestingly enough, the size of the Metropolitan Areas' population behaves as a significant determinant of the allocation of time: prime-age males work less when residing in more populated Metropolitan Areas, possibly because of the larger set of recreation activities available. In particular, the amount of market hours decreases, on average, 0.57 per cent when the population of a Metropolitan Area increases by one per cent.

The results in Table 1.2 also suggest that the EIS of market time with respect to the price of leisure time is larger than the EIS with respect to the price of recreation goods, even though we could not reject—at 95 per cent of significance level—that both are equal or even that the latter exceeds the former. As we pointed out in the discussion of the theoretical model, a positive EIS with respect to the price of recreation goods accompanied by a larger EIS with respect to the price of leisure time would be evidencing that either the share of the cost of leisure time in the total cost of recreation, ζ, is greater than one half, or that the elasticity at which recreation is intertemporally substituted, γ, is not much larger than the elasticity at which leisure time and recreation goods are contemporaneously substituted in the production of recreation, ρ. Moreover, given that the ratio of market time to leisure time for an average individual in our sample amounts to 0.58,[36] the estimated elasticities in Column 2 of Table 1.2 point to an estimate for γ of 0.17, while if we pay attention to the elasticities in columns 3 or 4, the suggested value of γ is 0.24. Since the estimated sign of the EIS with respect to the price of recreation goods is positive, the value of ρ must be lower than the value of γ we consider as more plausible.

[36] It is assumed that each individual disposes of 5,824 annual hours—16 daily hours times 7 days a week times 52 weeks a year—to be allocated between work in the market and leisure, while the average amount of hours worked by an individual in our sample is 2,140.

1.5.2 Marginal Rate of Substitution Equation for Labor Supply

We now turn to discuss the results of estimating the Marginal Rate of Substitution equation established in Eq. (1.28). They are displayed in Table 1.3. The expenditures in other consumption goods are proxied by means of the food expenditures measure available in the PSID. Since this variable was not asked in the interview years 1988 and 1989, we can not utilize the observations corresponding to those years. The unobserved heterogeneity present at Eq. (1.28), is proxied by means of a race binary indicator and a variable measuring the years of schooling completed by each sampled individual. *Nonwhite* takes on value 1 when the individual declares to be non-white, while *Education* codifies the highest grade finished.

The first column of Table 1.3 shows the output of a simple Pooled OLS estimation. The sign of the estimated coefficients associated to the price of leisure time and expenditures in other consumption goods are not those theoretically expected, what could be due to the measurement errors affecting both variables. To get consistent estimates of the parameters in Eq. (1.28), we attempt an instrumental variables strategy: in columns 2 and 3, the price of leisure time and expenditures in other consumption goods are instrumented with an individual-specific permanent component of the wage and ϖ. In Column 2, the individual-specific permanent component of the wage was obtained, following Altonji (1986), from a regression of ϖ on dummy variables for each individual and other time-varying variables like human capital and health status controls. Since years of schooling completed is revealed to be not statistically different from zero in the set of estimates given in Column 2, it is utilized as the individual-specific permanent component of the wage in Column 3.

TABLE 1.3

LABOR SUPPLY ESTIMATES USING FOOD CONSUMPTION AS A PROXY FOR λ_i (See Eq. [1.28])

	(1)	(2)	(3)
$\ln P_{jt}$	0.0673	0.1273	0.1417*
	(0.0709)	(0.0850)	(0.0837)
$\ln W_{it}$	-0.0502***	0.0765	0.0969**
	(0.0158)	(0.0522)	(0.0445)
LnC_{it}	0.0972***	-0.1454	-0.1931
	(0.0129)	(0.1511)	(0.1360)
Age	0.0060	0.0134**	0.0132**
	(0.0045)	(0.0065)	(0.0061)
Age^2	-0.0001	-0.0002**	-0.0002**
	(0.0001)	(0.0001)	(0.0001)
Married	0.0460***	0.0671***	0.0753***
	(0.0150)	(0.0253)	(0.0241)
No. Children	0.0133	-0.0027	-0.0025
	(0.0090)	(0.0114)	(0.0113)
$(No. Children)^2$	-0.0018	-0.0020	-0.0025
	(0.0013)	(0.0016)	(0.0016)
Family size	-0.0094	0.0248	0.0309
	(0.0059)	(0.0208)	(0.0190)
Bad health	-0.1107***	-0.1027***	-0.1019***
	(0.0204)	(0.0208)	(0.0207)
Nonwhite	-0.0222**	-0.0464**	-0.0498**
	(0.0102)	(0.0206)	(0.0195)
Education	0.0059**	0.0015	—
	(0.0023)	(0.0026)	
LnPopulation	0.0744	-0.0202	-0.0350
	(0.0494)	(0.0847)	(0.0815)
Intercept	6.0585***	7.8150***	8.1809***
	(0.4480)	(1.2934)	(1.1984)
Observations	7,506	7,506	7,506

NOTE.— All regressions include Metropolitan Area dummies. In Column (2), $\ln W_{it}$ and $\ln C_{it}$ are instrumented with an individual-specific permanent component of the wage and the straight-time hourly wage asked of those workers paid hourly. In Column (3), $\ln W_{it}$ and $\ln C_{it}$ are instrumented with years of schooling and the straight-time hourly wage. Heteroskedasticity and autocorrelation within panels robust standard errors in parentheses. Standard errors **corrected** for the presence of generated regressors. * significant at 10%; ** significant at 5%; *** significant at 1%

The EIS of market time with respect to the price of recreation goods is estimated to be, again, positive and of a size similar to those previously obtained. This empirical regularity should increase our confidence in the results since, irrespective of the specification utilized and of the sample size available, the sign of this elasticity remains the same and its magnitude does not show abrut variations. Moreover, it is again statistically different from zero—at 10 per cent of significance level—in one of the estimations.

The estimated coefficients associated with the price of leisure time and expenditures in other consumption goods have now the sign predicted by the theory. Although the magnitude of the estimated coefficients in columns 2 and 3 are quite similar, we should emphasize those in Column 3, since we reject—at the 5 per cent of significance level—the exogeneity of the instruments suggested by Altonji (1986) utilized in Column 2.[37] Regarding other demographic effects, we observe that the age and marital status of the individual are now significant explanatory variables, and that, on the contrary, the population of each Metropolitan Area has become irrelevant. Even though these changes could be due to the different sample sizes underlying the regressions contained in tables 1.2 and 1.3, they are more likely due to the different nature of the confounding factors they are controlling for. As before, however, the health status of the individual exerts a non-trivial influence on the allocation of time. Besides, the race binary indicator is statistically different from zero: a non-white individual works, on average, 5 per cent less hours in the market than a white male of similar characteristics.

[37] The p-values associated with the J statistic of Hansen (1982) are 0.04 for the instruments considered in Column 2, and 0.73 for the instruments in Column 3.

Notice, finally, that our previous conclusions regarding the behavioural parameters ζ, γ, and ρ are now partially modified. Although the estimated EIS of market time with respect to the price of recreation goods provides further evidence bearing out that γ is larger than ρ, the relationship between this estimated elasticity and the EIS with respect to the price of leisure time indicates than ζ should be lower than one half and γ much larger than ρ—by a factor of $\frac{2(1-\zeta)}{(1-2\zeta)}$, at least. Besides, the suggested values for γ are now 0.12 with the estimates given in Column 2 of Table 1.3, and 0.14 with the estimates in Column 3. Even though important from the behavioural point of view, this lack of agreement should not be overemphasized since, on one hand, it does not invalidate the theoretical model and, on the other hand, it is compatible with the main conclusions regarding sign, magnitude, and statistically significativeness of the EIS of market time with respect to the price of recreation goods.

1.6 Concluding Remarks

This chapter, by conceiving leisure time and recreation goods as non-separable in the preference ordering of the individual, has extended a standard model of intertemporal choice to analyze the effect caused by the price of recreation goods on the allocation of market time over the life-cycle. The model predicts that the elasticity of intertemporal substitution of market time with respect to the price of recreation goods may be positive or negative, depending crucially on the rate at which recreation is substituted across periods of time and the rate at which leisure time and recreation goods may be contemporaneously substituted.

The combination of individual-level data for the population of U.S. prime-age males with indices of prices of recreation goods at the level of U.S. Metropolitan Areas, has allowed the estimation of this elasticity, that was found to be:

1. Positive, meaning that prime-age males change the age at which they recreate more readily than they change the sort of recreation activities consumed, a behaviour that could be reflecting the existence of habits in the recreation activities usually engaged in.

2. Of a magnitude around 0.15, meaning that a prime-age male working two thousand hours a year will work 3 hours more when faced with a one percent increase in the price of recreation goods. This magnitude brings out another margin of substitution of work effort along time that could be of relevance for business cycle and growth theory.

3. Statistically different from zero at standard significance levels, what rejects the contemporaneous separability between leisure time and recreation goods in the preference ordering of the individual assumed in most of the life-cycle literature.

1.A Sample Selection Criteria

This appendix lists the selection criteria for the sample used in the empirical analysis. Marginal losses of person-years are given for each criterion.

We started downloading data from the PSID for the interview years 1976 to 1993. There are a total of 53,013 persons, with 26,095 declaring being males. For these, only observations of heads (374,682 person-years lost), present in the household at the moment of the interview (2,117 person-years lost), and with known age (4 person-years lost) were kept. 23,807 observations were dropped because they corresponded to person-years not living in a U.S. Metropolitan Area, and 30,222 observations were deleted because the corresponding person resided in a Metropolitan Area for which price indices were not available. Observations for male heads residing in Miami in 1976 were dropped because the indices needed to construct the price of recreation goods were not available there until 1977 (43 person-years deleted). After these changes, a total of 38,835 observations were available.

Since the question regarding total annual hours of market work refers to the calendar year previous to the year of the interview, we lagged one year most of the variables to consistently assign data to the year in which the hours of market work were supplied—a total of 6,049 person-years were deleted. After this change, we applied the following criteria: (1) Only observations of individuals between 25 and 60 years old (person-years lost: 6,979). (2) Total annual hours of market work must be positive and no greater than 4,860 (person-years lost: 1,749). (3) Observations for which annual earnings are zero or unknown were dropped (person-years lost: 118). (4) Total annual hours of market work must not rise by more than 250 percent or fall by more than 60 percent from the preceding year, and the absolute change in hours must be less than 3,000 (person-years lost: 751). (5) The real hourly wage, calculated as real annual earnings—in terms of food plus beverages, housing and transportation—divided by total annual hours of market work, must exceed \$0.96 and be lower than \$600—in 1982-84 dollars—, must not rise by more than 250 percent or fall by more than 60 percent from the preceding year, and must not change from the preceding year by more than \$31 (person-years lost: 692). (6) Observations for which the marital status, the educational attainment, or the health status of the person were not available, were dropped (person-years lost: 0, 143, and 38, respectively). The surviving sample consisted of 3,742 persons and 22,316 person-years.

When food expenditures is added as explanatory variable, criterion (5) is applied over a real hourly wage calculated in terms of food plus beverages only (person-years lost: 690), criterion (6) is complemented by dropping observations with invalid codification for race (person-years lost: 80), and an additional sample selection criterion is that real food expenditures must not rise by more than 250 percent or fall by more than 60 percent from the preceding year, and it must not be missing or zero (person-years lost: 3,430). The surviving sample contained 3,651 persons and 18,808 person-years.

In our opinion, the concern with the representativeness of the results obtained for the population of U.S. prime-age males emerges mainly from the geographic selection criterion described above. To study this question, we have performed standard difference in means and proportions tests for the distributions of some variables in the selected sample (22,316 observations) and in the sample of observations dropped because they corresponded to a male living in a Metropolitan Area without the necessary price indices (30,905 observations). Thus, the average number of hours worked in the market in the selected sample is 2,140 (standard error 590.1), while in the sample of dropped observations is 2,203 (s.e. 616.7); it is rejected, at the 1% of significance level, that mean market hours in both populations are the same. The same occurs with the real hourly wage rate—\$13.18 (s.e. 9.00) in the selected sample, while only \$10.17 (s.e. 6.57) in the sample dropped, both figures in dollars of 1982-84—, and completed education—13.21 years (s.e. 2.86) versus 12.62 years (s.e 2.77), respectively. The proportion of observations of married males in the selected sample is 0.835 (s.e. 0.371), while is 0.873 (s.e. 0.333) in the dropped sample of observations, rejecting the equality of population proportions at the 1% of significance level. This, of course, limits the generality of the findings in this study.

1.B The Model with Uncertainty

This appendix aims at developing the decision-making model presented in the main text under the more realistic assumption of uncertain future prices and tastes. The presence of uncertainty will be handled within the framework of the expected utility theory. In what follows, it is assumed that current prices and tastes are revealed at the beginning of each time period, and that the consumer has rational expectations regarding future prices and tastes. The notation is essentially the same as in Section 1.2.

The problem of an individual at age t consists in maximizing

$$\mathrm{E}_t\left\{\sum_{\tau=t}^{T}\frac{1}{(1+\delta)^{\tau-t}}\left(\frac{C_{i\tau}^{*1-\frac{1}{\theta}}-1}{1-\frac{1}{\theta}}+\psi_{i\tau}\left[\frac{1}{1-\frac{1}{\gamma}}\left(X_{i\tau}^{1-\frac{1}{\rho}}+\alpha_{i\tau}L_{i\tau}^{1-\frac{1}{\rho}}\right)^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}}\right]\right)\right\} \tag{1.B.1}$$

subject to

$$A_{i\tau+1}=(1+r_\tau)\,A_{i\tau}+W_{i\tau}^{*}\,(1-L_{i\tau})-C_{i\tau}^{*}-P_{i\tau}X_{i\tau},\quad \tau=t,...,T, \tag{1.B.2}$$

$$C_{i\tau}^{*},X_{i\tau},L_{i\tau}\geq 0,\quad \tau=t,...,T, \tag{1.B.3}$$

and

$$A_{iT+1} \geq 0, \tag{1.B.4}$$

where E_t represents the expectational operator taken with all the information available at time t and A_{it} is given.

This problem can be re-formulated using the Bellman's Principle of Optimality:[38]

$$V_i\left(A_{it}, t\right) = \max_{\left\{C^*_{it}, X_{it}, L_{it}, A_{it+1}\right\}} \left\{ \begin{array}{c} \frac{C_{it}^{*1-\frac{1}{\theta}}-1}{1-\frac{1}{\theta}} + \psi_{it}\left[\frac{1}{1-\frac{1}{\gamma}}\left(X_{it}^{1-\frac{1}{\rho}} + \alpha_{it} L_{it}^{1-\frac{1}{\rho}}\right)^{\frac{1-\frac{1}{\gamma}}{1-\frac{1}{\rho}}}\right] + \\ + \frac{1}{(1+\delta)} E_t V_i\left(A_{it+1}, t+1\right) \end{array} \right\} \tag{1.B.5}$$

subject to

$$A_{it+1} = \left(1+r_t\right) A_{it} + W^*_{it}\left(1-L_{it}\right) - C^*_{it} - P_{it} X_{it} \tag{1.B.6}$$

and

$$C^*_{it}, X_{it}, L_{it} \geq 0. \tag{1.B.7}$$

$V_i\left(A_{it}, t\right)$ represents the maximum attainable utility from period t on by individual i given initial resources A_{it}. Assuming an interior optimum, the optimality conditions are characterized by the budget constraint in Eq. (1.B.6) and the next set of first order conditions:

$$C_{it}^{*\frac{-1}{\theta}} = \lambda_{it}, \tag{1.B.8}$$

38 See, for instance, Dixit (1990).

$$\psi_{it}\Omega_{it}X_{it}^{\frac{-1}{\rho}} = \lambda_{it}P_{it}, \tag{1.B.9}$$

$$\psi_{it}\Omega_{it}\alpha_{it}L_{it}^{\frac{-1}{\rho}} = \lambda_{it}W_{it}^{*}, \tag{1.B.10}$$

$$\frac{1}{(1+\delta)}E_t\left\{\lambda_{it+1}\left(1+r_{t+1}\right)\right\} = \lambda_{it}, \tag{1.B.11}$$

where, again,

$$\Omega_{it} = \left(X_{it}^{1-\frac{1}{\rho}} + \alpha_{it}L_{it}^{1-\frac{1}{\rho}}\right)^{\frac{\frac{1}{\rho}-\frac{1}{\gamma}}{1-\frac{1}{\rho}}}, \tag{1.B.12}$$

λ_{it} is the marginal utility of period t wealth of individual i, and in Eq. (1.B.11)—the intertemporal optimality condition—we made use of the Envelope Theorem.

As emphasized by MaCurdy (1983) and Altonji (1986), the introduction of uncertainty into intertemporal models of choice has a significant theoretical consequence: the marginal utility of wealth, which is constant in a perfect foresight model, is now steadily updated as new information becomes available to the individual, who tries to equalize the suitably discounted marginal utilities of wealth across periods of time—condition (1.B.11). This theoretical complexity has repercussions on the empirical strategy utilized to estimate the response of market hours to anticipated price change: on one hand, it is needed to transform the data by first-differencing the observations corresponding to each individual, reducing, as a consequence, the size of the available sample. On the other hand, the impossibility to correctly anticipate prices and tastes, will generate a forecast error that will be correlated with all contemporaneously dated variables, and, as a consequence, it is necessary to instrument these variables in order to consistently assess the effect they exert on the allocation of work effort.

To see this, notice that the intertemporal labor supply function is:[39]

[39] The analysis that follows considers in detail the specification and estimation method of the Euler equation

$$N_{it}^{*}=1-\psi_{it}^{\gamma}\left(\frac{W_{it}^{*}}{\alpha_{it}}\right)^{-\rho}\left(P_{it}^{1-\rho}+\alpha_{it}^{\rho}W_{it}^{*1-\rho}\right)^{\frac{\rho-\gamma}{1-\rho}}\lambda_{it}^{-\gamma}. \tag{1.B.13}$$

This equation is essentially the same as Eq. (1.10) and, therefore, the elasticities of intertemporal substitution (EIS) given in (1.11) and (1.12) continue to be valid. By taking a log-linear approximation to Eq. (1.B.13) around the individual equilibrium, we would get

$$\ln N_{it}^{*}=\beta_0+\beta_1\ln P_{it}+\beta_2\ln W_{it}^{*}+\beta_3\ln\psi_{it}+\beta_4\ln\alpha_{it}+\beta_5\ln\lambda_{it}, \tag{1.B.14}$$

while by assuming that the functional forms for taste-shifters and measures of hours and prices given in the main text are appropriate, the alternative estimating equation becomes

$$\ln N_{it}=\beta_0+dMA_{it}+\bar{\beta}_1\ln P_{jt}+\beta_2\ln W_{it}+\mathbf{y}_{it}'\boldsymbol{\phi}+\beta_5\ln\lambda_{it}+a_i+e_{it}, \tag{1.B.15}$$

where $\bar{\beta}_1 \equiv \beta_1\tau$, $\boldsymbol{\phi} \equiv \left(\boldsymbol{\phi}^{\psi}\beta_3+\boldsymbol{\phi}^{\alpha}\beta_4\right)$, $a_i \equiv \left(\beta_3 y_i^{\psi}+\beta_4 y_i^{\alpha}\right)$, $e_{it} \equiv \left(\beta_3\xi_{it}^{\psi}+\beta_4\xi_{it}^{\alpha}+e_{it}^{N}+\beta_1 e_{it}^{P}-\beta_2 e_{it}^{W}\right)$, and dMA_{it} stands for the set of Metropolitan Area of residence dummies.

Taking a first-differences transformation within the observations belonging to the same individual and using Eq. (1.B.11) to eliminate $\ln\lambda_{it}-\ln\lambda_{i(t-1)}$,[40] we get:

$$\begin{aligned}D\ln N_{it} &= DdMA_{it}+\bar{\beta}_1 D\ln P_{jt}+\beta_2 D\ln W_{it}+D\mathbf{y}_{it}'\boldsymbol{\phi}\\ &\quad+\beta_5\left(\delta-r_t\right)+De_{it}+u_{it},\end{aligned} \tag{1.B.16}$$

for labor supply. The Marginal Rate of Substitution equation remains exactly the same as in the model under perfect certainty and, therefore, its empirical specification, estimation method, and associated set of results have not changed.

[40] See Altonji (1986).

where D represents the first-differences operator and u_{it} is a forecast error correlated with contemporaneous regressors but orthogonal to information dated previously if individuals have rational expectations. As a consequence, all variables contemporaneously dated with the forecast error need to be instrumented. $D \ln W_{it}$ is instrumented with, on one hand, the first differences in labor market experience, and, on the other hand, the first differences of the straight-time hourly wage of those workers paid hourly, ϖ. To avoid the correlation with the forecast error, we follow Arellano and Bond (1991) and instrument $D \ln P_{jt}$ with suitable lags of $\ln P_j$.[41] This identification strategy, however, is not fully reliable since we shall find evidence of autocorrelation in the idiosyncratic error of Eq. (1.B.15), and the estimation output should be taken cautiously.

The results of estimating Eq. (1.B.16) by the difference GMM estimator of Arellano and Bond (1991) are given in Table 1.B.1. A time trend specific to each Metropolitan Area and the first differences of the natural logarithm of the population of each area were added to the set of explanatory variables in the hope to control for, respectively, spatial differences in the subjective and market discount rates and the simultaneity bias associated with the extend of the market for recreation. In Column 1 of Table 1.B.1 the price of leisure time is instrumented with labor market experience squared, while in Column 2 ϖ is the instrument utilized. Although the Hansen (1982) test of overidentifying restrictions does not invalidate our sets of instruments—p-values 0.39 and 0.19, respectively—, we detect the existence of second-order serial correlation in the residuals of Eq. (1.B.16) that casts doubts on the consistency of the GMM estimator.[42]

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41 We utilize all available lags of $\ln P$ dated $t-2$ or earlier.

42 The value of the m_2 statistic given by Arellano and Bond (1991) is -3.51 and -2.40, respectively.

TABLE 1.B.1

FIRST-DIFFERENCE EQUATIONS FOR LABOR SUPPLY (Dependent Variable = $D\ln N_{it}$)

	(1)	(2)
$D\ln P_{jt}$	0.0999	0.2555***
	(0.0645)	(0.0943)
$D\ln W_{it}$	0.0879	0.0803
	(0.0576)	(0.0528)
Dage	0.0076	0.0109
	(0.0073)	(0.0100)
$DAge^2$	-0.0001*	-0.0002*
	(0.0001)	(0.0001)
Dmarried	-0.0037	-0.0280
	(0.0119)	(0.0183)
Dchildren	0.0058	0.0032
	(0.0080)	(0.0126)
$DChildren^2$	0.0007	0.0017
	(0.0016)	(0.0023)
DFamily size	-0.0035	0.0010
	(0.0043)	(0.0064)
DBad health	-0.0036	0.0001
	(0.0086)	(0.0122)
DlnPopulation	-0.4740**	-1.3328
	(0.2107)	(1.0019)
Observations	17,587	5,899

NOTE.— *D* denotes the first-differences operator. All regressions include Metropolitan Area (MA) dummies and a time trend specific to each MA. $D\ln P_{jt}$ is instrumented with lags of lnP dated (t-2) or earlier. In Column (1), $D\ln W_{it}$ is instrumented with the change in labor market experience squared, while in Column (2) it is instrumented with the change in the straight-time hourly wage of those workers paid hourly. Heteroskedasticity and autocorrelation within panels robust standard errors in parentheses. Standard errors **corrected** for the presence of generated regressors. * significant at 10%; ** significant at 5%; *** significant at 1%

Regarding our main parameters, perhaps the more significant conclusion we could reach is that the estimated EIS of market time with respect to the price of recreation goods continues to be positive, although its estimated magnitude varies a lot, and the estimates offered in Table 1.B.1 occupy the extremes of the range of possible values obtained in this chapter.

1.C A Brief Comment on the Price of Recreation Goods as a Determinant of Males' Other Uses of Time

The terms leisure time and non-market time are treated as synonymous in this chapter. Actually, however, they refer to different categories of time: in time-use studies, non-market time is usually conceived as made up of housework, personal care, and leisure time.[43] There would exist the possibility that changes in the price of recreation goods were affecting market time while leaving leisure time intact.

For a population and time period close to the ones analyzed in this study, the American's Use of Time Project (see Robinson and Godbey [1997]) reports that an employed male between 18-64 years old devoted in 1965 46.5 weekly hours to market work, 11.1 to housework, 77.4 to personal care, and 33.0 to leisure. The corresponding figures for 1985 are 39.7, 14.5, 77.5, and 36.3 weekly hours. Thus, time devoted to personal care seems to have been constant while the price of recreation goods in terms of other consumption goods has dropped approximately 20% between both years.[44] This finding should not

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43 See, for instance, Juster and Stafford (1991), Robinson and Godbey (1997), Gershuny (2000), and National Research Council (2000).

44 See Figure 3.2.

surprise us, since the main item of personal care, sleep, makes this category roughly constant along time.[45]

A variable provided by the University of Michigan Panel Study of Income Dynamics measuring the time devoted to housework by the head of the household, gives the possibility to check whether housework is affected by the price of recreation goods. This variable is the annualized version of the usual weekly hours of housework in the week of the survey. It was regressed on the explanatory variables included in the structural equation for market time: the price of recreation goods, the price of leisure time, time-varying taste controls like age, marital status, number of children in the family unit, family size, and health status, plus a time trend. The estimation methods were OLS, Tobit—since near 15% of the observations reported zero hours of housework—, and Fixed Effects. The price of recreation goods was not statistically different from zero at 10% of significance level in any of the estimations. This conclusion should justify the initial statement of this appendix.

45 Although see Biddle and Hamermesh (1990).

Chapter 2 of my Ph. D. Thesis is based on the following article:

González Chapela, J. Recreation, home production, and intertemporal substitution of female labor supply: Evidence on the intensive margin. Review of Economics Dynamics. 2011 [article in press]

Chapter 2
On the Price of Recreation Goods as a Determinant of Female Labor Supply

2.1 Motivation

This chapter studies from an empirical point of view the effect exerted by the price of recreation goods on the intensive margin of labor supply of prime-age females.[46] The individualistic dynamic decision-making model developed and tested for the population of prime-age males in the previous chapter, has found the price of recreation goods as a significant determinant of the allocation of time. It is well known that estimates of the female elasticity of intertemporal substitution of market time with respect to the price of leisure time have shown to be systematically larger than those found for males,[47] and we would like to know whether this different behaviour extends to the response caused by alterations in the price of goods consumed in conjunction with leisure time.

The estimation of the structural equation governing the amount of hours worked in the market by part of prime-age females, will take into account three sources of endogeneity affecting the parameter estimates: unobserved heterogeneity, selection bias, and measurement error. As we saw, the Frisch labor supply function derived from intertempo-

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[46] In addition to the advice received from the people referenced in the acknowledgments, this chapter has also benefited from the advice and encouragement provided by Sergi Jiménez Martín.

[47] See, for males' estimates, the surveys by Card (1994) and Blundell and MaCurdy (1999). For females' estimates, in addition to the latter reference, see also Heckman and MaCurdy (1980, 1982), Hotz and Miller (1988), and Mulligan (1999).

ral models of choice includes as a regressor the marginal utility of wealth, which, under the assumption of perfect foresight, is a time constant unobserved individual effect correlated with prices and tastes in all time periods. Besides, the intertemporal labor supply function describes the behaviour of those individuals in the population who participate in the labor market; if this sub-population is non-randomly drawn from the overall population, straightforward regression analysis leads to inconsistent parameter estimates. Finally, we must take into account that the empirical counterpart of some model's regressors suffer from classical measurement error.

To simultaneously solve these three endogeneity problems, an extension of the Wooldridge (1995) estimator correcting for selection bias in panel data models is utilized. Although this estimator is presented under the assumption of strict exogeneity of the model's regressors, our extended version cope with the presence of endogenous regressors in the structural equation after having corrected the unobserved heterogeneity and selection bias by making use of a generalized method of moments estimation procedure.

There exist other estimators particularly designed to correct for selection bias in panel data contexts, like those proposed by Kyriazidou (1997) and Rochina-Barrachina (1999). While Wooldridge (1995) models the conditional means of the unobserved heterogeneity and the idiosyncratic error in the main equation, Kyriazidou (1997) and Rochina-Barrachina (1999) difference out the unobserved heterogeneity in the structural equation and then, either model the conditional mean of the differenced idiosyncratic error—as in Rochina-Barrachina (1999)—, or match pairs of observations for a given individual for whom this conditional expectation is zero—as in Kyriazidou (1997). Apart from this methodological difference determining the sample size used in the estimations, the Wooldridge (1995) estimator is preferred on the grounds of its similarity with the classic Heckman (1979) sample selection two-stage estimator and its computational simplicity: only normality of the errors in the selection equation and a linear conditional mean assumption of the errors in the main equation are required, and thus, only a probit estimation followed by a linear regression are needed to, under valid identification assumptions, obtain consistent estimates of the structural parameters.

Not many applications of these estimators exist in the literature. Askildsen, Baltagi, and Holmås (2002) use the estimator proposed by Kyriazidou (1997) to estimate the wage elasticity of nurses' labor supply, while Dustmann and Rochina-Barrachina (2000) compare the three estimators in the analysis of females' wage equations. This thesis pretends to contribute to this literature by estimating elasticities of intertemporal substitution for the intensive margin of females' labor supply.

The chapter proceeds as follows. Section 2.2 discusses the empirical specification of the structural and participation equations plus the econometric methodology. In Section 2.3 we discuss the empirical results, with Section 2.4 offering some concluding remarks. Supporting materials, including an alternative formulation of the structural equation, are relegated to appendices.

2.2 Empirical Model

2.2.1 Structural Equation for Labor Supply

In the previous chapter, we conceived the intertemporal allocation of time between work in the market and leisure as the outcome of the constrained optimization of a preference ordering characterized by block-additivity across periods of time and contemporaneous non-separability between leisure time (L) and recreation goods (X).[48] Such allocative behaviour is governed by the intertemporal budget constraint in Eq. (1.2) and the next set of first order conditions:

$$
\begin{aligned}
\frac{1}{(1+\delta)^t} C_{it}^{*\frac{-1}{\theta}} &= \lambda_i R_t, && (2.1)\\
\frac{1}{(1+\delta)^t} \psi_{it} \Omega_{it} X_{it}^{\frac{-1}{\rho}} &= \lambda_i R_t P_{it}, && (2.2)\\
\frac{1}{(1+\delta)^t} \psi_{it} \Omega_{it} \alpha_{it} L_{it}^{\frac{-1}{\rho}} &\geq \lambda_i R_t W_{it}^{*}, && (2.3)
\end{aligned}
$$

where Ω_{it} was defined in Eq. (1.8). Hereafter, i distinguishes individuals and t indicates periods of time. C^* denotes expenditures in other consumption goods, λ stands for the marginal utility of wealth, and P and W^* represent, respectively, the price of recreation goods and the price of leisure time in units of other consumption goods. ψ and α are taste-shifters, with δ and R standing for, respectively, the subjective and market discount rates. Finally, γ and ρ are behavioural parameters assumed constant across individuals:

[48] In this chapter, leisure time and non-market time are treated as synonymous too. As in the case of males, we inquired about the price of recreation goods as a determinant of females' other uses of time. Thus, for instance, we regressed the time devoted to housework by each of the females included in our sample on the price of recreation goods, the price of leisure time, time-varying taste controls like age, marital status, number of children in different age intervals, family size, health status, and a time trend. The estimation methods were OLS and Fixed Effects. The price of recreation goods was not statistically different from zero at 10% of significance level in any of the estimations. Notice that the housework variable available in the Panel Study of Income Dynamics includes "time spent cooking, cleaning, and doing other work around the house", therefore not explicitly including child care.

the former reflects the elasticity at which the consumption of recreation activities may be intertemporally substituted, while the latter captures the elasticity of contemporaneous substitution between recreation goods and leisure time in the production of recreation.

Assuming an interior solution, the intertemporal labor supply function of those females whose wage offered exceeds the marginal utility of leisure time at full leisure—the reservation wage—is given by[49]

$$N_{it}^{*} = 1 - \psi_{it}^{\gamma} \left(\frac{W_{it}^{*}}{\alpha_{it}} \right)^{-\rho} \left(P_{it}^{1-\rho} + \alpha_{it}^{\rho} W_{it}^{*1-\rho} \right)^{\frac{\rho-\gamma}{1-\rho}} \left(\lambda_i \left(1+\delta\right)^t R_t \right)^{-\gamma}. \tag{2.4}$$

Taking a log-linear approximation around the individual equilibrium to Eq. (2.4), we get the Euler equation for labor supply:[50]

$$\begin{aligned} \ln N_{it}^{*} &= \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln W_{it}^{*} + \beta_3 \ln \psi_{it} + \beta_4 \ln \alpha_{it} \\ &\quad + \beta_5 \left(\textstyle\sum_{\kappa=0}^{t-1} \left(\delta - r_\kappa\right) \right) + \beta_5 \ln \lambda_i, \end{aligned} \tag{2.5}$$

where, as in the previous chapter, the population parameters β_1 and β_2 are the elasticities of intertemporal substitution of market time with respect to, respectively, the price of recreation goods and the price of leisure time. As before, the taste-shifter variables ψ and α are approximated by the log-linear functions given in Eqs. (1.17) and (1.18), respectively, while the differences between the subjective and market discount rates are controlled for by means of a time trend specific to each Metropolitan Area.

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49 The construction of an equivalent structural equation—the Marginal Rate of Substitution equation—, its corresponding empirical specification, and its estimation by related methods are discussed in Appendix 2.C.

50 We made use of the approximations $\ln(1+\delta) \approx \delta$ and $\ln(1+r_t) \approx r_t$.

As a consequence of these changes, our main equation becomes

$$\ln N_{it}^{*} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln W_{it}^{*} + \mathbf{y}_{it}'\boldsymbol{\phi} + \beta_5 t + c_i + \varepsilon_{it}, \tag{2.6}$$

where $\boldsymbol{\phi} \equiv (\boldsymbol{\phi}^{\psi}\beta_3 + \boldsymbol{\phi}^{\alpha}\beta_4)$, $c_i \equiv \left(\beta_5 \ln \lambda_i + \beta_3 y_i^{\psi} + \beta_4 y_i^{\alpha}\right)$, and $\varepsilon_{it} \equiv \left(\beta_3 \xi_{it}^{\psi} + \beta_4 \xi_{it}^{\alpha}\right)$. Using a more compact notation, it may be rewritten as

$$\ln N_{it}^{*} = \beta_0 + \mathbf{x}_{it}^{*\prime}\boldsymbol{\beta} + c_i + \varepsilon_{it}, \tag{2.7}$$

with $\mathbf{x}^{*} \equiv (\ln P, \ln W^{*}, \mathbf{y}', t)'$ and $\boldsymbol{\beta} \equiv (\beta_1, \beta_2, \boldsymbol{\phi}', \beta_5)'$. It is assumed that $E\left(\varepsilon_{it} | \, c_i, \mathbf{x}_i^{*}\right) = 0$, where $\mathbf{x}_i^{*} \equiv (\mathbf{x}_{i1}^{*\prime}, ..., \mathbf{x}_{iT}^{*\prime})$.

2.2.2 Selection Equation

Following Heckman (1974b), a female participates in the labor market when the—assumed exogenous—offered wage, W^{*}, exceeds the reservation wage, W^{R}. As may be deduced from Eqs. (2.2) and (2.3), the reservation wage is an implicit function of tastes, discount rates, prices of recreation goods, and the marginal utility of wealth. Therefore, the propensity to participate in the labor market is modeled by means of a linear latent index that includes an unobserved time-constant individual effect assumed correlated with the model's regressors:

$$h_{it}^{*} = \mathbf{z}_{it}'\boldsymbol{\varphi} + \epsilon_i + a_{it}, \tag{2.8}$$

$$s_{it} \equiv 1\left[h_{it}^{*} > 0\right], \tag{2.9}$$

where, as usual, $1[.]$ is an indicator function which is equal to one if its argument is true and zero otherwise. Notice that the notation for the vector of regressors in the selection equation, $\mathbf{z}$, has changed with respect to the notation established in the main equation, $\mathbf{x}^*$. We do so in order to emphasize that in the empirical application that follows, only the instruments of the endogenous regressors in the structural equation (2.7) will appear in the reduced-form selection equation (2.8). We do not establish exclusion restrictions on the structural equation, since the theoretical model shows that the same set of prices and tastes determining the decision to participate in the labor market is considered when deciding the amount of hours supplied to the market. Although controversial, identification of the selection bias will be solely based on functional form.

It is assumed that (ϵ_i, a_{it}) is jointly normally distributed with $E(a_{it}) = 0$ and a_{it} independent of $\mathbf{z}_i \equiv (\mathbf{z}'_{i1}, ..., \mathbf{z}'_{iT})$. To allow ϵ_i to be correlated with $\mathbf{z}_i$, we specify, following Mundlak (1978),

$$\epsilon_i = \eta_0 + \bar{\mathbf{z}}'_i \boldsymbol{\eta} + f_i, \tag{2.10}$$

where $\bar{\mathbf{z}}_i$ is a vector of individual observations averaged across periods of time and f_i is independent of $\mathbf{z}_i$ with a zero mean normal distribution. The reason to prefer the Mundlak (1978) simplified specification to other popular specifications suggested by Chamberlain (1980) and Wooldridge (1995) is of a practical nature: in Chamberlain (1980) and Wooldridge (1995) the unobserved heterogeneity in the selection equation is not constrained to show identical partial correlations with the model's regressors in every time period and, as a consequence, $\mathbf{z}_i$ is included among the explanatory variables in Eq. (2.8).

In the application that follows, however, we are forced to restrict the partial correlations: since the available measure of the price of recreation goods does not show abrut variations from one period to another, it is highly predictable from its own observations in other periods, giving rise to a significant collinearity between differently dated P's that prevents us to assess the effect it exerts on the propensity to participate in the labor market.

Hence, the latent variable is rewritten as

$$h_{it}^{*} = \tilde{\mathbf{z}}_{it}'\mathbf{q} + v_{it}, \tag{2.11}$$

where $\tilde{\mathbf{z}}_{it} \equiv (1, \bar{\mathbf{z}}_i', \mathbf{z}_{it}')'$, $\mathbf{q} \equiv (\eta_0, \boldsymbol{\eta}', \boldsymbol{\varphi}')'$, and $v_{it} \equiv f_i + a_{it}$ has a zero mean normal distribution and is independent of $\mathbf{z}_i$.[51]

2.2.3 Correcting for Sample Selection with Panel Data

From now on, we assume the existence of N independently sampled individuals, each of whom reporting T_i observations.[52] N is large and T_i is small for all i. Given this data structure, to simultaneously correct for sample selection and unobserved heterogeneity we parameterize the conditional means of the idiosyncratic error and the unobserved heterogeneity of the Euler equation for labor supply as suggested by Wooldridge (1995):[53]

$$E\left(\varepsilon_{it} \middle| \mathbf{z}_i, v_{it}\right) = E\left(\varepsilon_{it} \middle| v_{it}\right) = \omega_t v_{it}, \tag{2.12}$$

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[51] As pointed out by Wooldridge (1995), unless a_{it} has a very specific type of autocorrelation, v_{it} is serially correlated across periods of time. Also, var(v_{it}) can change over time if var(a_{it}) does.

[52] Our panel dataset is unbalanced because of sample attrition (see the discussion in Note 28) and the sample selection criteria given in Appendix 2.B.

[53] The covariance between the idiosyncratic errors in the participation and main equations is not restricted to be constant across periods of time, reflecting the time series dimension of the longitudinal data at hand.

$$E\left(c_i|\,\mathbf{z}_i, v_{it}\right) = L\left(c_i|\,1, \mathbf{z}_i, v_{it}\right) = \pi_0 + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \iota_t v_{it}, \tag{2.13}$$

where $L\left(\cdot|\,\cdot\right)$ denotes the linear projection operator. Notice that using, again, the Mundlak (1978) simplification, we assume that c_i depends on $\mathbf{z}_i$ only through the time average. As a consequence:

$$E\left(\ln N_{it}^*|\,\mathbf{z}_i, v_{it}\right) = \tilde{\beta}_0 + \mathbf{x}_{it}^{*\prime}\boldsymbol{\beta} + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt} v_{it}, \tag{2.14}$$

with $\tilde{\beta}_0 \equiv \beta_0 + \pi_0$ and $\beta_{mt} \equiv (\omega_t + \iota_t)$. Since the binary selection indicator s_{it} depends exclusively on $\mathbf{z}_i$ and v_{it},

$$E\left(\ln N_{it}^*|\,\mathbf{z}_i, v_{it}\right) = E\left(\ln N_{it}^*|\,\mathbf{z}_i, v_{it}, s_{it}\right), \tag{2.15}$$

and, by the Law of Iterated Expectations,

$$\begin{aligned} E\left(\ln N_{it}^*|\,\mathbf{z}_i, s_{it}\right) &= \tilde{\beta}_0 + \mathbf{x}_{it}^{*\prime}\boldsymbol{\beta} + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt} E\left(v_{it}|\,\mathbf{z}_i, s_{it}\right) \\ &= \tilde{\beta}_0 + \mathbf{x}_{it}^{*\prime}\boldsymbol{\beta} + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt} E\left(v_{it}|\,s_{it}\right), \end{aligned} \tag{2.16}$$

the second equality obtained under the assumption that v_{it} is independent of $\mathbf{z}_i$. Then, the model that applies to the observations in our sample is

$$\begin{aligned} E\left(\ln N_{it}^*|\,\mathbf{z}_i, s_{it} = 1\right) &= \tilde{\beta}_0 + \mathbf{x}_{it}^{*\prime}\boldsymbol{\beta} + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt} E\left(v_{it}|\,s_{it} = 1\right) \\ &= \tilde{\beta}_0 + \mathbf{x}_{it}^{*\prime}\boldsymbol{\beta} + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt} E\left(v_{it}|\,v_{it} > -\tilde{\mathbf{z}}_{it}'\mathbf{q}\right). \end{aligned} \tag{2.17}$$

Assuming now that $E\left(v_{it}^2\right) = 1$, we have

$$E\left(v_{it}\right| v_{it} > -\tilde{\mathbf{z}}_{it}'\mathbf{q}) = \lambda_m\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right), \tag{2.18}$$

where $\lambda_m(\cdot)$ denotes the inverse of Mill's ratio.

Hence, the estimating Euler equation for labor supply after having controlled for unobserved heterogeneity and selection bias is

$$\ln N_{it}^* = \tilde{\beta}_0 + \mathbf{x}_{it}^{*\prime}\boldsymbol{\beta} + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt}\lambda_m\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right) + error_{it}. \tag{2.19}$$

2.2.4 Imperfect Measures

The variables needed to estimate this empirical model are suministered by the University of Michigan Panel Study of Income Dynamics (PSID) and the U.S. Bureau of Labor Statistics (BLS). Hours worked in the market, the price of leisure time, other demographic variables, and a Metropolitan Area of residence identifier, are suministered by the PSID,[54] while the BLS supplies the price indices needed to transform nominal variables to real terms and to construct the price index for recreation goods. See Section 1.3 for a description of these variables. A set of descriptive statistics for the sample of prime-age females used in this chapter is provided in Table 2.A.1 contained in Appendix 2.A.

Unfortunately, the strict exogeneity assumption of the model's regressors in the Euler equation for labor supply reveals as unsuitable once we consider the regressors' empirical counterparts: the questions included in the PSID utilized to construct the hours worked in the market and labor earnings measures, refer to the natural year previous to the moment of

54 The PSID also furnishes the variable with food expenditures utilized in the empirical application contained in Appendix 2.C.

the interview and, therefore, recall bias make hours and earnings to be subject to classical measurement error:

$$\ln N_{it} = \ln N_{it}^{*} + e_{it}^{N}, \tag{2.20}$$

$$\ln W_{it} = \ln W_{it}^{*} + e_{it}^{W}. \tag{2.21}$$

Besides, the price of recreation goods may not be observed at the individual level. Instead, it is approximated by the existing price at the level of the 27 U.S. Metropolitan Areas displayed in Figure 1.2:

$$\ln P_{it} = \tau \ln P_{jt} + e_{it}^{P}, \tag{2.22}$$

where j denotes Metropolitan Area of residence.

The Euler equation for labor supply in Eq. (2.19) rewritten in its extended form taking into account the imperfect measures of the dependent and independent variables is

$$\ln N_{it} = \tilde{\beta}_0 + dMA_{it} + \bar{\beta}_1 \ln P_{jt} + \beta_2 \ln W_{it} + \mathbf{y}_{it}'\boldsymbol{\phi} + \beta_5 t + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt}\lambda_m + \tilde{\varepsilon}_{it}, \tag{2.23}$$

where $\bar{\beta}_1 \equiv \beta_1\tau$, $\tilde{\varepsilon}_{it} \equiv \left(error_{it} + e_{it}^{N} + \beta_1 e_{it}^{P} - \beta_2 e_{it}^{W} + \pi_1 \bar{e}_i^{P}\right)$, and dMA_{it} stands for the set of Metropolitan Area of residence dummies.

As we discussed in the previous chapter, the measure of the price of leisure time constructed as real annual earnings divided by annual hours of market work, W, is correlated with the measurement error terms e^W and e^N. As a consequence, W is not included into $\mathbf{z}$. Since the price of leisure time is partially correlated in our sample with the price of recreation goods,[55] it is necessary a valid instrument for the former to consistently estimate the coefficient associated to the latter. Yet, it is not sufficient: since $\ln P_{jt}$ is only imperfectly correlated with $\ln P_{it}$, its associated coefficient, $\bar{\beta}_1$, is possibly attenuated with respect to the true one, β_1,[56] although if the economic agent's relevant market for recreation goods approaches the Metropolitan Area in which she resides, this bias should not be too significant. As we did in the case of prime-age males, we add the natural logarithm of the population of each Metropolitan Area to the set of explanatory variables of Eq. (2.23) in the hope to control for simultaneity bias.[57]

2.2.5 Identification and Estimation Method

To consistently estimate the parameters of the intertemporal labor supply equation written in Eq. (2.23), an instrumental variables strategy is pursued. In order to specify the set of instruments available, notice, firstly, that the error term $\tilde{\varepsilon}_{it}$ presents an autocorrelated structure that precludes us to instrument the price of leisure time either with its lags or with differences of its lags as in Arellano and Bover (1995): the heteroskedasticity-robust test for AR(1) serial correlation after Pooled OLS in the presence of non-strictly exogenous regressors,[58] clearly rejects the null hypothesis.[59] As a consequence, we must rely on ex-

55 The estimated partial correlation coefficient amounts to 0.48, robust s.e. 0.08.

56 See Geronimus, Bound, and Neidert (1996).

57 We lack a valid excluded instrument for P_{jt} and, as shown below, the autocorrelated structure of the idiosyncratic error in Eq. (2.23) precludes us to utilize any lag or lead of this variable to instrument it.

58 See Wooldridge (2002, Ch. 7).

59 The estimated AR(1) coefficient is 0.72, robust s.e. 0.01. Although the autocorrelated structure of the idiosyncratic error in Eq. (2.23) may be a consequence of the term $\bar{e}^P$ included in $\tilde{\varepsilon}_{it}$, such a sizeable serial correlation calls into question the dynamic completeness of the conditional mean in Eq. (2.17) and, therefore, the dynamic structure of the underlying theoretical model. We shall continue with the estimation of Eq. (2.23), even though a deep revision of the theoretical model at hand is among the topics of our research agenda.

cluded instruments: on one hand, accumulated labor market experience and, on the other hand, the straight-time hourly wage of those women who are paid on an hourly basis.

Labor market experience is constructed from the work history information available in the PSID for each women being surveyed.[60] Mroz (1987) does not reject the exogeneity of experience after controlling for self-selection into the labor force. The straight-time hourly wage, ϖ, proposed by Altonji (1986) as an alternative measure of the price of leisure time, is obtained from a question separate from those used to construct N and W and, thus, it is assumed that is uncorrelated with e^N and e^W. We shall verify the validity of both instruments when discussing the empirical results.

Hence, the estimation strategy of Eq. (2.23) is as follows. We first estimate $P\left(s_{it}=1|\,\mathbf{z}_i\right)=\Phi\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right)$ using standard probit. The vector $\mathbf{z}$ excludes W and includes, instead, its set of instruments.[61] For $s_{it}=1$, we compute the inverse of Mill's ratio $\lambda_m\left(\tilde{\mathbf{z}}_{it}'\hat{\mathbf{q}}\right)$, and then we estimate Eq. (2.23) by means of a two-step feasible generalized method of moments (GMM) procedure, with λ_m interacted with year dummies to allow for time-varying covariance between the residual in the selection equation and the unobservables in the main equation.

It is assumed that $\tilde{\varepsilon}$, the $\sum_{i=1}^{N} T_i \times 1$ vector of errors, has mean zero and covariance matrix Σ given by

$$\Sigma \equiv \begin{pmatrix} \Sigma_1 & & & & 0 \\ & \ddots & & & \\ & & \Sigma_m & & \\ & & & \ddots & \\ 0 & & & & \Sigma_N \end{pmatrix},$$

60 See Appendix 2.D for details on the construction of this variable.

61 Except when it is instrumented with the hourly wage, only observable for working females.

where Σ_m is a $T_m \times T_m$ intra-cluster unrestricted covariance matrix. Thus, while we assume that the N women are randomly sampled, we allow for autocorrelation and time series heteroskedasticity of arbitrary form in the $\tilde{\varepsilon}_{it}$.

If the instruments are relevant and valid, and if the GMM weighting matrix converges in probability to a positive definite matrix as $N \to \infty$, then the GMM estimator is consistent, $\sqrt{N}-$asymptotically normally distributed, an asymptotically efficient in the class of estimators given by the orthogonality condition

$$E\left(Z_i' \tilde{\boldsymbol{\varepsilon}}_i\right) = \mathbf{0}, \tag{2.24}$$

where Z_i is the $T_i \times l$ matrix of instrumental variables.[62]

The standard errors of the GMM vector of estimated parameters must be adjusted to take into account that we are conditioning on estimated parameters—those involved in the computation of the inverse of Mill's ratio. The asymptotic covariance matrix of the GMM estimator with generated regressors is given in Appendix 2.E.

2.3 Results

We now turn to the empirical results. They are displayed in Table 2.1, whose three columns of results share the method of estimation discussed above, but differ in the set of instruments for the price of leisure time: Column 1 utilizes the accumulated years of labor market experience and its square; the straight-time hourly wage of those females who are paid on an hourly scheme is utilized in Column 2, while Column 3 uses both. When the straight-

[62] See Wooldridge (2002, Ch. 8) for proofs and further discussion of these results.

time hourly wage is included among the instruments, the size of the available sample diminishes significatively, since the observations of those women who are not paid hourly are discarded. The estimation of behavioural parameters in samples of different size, provides us once more with the opportunity to assess the robustness of our model.

Apart from the prices of recreation goods and leisure time, the next set of variables is included among the regressors of the Euler equation for labor supply given in Eq. (2.23): age—in years—and its square, marital status—the variable *Married* takes on value 1 when the female is legally married or permanently cohabiting—,[63] number of children in the family unit—grouped in three different age intervals: 0-2, 3-5, and 6-17 years old—,[64] size of the family unit, health status—the variable *Bad health* takes on value 1 when the female has any physical or nervous condition that limits the type of work or the amount of work she can do—, Metropolitan Area dummies, a time trend specific to each Metropolitan Area,[65] the inverse of Mill's ratio obtained in a previous Pooled Probit regression,[66] and the set of individually averaged exogenous variables. The presence of the Metropolitan Area dummies and the time trends should mitigate the kind of misspecification discussed in

63 The marital status decision is considered here as exogenous, although see Van der Klaauw (1996).

64 In the PSID, all persons in the family unit younger than 18 years old are considered as children, irrespective of the family ties with the female being surveyed.

65 In columns 2 and 3 of Table 2.1, a unique time trend is included among the regressors. Possibly because of the curtailed sample size when leisure time is instrumented with the hourly wage of those women paid on an hourly scheme, if we had added a time trend specific to each Metropolitan Area the number of clusters would be insufficient to calculate the covariance matrix of the moment conditions.

66 The estimated probit coefficients are shown in Table 2.A.2 of Appendix 2.A. The last two columns of this table are the first-stage probits for the model with expenditures in other consumption goods added as explanatory variable discussed in Appendix 2.C. We see, in general, significant demographic effects, with the estimated coefficients showing the expected signs. Notice that in columns 2 and 3 of Table 2.A.2 the population of each Metropolitan Area behaves as a significant determinant of the probability of participating in the labor market. This result, however, should not be emphasized, since, as explained in the previous note, it is led by the absence of a time trend specific to each Metropolitan Area.

Moulton (1990). Besides, in the hope to control for simultaneity bias affecting the elasticity of intertemporal substitution (EIS) of market time with respect to the price of recreation goods, we have added the natural logarithm of the population of the Metropolitan Area in which each sampled female resides.

Before comment on the results, it is important to bear in mind the main predictions of the theoretical model developed in the previous chapter regarding the intertemporal allocation of work effort in response to anticipated price changes under the assumption of contemporaneous non-separability between leisure time and recreation goods. They might be summarized as follows. Firstly, the EIS of market time with respect to the price of leisure time must be positive, while the EIS of market time with respect to the price of recreation goods may be positive, negative, or even zero, depending on whether the elasticity at which recreation activities are intertemporally substituted, γ, is larger, lower, or equal than the elasticity at which leisure time and recreation goods are contemporaneously substituted in the production of recreation, ρ.[67] Secondly, if the EIS of market time with respect to the price of recreation goods is negative, it must be lower in absolute value than the elasticity with respect to the price of leisure time since, while in the former the intertemporal and contemporaneous margins of substitution move in opposing directions, in the latter both add up in the magnitude of the response.

[67] The EIS of market time with respect to the price of recreation goods is zero too when the share of the cost of leisure time in the total cost of recreation, ζ, approaches one.

TABLE 2.1

EULER EQUATION FOR LABOR SUPPLY

(Dependent Variable = $\ln N_{it}$)

	(1)	(2)	(3)
LnP_{jt}	-0.3598*	-0.1975	-0.1755
	(0.1897)	(0.1577)	(0.1395)
LnW_{it}	0.8716***	0.2274***	0.1768***
	(0.2966)	(0.0311)	(0.0337)
Age	-0.0159	0.0026	-0.0114
	(0.0169)	(0.0169)	(0.0166)
Age^2	0.0001	-0.00004	0.0001
	(0.0001)	(0.0001)	(0.0001)
Married	-0.0825***	-0.0313	-0.0057
	(0.0287)	(0.0367)	(0.0353)
Children [0-2]	-0.1227***	-0.1299***	-0.0828***
	(0.0305)	(0.0356)	(0.0308)
Children [3-5]	-0.0748***	-0.1167***	-0.0756***
	(0.0271)	(0.0302)	(0.0263)
Children [6-17]	-0.0421***	-0.0394***	-0.0240*
	(0.0147)	(0.0148)	(0.0141)
Family size	0.0198	0.0279**	0.0370***
	(0.0134)	(0.0130)	(0.0126)
Bad health	-0.0713***	-0.1121***	-0.0651**
	(0.0263)	(0.0312)	(0.0292)
LnPopulation	0.0472	0.1156	0.1869
	(0.4970)	(0.1911)	(0.1835)
Mill's	-0.6990***	0.1582	-0.0887
	(0.1084)	(0.1268)	(0.0916)
Intercept	7.7790**	8.1220***	7.6793***
	(3.0281)	(2.1257)	(2.0382)
Observations	19,191	7,731	7,731

NOTE.— All regressions include Metropolitan Area (MA) dummies, the individually-averaged exogenous explanatory variables, and the interaction of the inverse of Mill's ratio with year dummies. Regressions (2) and (3) include a time trend, while regression (1) includes a time trend specific to each MA. "$\ln W_{it}$" is instrumented with labor market experience and its square in Column (1), the straight-time hourly wage in Column (2), and both in Column (3). Heteroskedasticity and autocorrelation within panels robust standard errors in parentheses. Standard errors **corrected** for the presence of generated regressors (inverse of Mill's ratio). * significant at 10%; ** significant at 5%; *** significant at 1%

We now turn to discuss the results. The estimated coefficient associated to the price of recreation goods is invariably negative, suggesting that a prime-age female is more propense to contemporaneously substitute goods and leisure time in the enjoyment of recreation than to intertemporally substitute the consumption of recreation activities. That is, if an individual of this population anticipates that admissions to the cinema are going to increase in the next period, she prefers to read a book the next period rather than to attend the cinema this period. This behaviour is exactly the opposite of what is more likely in males of similar age. The absolute value of the estimated EIS of market time with respect to the price of recreation goods ranges from 0.36 to 0.18.[68] Although we could not reject at the 5% of significance level that the three point estimates are the same, this range of possible values entails non-trivial behavioural differences: an average prime-age female would reduce her annual hours of market work per unit of percentage increase in the price of recreation goods between 2 and 4 hours depending on what estimated elasticity we considered as more plausible. Moreover, the price of recreation goods reveals as a statistically significant determinant of the allocation of time only in Column 1 of Table 2.1, when the price of leisure time is instrumented with labor market experience and the whole sample of working females is used in the estimation.

Regarding the other estimated coefficients, the results show strong wage and demographic effects. The estimated EIS of market time with respect to the price of leisure time ranges from 0.87 to 0.18, depending on the set of instruments utilized. Although all instruments are revealed to be relevant,[69] not all are, however, valid: the value of the J statistic

68 As pointed out by Geronimus *et al.* (1996), however, this elasticity could be attenuated.

69 The values of the F-statistic to test for joint significance of the instruments in the first-stage regression are

of Hansen (1982) is 1.82—p-value 0.18—when the set of instruments is made up of labor market experience and its square, and 19.4—p-value 10^{-4}—when the wage rate is instrumented with experience and the straight-time hourly wage. Thus, the test of overidentifying restrictions discards the hourly wage of those women paid on an hourly basis as a valid instrument for the price of leisure time while, in the line of Mroz (1987), it does not reject labor market experience as a valid instrument, at least after having controlled for self-selection into the labor force. As a consequence, since P and W are partially correlated in the sample and the point estimate for β_2 is also affecting the point estimate for $\bar{\beta}_1$, the more reliable set of estimates is given in the first column of Table 2.1. They evidence elasticities of intertemporal substitution of market time with respect to the price of leisure time and the price of recreation goods of about, respectively, 0.87 and -0.36, that conform with the predictions of the theoretical model. These elasticities imply that an average prime-age female works near 10 annual hours more in the market when her real wage rate increases one per cent, and 4 hours less when the price of recreation goods increases one per cent. Both responses are larger in absolute value to those found in the case of males. Moreover, since the ratio of market time to leisure time for an average individual in our sample amounts to 0.25 and the estimated sign of the EIS of market time with respect to recreation goods is negative,[70] these estimated elasticities point to an estimate for γ of 0.13 and to a value of ρ strictly greater than 0.13.

16.30 in the case of labor market experience and its square—Column 1 of Table 2.1—, 1,232 for the straight-time hourly wage—Column 2 of Table 2.1—, and 369.7 when the price of leisure time is instrumented with both—Column 3 of Table 2.1.

70 The ratio of market time to leisure time, 0.25, is calculated by dividing the average amount of hours worked by a prime-age female in our sample, 1,146, by the difference between the total annual hours available to be allocated between work and leisure—16 daily hours times 7 days a week times 52 weeks a year—and the hours actually worked.

Regarding the demographic effects, the estimates in Column 1 of Table 2.1 suggest that a married female supplies, on average, an amount of market hours that is 8 per cent lower than the amount supplied by an unmarried one. Also, the amount of hours supplied to the market is affected by the composition of the family unit: the presence of children reduces the supply of market hours, being the size of the reduction decreasing with the age of the children. On the contrary, the size of the family unit tend to be positively related with the amount of hours offered to the market—although in the first column this variable is not statistically different from zero. Suffering from a disability reduces—on average—the amount of hours worked in the market by 7 per cent. Finally, the size of the population residing in each Metropolitan Area is estimated to be statistically insignificant regarding the life-cycle allocation of work effort, what might be evidencing that the simultaneity bias hypothesized before is not too important.

To test for selection bias in the Euler equation for labor supply, we included the inverse of Mill's ratio among the set of explanatory variables. It is generated from a first-stage reduced form Probit estimation of the conditional probability of participation in the labor market.[71] The identification of the selection bias is based exclusively on functional form, since the theoretical model does not indicate which variables affecting the decision to participate could be excluded from the main equation. The inverse of Mill's ratio is interacted with year dummies in order to allow the covariance between the idiosyncratic errors in the participation and main equations to differ across periods of time. The estimated coefficient associated with λ_m showed in each column of Table 2.1 corresponds to the year

[71] See Table 2.A.2 in Appendix 2.A.

1976. Although it is only statistically different from zero in Column 1, the Wald test of joint statistical significance for the whole set of interactions firmly rejects the null in the three regressions displayed in Table 2.1—p-values below 10^{-4}—, evidencing its statistical significance at least in some of the periods considered. Therefore, if the intertemporal allocation of work effort in the population of working females is different from that carried out in the population of females as a whole, the presence of the inverse of Mill's ratio guarantees that the estimated behavioural parameters apply to the larger population.

2.4 Concluding Remarks

This chapter has developed an empirical model for the life-cycle allocation of work effort by part of prime-age females in which the price of the goods consumed in conjunction with leisure time was added to the set of regressors. We have estimated the model by means of an extended version of the Wooldridge (1995) estimator controlling for selection bias in a panel data context, applied over a dataset constructed from individual-level data suministered by the University of Michigan Panel Study of Income Dynamics and price indices supplied by the U.S. Bureau of Labor Statistics.

The main empirical results may be summarized as follows:

1. The elasticity of intertemporal substitution of market time with respect to the price of recreation goods is negative in all the estimations, evidencing that prime-age females are, on the contrary than males, more propense to contemporaneously substitute goods

and leisure time in the enjoyment of recreation than to intertemporally substitute the consumption of recreation activities.

2. A reasonable estimate of the size of this elasticity is -0.36, implying that an average prime-age female reacts working 4 annual hours less in the market when the price of recreation goods rises one per cent.

3. The elasticities of intertemporal substitution of market time with respect to the price of leisure time and the price of recreation goods are larger, in absolute value, for the population of prime-age females than for the population of prime-age males, a result that agrees with previous empirical evidence regarding the labor market behaviour of both populations.

2.A Data Appendix

TABLE 2.A.1

DESCRIPTIVE STATISTICS

	All Females	Working Females	Hourly Paid Females
Hours	1,146	1,646	1,665
	(932.2)	(651.7)	(598.3)
$\mathbf{I^P_{jt}}$	105.6	105.4	104.9
	(8.43)	(8.18)	(7.55)
$\mathbf{W_{it}}$	—	8.65	7.50
		(5.94)	(4.08)
$\boldsymbol{\varpi_{it}}$	—	—	7.12
			(6.84)
Age	38.9	38.0	37.9
	(10.2)	(9.66)	(9.47)
Experience	13.2	15.0	15.0
	(8.76)	(8.14)	(8.16)
Married	0.63	0.62	0.60
	(0.48)	(0.48)	(0.49)
Family size	3.35	3.13	3.29
	(1.68)	(1.54)	(1.57)
Children [0-2]	0.19	0.15	0.17
	(0.44)	(0.40)	(0.43)
Children [3-5]	0.21	0.17	0.19
	(0.47)	(0.42)	(0.44)
Children [6-17]	0.92	0.82	0.91
	(1.17)	(1.07)	(1.09)
Bad health	0.16	0.09	0.09
	(0.37)	(0.29)	(0.29)
Sample size:			
Individuals	4,505	3,630	2,158
Observations	27,568	19,191	7,731

NOTE.— Standard errors in parenthesis. *Hours*: Annual hours worked in the main job, secondary job/s, and overtime. I^P_{jt}: Index of the price of recreation goods in Metropolitan Area *j* and period *t*; base period 1982-84=100. W_{it}: First measure of the price of leisure time for individual *i* in period *t*, obtained as annual earnings in 1982-84 dollars divided by annual hours worked. ϖ_{it}: Second measure of the price of leisure time; straight-time hourly wage in 1982-84 dollars, asked of those workers who are paid on an hourly basis. *Experience*: Accumulated years of labor market experience; see Appendix 2.D. *Married*: Binary indicator taking on value 1 when the female is legally married or permanently cohabiting. *Children [-]*: Number of people in the family unit in the referred age intervals. *Bad health*: Binary indicator taking on value 1 when the female has any physical or nervous condition that limits the type of work or the amount of work she can do.

TABLE 2.A.2

THE PARTICIPATION REDUCED FORM PROBIT EQUATIONS
(Estimated Coefficients)

	(1)	(2)	(3)	(4)	(5)
$\ln P_{jt}$	-0.1921	-0.1469	-0.3168	-0.3756	-0.2594
	(0.2132)	(0.1618)	(0.1998)	(0.2983)	(0.2440)
Age	0.0005	0.1235***	-0.0004	-0.0863***	0.1031***
	(0.0288)	(0.0204)	(0.0283)	(0.0235)	(0.0161)
Age^2	0.0001	-0.0013***	0.00004	0.0002	-0.0012***
	(0.0003)	(0.0002)	(0.0003)	(0.0003)	(0.0002)
Married	-0.3047***	-0.2529***	-0.3146***	-0.3961***	-0.3146***
	(0.0574)	(0.0451)	(0.0570)	(0.0661)	(0.0537)
Children [0-2]	-0.4826***	-0.3816***	-0.4826***	-0.5464***	-0.4455***
	(0.0429)	(0.0346)	(0.0429)	(0.0443)	(0.0378)
Children [3-5]	-0.3558***	-0.3115***	-0.3601***	-0.3907***	-0.3522***
	(0.0368)	(0.0306)	(0.0369)	(0.0396)	(0.0341)
Children [6-17]	-0.1071***	-0.1105***	-0.1048***	-0.1081***	-0.1181***
	(0.0245)	(0.0195)	(0.0245)	(0.0254)	(0.0206)
Family Size	0.0476**	0.0287	0.0477**	0.0618***	0.0394**
	(0.0228)	(0.0176)	(0.0229)	(0.0237)	(0.0189)
Bad health	-0.3238***	-0.2682***	-0.3173***	-0.3589***	-0.3038***
	(0.0385)	(0.0312)	(0.0382)	(0.0425)	(0.0355)
LnPopulation	0.6979	-0.8887***	-0.8337***	-0.3464	-0.3264
	(0.8706)	(0.2506)	(0.2760)	(0.2517)	(0.2349)
Experience	0.2405***	—	0.2339***	0.2310***	—
	(0.0130)		(0.0126)	(0.0134)	
Experience^2	-0.0041***	—	-0.0040***	-0.0041***	—
	(0.0003)		(0.0003)	(0.0003)	
Education	—	—	—	0.0405***	0.0851***
				(0.0086)	(0.0081)
Nonwhite	—	—	—	-0.0332	0.0384
				(0.0466)	(0.0485)
Intercept	6.1927	14.2391***	13.4074***	13.0987***	12.0024***
	(5.3694)	(2.7397)	(2.7841)	(3.4763)	(3.3498)
Observations	27,568	27,568	27,568	21,906	21,906

NOTE.— All probits include Metropolitan Area (MA) dummies and the individually-averaged exogenous explanatory variables. Probits (2) and (3) include a time trend, while probit (1) includes a time trend specific to each MA. In probits (4) and (5) the number of observations is curtailed since food expenditures is not available in the PSID in 1988 and 1989. *Education*: years of completed schooling; a value of 17 indicates some postgraduate work. *Nonwhite* takes on value 1 when the individual declares to be non-white. Robust standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

2.B Sample Selection Criteria

This appendix lists the selection criteria for the sample used in the empirical analysis. Marginal losses of person-years are given for each criterion.

We started downloading data from the PSID for the interview years 1976 to 1993. There are a total of 53,013 persons, with 26,918 declaring being females. For these, only observations of heads or wives (368,199 person-years lost),[72] present in the household at the moment of the interview (1,617 person-years lost), and with known age (6 person-years lost) were kept. 27,520 observations were dropped because they corresponded to person-years not living in a U.S. Metropolitan Area. 36,544 observations were deleted because the corresponding person resided in a Metropolitan Area for which price indices were not available. Observations for females residing in Miami in 1976 were dropped because the indices needed to construct the price of recreation goods were not available there until 1977 (57 person-years deleted). After these changes, a total of 50,581 observations were available.

Since the question regarding total annual hours of market work refers to the calendar year previous to the year of the interview, we lagged one year most of the variables to consistently assign data to the year in which the hours of market work were supplied—a total of 6,539 person-years were deleted. After this change, we applied the following criteria: (1) Only observations of individuals between 25 and 60 years old (person-years lost: 11,206). (2) Total annual hours of market work must be no greater than 4,860 (person-years lost: 20). (3) Observations in which annual earnings are zero and annual hours

72 In the PSID, a female is considered a wife when is either legally married or permanently cohabiting.

positive or vice versa were dropped (person-years lost: 85). (4) When the female works in two consecutive years, total annual hours of market work must not rise by more than 250 percent or fall by more than 60 percent from the preceding year, and the absolute change in hours must be less than 3,000 (person-years lost: 1,499). (5) When the female works in two consecutive years, her real hourly wage, calculated as real annual earnings—in terms of food plus beverages, housing and transportation—divided by total annual hours of market work, must exceed \$0.96 and be lower than \$600—in 1982-84 dollars—, must not rise by more than 250 percent or fall by more than 60 percent from the preceding year, and must not change from the preceding year by more than \$31 (person-years lost: 777). (6) Observations for which the marital status, the labor market experience, or the health status of the person were not available, were dropped (person-years lost: 1, 635, and 2,251, respectively). The surviving sample consisted of 4,505 persons (27,568 person-years), of whom 3,630 persons worked at least one year (19,191 person-years).

In our opinion, the geographic selection criterion described above generates concerns regarding the representativeness of the behaviour detected in this sample of prime-age females with respect to the actual behaviour in the whole U.S. prime-age female population. To study this question, we have performed standard difference in means and proportions tests for the distributions of some variables in the selected sample (27,568 observations, of which 19,191 corresponded to working females), and in the sample of observations dropped because they corresponded to a female living in a Metropolitan Area without the necessary price indices (32,576 observations, of which 23,425 corresponded to working females): it is rejected at the 5% significance level that both samples exhibit the same proportion of person-years working in the market, the same number of market hours per person, and the same price of leisure time (the p-values are, in the three tests, lower than 10^{-4}). These facts, of course, limit the generality of the findings of this study.

2.C Marginal Rate of Substitution Equation for Labor Supply

2.C.1 Empirical Model

By making use of the first order condition in Eq. (2.1), we could get an equivalent expression for the intertemporal labor supply function in Eq. (2.4), in which the effects exerted by the marginal utility of wealth and the discount factors are captured by the expenditures in other consumption goods:

$$N_{it}^{*} = 1 - \psi_{it}^{\gamma} \left(\frac{W_{it}^{*}}{\alpha_{it}} \right)^{-\rho} \left(P_{it}^{1-\rho} + \alpha_{it}^{\rho} W_{it}^{*1-\rho} \right)^{\frac{\rho-\gamma}{1-\rho}} C_{it}^{*\frac{\gamma}{\theta}}. \tag{2.C.1}$$

By taking a log-linear approximation to Eq. (2.C.1) and defining the taste-shifter variables as in Eqs. (1.17) and (1.18), we get an alternative expression for the main estimating equation usually labeled as the Marginal Rate of Substitution equation for labor supply:

$$\ln N_{it}^{*} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln W_{it}^{*} + \beta_6 \ln C_{it}^{*} + \mathbf{y}_{it}' \boldsymbol{\phi} + c_{i1} + \varepsilon_{it}, \tag{2.C.2}$$

with $c_{i1} \equiv \left(\beta_3 y_i^{\psi} + \beta_4 y_i^{\alpha} \right)$ and $\boldsymbol{\phi}$ and ε_{it} were defined in the main text. Notice that, as a difference with the Euler equation, there are no theoretical reasons behind the inclusion of the unobserved heterogeneity term c_{i1}. Thus, in the empirical application that follows, it is preferred to proxy c_{i1} by variables reflecting time-invariant individual tastes for work rather than to parameterize some moment of its conditional distribution.

Using a more compact notation, Eq. (2.C.2) may be rewritten as

$$\ln N_{it}^{*} = \beta_0 + \mathbf{x}_{it1}^{*\prime}\boldsymbol{\beta}_1 + c_{i1} + \varepsilon_{it}, \tag{2.C.3}$$

where $\mathbf{x}_1^{*} \equiv (\ln P, \ln W^{*}, \ln C^{*}, \mathbf{y}')'$ and $\beta_1 \equiv (\beta_1, \beta_2, \beta_6, \boldsymbol{\phi}')'$. As in the case of the Euler equation, it is assumed that $E\left(\varepsilon_{it} | \, c_{i1}, \mathbf{x}_{i1}^{*}\right) = 0$, with $\mathbf{x}_{i1}^{*} \equiv \left(\mathbf{x}_{i1,1}^{*\prime}, ..., \mathbf{x}_{iT,1}^{*\prime}\right)$.

From now on, we refer to the same model of labor market participation established in Eqs. (2.8)-(2.10). To estimate Eq. (2.C.3) taking into account self-selection into the labor force, we draw upon Gronau (1974) and Lewis (1974), and we specify the conditional distribution of the idionsyncratic error as:

$$E\left(\varepsilon_{it} | \, \mathbf{z}_i, v_{it}\right) = E\left(\varepsilon_{it} | \, v_{it}\right) = \omega_t v_{it}. \tag{2.C.4}$$

Repeating the same algebraic steps than in the main text, we reach the estimating Marginal Rate of Substitution equation after having controlled for selection bias:

$$\ln N_{it}^{*} = \beta_0 + \mathbf{x}_{it1}^{*\prime}\boldsymbol{\beta}_1 + c_{i1} + \omega_t \lambda_m\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right) + error_{it}. \tag{2.C.5}$$

2.C.2 Estimation and Results

We must now take into account the imperfect empirical counterparts of the model's regressors. The log-linear measurement error models for the dependent and price of leisure time variables are given in Eqs. (2.20) and (2.21) in the main text. Nevertheless, since the PSID question about expenditures in other consumption goods is asked only for food expenditures, the incorrect match between the category of goods entering the individual's preferences and that empirically measured, requires us to specify a classical measurement error model for C^*:

$$\ln C_{it} = \ln C^*_{it} + e^C_{it}. \tag{2.C.6}$$

Rewriting Eq. (2.C.5) in its extended form with the imperfect measures becomes

$$\ln N_{it} = \beta_0 + dMA_{it} + \bar{\beta}_1 \ln P_{jt} + \beta_2 \ln W_{it} + \beta_6 \ln C_{it} + \mathbf{y}'_{it}\boldsymbol{\phi} + c_{i1} + \omega_t \lambda_m + \breve{\varepsilon}_{it}, \tag{2.C.7}$$

where $\breve{\varepsilon}_{it} \equiv \left(error_{it} + e^N_{it} + \beta_1 e^P_{it} - \beta_2 e^W_{it} - \beta_6 e^C_{it}\right)$. To overcome the endogeneity in the price of leisure time and expenditures in other consumption goods, we attempt an instrumental variables empirical strategy. Since the error term in Eq. (2.C.7) is again autocorrelated,[73] we follow Altonji (1986) and instrument expenditures in other consumption goods with an individual-specific permanent component of the wage, obtained through a dummy variable regression of the straight-time hourly wage, ϖ, on individual, time, and Metropolitan Area dummies, human capital controls—experience and the interaction of years of schooling and experience—, and a health binary indicator. The instruments for the price of leisure time are, in turn, labor market experience and its square, and ϖ.[74]

73 The estimated AR(1) coefficient amounts to 0.65, robust s.e. 0.02.

74 The set of instruments includes the individually-averaged exogenous variables present at the first-stage reduced form participation equation.

Therefore, the estimation of the main parameters in Eq. (2.C.7) is as follows. We firstly estimate the reduced form participation equation using standard probit, obtaining the inverse of Mill's ratio $\lambda_m\left(\tilde{\mathbf{z}}_{it}'\hat{\mathbf{q}}\right)$.[75] Then, we apply a two-step feasible GMM estimation procedure over Eq. (2.C.7) with $\lambda_m\left(\tilde{\mathbf{z}}_{it}'\hat{\mathbf{q}}\right)$ interacted with year dummies to allow for different selection effects across periods of time. The term c_{i1} is proxied by means of a race binary indicator—the variable *Nonwhite* takes value 1 when the individual declares to be non-white—and years of schooling—*Education* contains the years of schooling completed by each female in the sample; a value of 17 indicates some post-graduate training. The intra-cluster covariance matrix is left unrestricted, and we correct the standard errors for the presence of the generated inverse of Mill's ratio.

The results of estimating Eq. (2.C.7) by the method just discussed are shown in Table 2.C.1. The first column displays the estimated parameters when the price of leisure time and expenditures in other consumption goods are instrumented with the individual-specific permanent component of the wage and labor market experience. In Column 2, ϖ is utilized in the place of labor market experience. While the instruments may be considered as relevant,[76] yet they are not always valid: the value of the J statistic of Hansen (1982) is 18.6—p-value 0.14—for the instruments utilized in the first column, and 22.2—p-value 0.01—for the instruments used in the second. Again, although the validity of ϖ as an instrument is questioned, we do not reject the exogeneity of labor market experience and the individual-specific permanent component of the wage.

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75 See the last two columns of Table 2.A.2.

76 The values of the F-statistic testing the joint significance of the instruments in the first-stage regressions are: in Column 1 of Table 2.C.1, 108.4 for the price of leisure time and 8.66 for expenditures in other consumption goods; in Column 2, 131.3 and 6.34, respectively.

TABLE 2.C.1

LABOR SUPPLY ESTIMATES USING FOOD CONSUMPTION AS A PROXY FOR λ_i (See Eq. [2.C.7])

	(1)	(2)
lnP_{jt}	-0.1450 (0.2100)	-0.1163 (0.2434)
lnW_{it}	0.3127*** (0.0571)	0.4255*** (0.0670)
LnC_{it}	-0.4401** (0.1895)	-0.5521** (0.2306)
Age	0.0014 (0.0130)	0.0119 (0.0148)
Age^2	-0.00002 (0.0002)	-0.0001 (0.0002)
Married	0.0424 (0.0563)	0.0606 (0.0703)
Children [0-2]	-0.1267*** (0.0358)	-0.1648*** (0.0459)
Children [3-5]	-0.0900*** (0.0319)	-0.1226*** (0.0401)
Children [6-17]	-0.0481*** (0.0146)	-0.0605*** (0.0183)
Family size	0.0938*** (0.0323)	0.1126*** (0.0390)
Bad health	-0.0266 (0.0341)	-0.0508 (0.0441)
LnPopulation	-0.0485 (0.1746)	-0.1511 (0.2000)
Education	-0.0325*** (0.0059)	-0.0333*** (0.0079)
Nonwhite	-0.0057 (0.0429)	-0.0089 (0.0494)
Mill's	-0.0043 (0.1066)	0.0958 (0.1493)
Intercept	11.7941*** (2.0090)	12.5833*** (2.3180)
Observations	5,872	5,872

NOTE.— All regressions include Metropolitan Area dummies and the interaction of the inverse of Mill's ratio with year dummies. In Column (1), lnW_{it} and lnC_{it} are instrumented with an individual-specific permanent component of the wage and labor market experience. In Column (2), lnW_{it} and lnC_{it} are instrumented with an individual-specific permanent component of the wage and the straight-time hourly wage. Heteroskedasticity and autocorrelation within panels robust standard errors in parentheses. Standard errors **corrected** for the presence of generated regressors (inverse of Mill's ratio). * significant at 10%; ** significant at 5%; *** significant at 1%

The signs of the estimated elasticities of intertemporal substitution (EIS) of market time with respect to the price of leisure time and expenditures in other consumption goods are the theoretically expected. Moreover, the latter variable is statistically significant at 5% of significance level, something that did not occur in the results reported in Altonji (1986). The EIS of market time with respect to the price of recreation goods is estimated to be negative, yet not statistically different from zero. Although its magnitude varies with the size of the sample,[77] its sign remains the same, a symptom of a robust underlying behaviour. The demographic effects are, roughly, those discussed in the main text. It is worth noting, however, that more educated females devote less hours to work in the market—a three per cent less per year of schooling completed—, and that we do not find race as a significant determinant of the allocation of time. The inverse of Mill's ratio is not statistically different from zero at 5% of significance level.[78] The same may be said when a Wald test of joint significance is performed for the whole set of interactions with year dummies.[79] Although cautiously, because identification rests in functional form, we could conclude that selection bias seems not a problem when expenditures in other consumption goods is added to the set of explanatory variables.

[77] We have lost near two thousand observations since the food expenditures variable is not available in the PSID in 1988 and 1989.

[78] The estimated coefficient associated with λ_m shown in Table 2.C.1 corresponds to the year 1976.

[79] The values of the chi-squared statistic are very close to the rejection region: the p-values are 0.06 for the regression shown in Column 1 of Table 2.C.1, and 0.08 for the one displayed in Column 2.

2.D Experience in the Labor Market

This appendix discusses the construction of the variable that measures the labor market experience of prime-age females. While for the population of males the definition of experience in the labor market as age minus years of schooling minus five generates a bearable lost in accuracy, for the population of females the errors of measurement could be too large. Fortunately, a more accurate measure of labor market experience may be obtained using the background information part of the questionnaire asked by the University of Michigan Panel Study of Income Dynamics (PSID). In 1976 and 1985 all heads and wives in the surveyed households were asked how many years they had worked since age 18. Besides, this information was asked of those who became new heads or new wives in the year they entered the PSID. For the rest of the years, we may update labor market experience by examining annual work hours. Thus, one year of experience is added when the individual reports having worked a positive amount of hours in the previous year. A STATA do file containing all the steps carried out to generate this variable is available from the author upon request.

2.E Computing the Standard Errors

Here we derive the standard errors for the most general model that controls for unobserved heterogeneity, measurement error, and sample selection bias. In what follows, we draw heavily upon Arellano and Meghir (1992).

The behavioural model we estimate has the form (see Eq. [2.23] in the text):

$$\ln N_{it} = \tilde{\beta}_0 + dMA_{it} + \mathbf{x}_{it}'\boldsymbol{\beta} + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt}\lambda_m\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right) + \tilde{\varepsilon}_{it}, \quad (2.E.1)$$

$$\lambda_m\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right) = \phi\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right) / \Phi\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right), \quad (2.E.2)$$

$\phi(\cdot)$ being the standard normal density function and $\Phi(\cdot)$ the standard normal distribution function. It may be rewritten as

$$\ln N_{it} = \tilde{\beta}_0 + dMA_{it} + \mathbf{x}_{it}'\boldsymbol{\beta} + \bar{\mathbf{z}}_i'\boldsymbol{\pi} + \beta_{mt}\lambda_m\left(\tilde{\mathbf{z}}_{it}'\hat{\mathbf{q}}\right) + \ddot{\varepsilon}_{it}, \quad (2.E.3)$$

where $\ddot{\varepsilon}_{it} \equiv \tilde{\varepsilon}_{it} + \beta_{mt}\left(\lambda_m\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right) - \lambda_m\left(\tilde{\mathbf{z}}_{it}'\hat{\mathbf{q}}\right)\right)$. This error can be approximated to first order around $\mathbf{q} = \hat{\mathbf{q}}$ by the following expression:

$$\ddot{\varepsilon}_{it} \simeq \tilde{\varepsilon}_{it} + \beta_{mt}\left(-\lambda_m\left[\lambda_m + \tilde{\mathbf{z}}_{it}'\mathbf{q}\right]\right)\tilde{\mathbf{z}}_{it}'\left(\hat{\mathbf{q}} - \mathbf{q}\right), \quad (2.E.4)$$

in which we made use of the fact $\partial\lambda_m / \partial\left(\tilde{\mathbf{z}}_{it}'\mathbf{q}\right) = -\lambda_m\left[\lambda_m + \tilde{\mathbf{z}}_{it}'\mathbf{q}\right]$. Therefore, $E\ddot{\boldsymbol{\varepsilon}}\ddot{\boldsymbol{\varepsilon}}'$ is given by

$$\Omega = \Sigma + AQVQ'A, \quad (2.E.5)$$

where $\Sigma \equiv E\tilde{\boldsymbol{\varepsilon}}\tilde{\boldsymbol{\varepsilon}}'$ was defined in the main text, $A \equiv diag(\beta_{mt}\left(-\lambda_m\left[\lambda_m + \tilde{\mathbf{z}}_{it}'\mathbf{q}\right]\right))$, Q is the matrix with the reduced form probit explanatory variables, and V denotes the asymptotic covariance for $\hat{\mathbf{q}}$. Therefore, the estimated asymptotic covariance matrix of the GMM estimator of all the unknown coefficients in Eq. (2.E.1) is

$$Av\hat{a}r\left(\hat{\boldsymbol{\beta}}_{GMM}\right) = \left(\left(X'Z\right)\left(Z'\hat{\Omega}Z\right)^{-1}\left(Z'X\right)\right)^{-1}, \quad (2.E.6)$$

where $\hat{\Omega}$ is obtained by replacing all unknown parameters in Ω by consistent estimates and Z differs from Q due to the inclusion of the inverse of Mill's ratio as an additional explanatory variable. To illustrate the importance of this correction, we show in Table 2.E.1 the corrected and uncorrected standard errors of the regression reported in Column 1 of Table 2.1.

TABLE 2.E.1

COMPARISON OF CORRECTED AND UNCORRECTED STANDARD ERRORS

(Column 1 of Table 2.1)

	Corrected	Uncorrected
LnP_{jt}	0.1897	0.1874
LnW_{it}	0.2966	0.2937
Age	0.0169	0.0165
Age^2	0.0001	0.0001
Married	0.0287	0.0279
Children [0-2]	0.0305	0.0295
Children [3-5]	0.0271	0.0264
Children [6-17]	0.0147	0.0144
Family size	0.0134	0.0131
Bad health	0.0263	0.0251
LnPopulation	0.4970	0.4801
Mill's	0.1084	0.1051
Intercept	3.0281	2.9370

Chapter 3
Time Allocation, Fertility, and Technology after the Malthusian Regime in the Process of Economic Development[80]

3.1 Motivation

This chapter presents a unified theory accounting for the evolution of human fertility after the Malthusian Regime in the process of economic development.[81] The post-malthusian era is characterized by an acceleration in the pace of technological progress, and this paper lays out the mechanisms through which the two dimensions of technological progress—one making more affordable existing goods, the other increasing the variety of available goods—might be affecting time allocation and fertility. We suggest a series of causal factors that could simultaneously explain the increase in fertility in the Post-Malthusian Regime, the secular decline in fertility rates observed in the Modern Growth Regime, and movements out of the trend like those labeled as baby booms in the latter era. Our theory draws upon core insights in Becker (1965) and Becker (1960): individuals optimally allo-

[80] This chapter is joint work with Xavier Sala i Martín.

[81] We follow the conventional terminology in Galor and Weil (2000), that divide the process of development in three eras: the Malthusian Regime, characterized by a constant level of income per capita and a positive relationship between this variable and population growth, the Post-Malthusian Regime, in which income per capita grows as a consequence of accelerated technological progress and the positive relationship between income per capita and population growth is still in place, and the Modern Growth Regime, mainly characterized by a negative relationship between the level of output and the growth rate of population. In what follows, we do not consider neither mortality nor migrations so, regarding the relationships among economic variables, the level of fertility will play the role of the rate of population growth.

cate time among alternative uses, and children are considered consumption goods whose production requires time.

The inverse relationship between the degree of economic development and the fertility rate in the Modern Growth Regime, is usually explained by means of technological progress that rises the productivity of the labor effort in the market sector of the economy. In some contributions, this kind of technological progress is associated to individuals' educative levels, triggering the quantity-quality trade-off: in Galor and Weil (2000), for instance, the changing economic environment induced by accelerated technological progress makes more profitable the investment in children's human capital, while in Fernández-Villaverde (2001) technological progress is assumed to be skill-biased, increasing the returns to education. Additionally, other contributions emphasize the increasing opportunity cost of non-working induced by increasing real wages: in Jones (2001), for instance, higher returns to market work lead to an increase in the opportunity cost associated to other time consuming activities like rearing children.

What these theories are not able to explain, however, is an out of trend movement of the magnitude and length as, for instance, the U.S. baby boom, and complementary hypothesis explaining human fertility have been proposed. Easterlin (2000) "relative income" theory puts forward, in fact, an alternative paradigm not directly concerned with technological progress to understand fertility decisions that, although appealing as an explanation of the baby boom, it has become criticized as an explanation of the secular decline in fertility rates.[82] On the other hand, Greenwood, Seshadri, and Vandenbroucke (2002) and Green-

[82] See Greenwood, Seshadri, and Vandenbroucke (2002).

wood and Seshadri (2002) try to reconcile the standard paradigm with the baby boom by recurring to technological progress that rises the productivity of the labor effort in household production. In short, their basic idea is that the massive introduction of appliances at home in the U.S. during the fifties would have reduced the amount of time needed to rear a children, and this extra time would have been devoted to bring up more children.

Even though the contributions by Greenwood *et al.* (2002) and Greenwood and Seshadri (2002) seem to be the more comprehensive for the U.S. experience, they exhibit some shortcomings, as almost all do. On one hand, it could be true that the introduction of appliances at home saved time to rear a child, but this extra time could also be devoted, for instance, to increase the education of existing children instead of bringing up new children. On the other hand, the introduction of appliances in the U.S. economy was not limited to the baby boom period:[83] Gershuny and Robinson (1988) report that, between 1965 and 1985, an average American female in the age group 25-49 reduced the *daily* amount of time devoted to routine domestic work in near an hour, even after controlling for the changing employment and family structural composition of that population between both time periods, and they suggest that at least part of this reduction could be driven by the introduction of time-saving appliances like dishwashers and microwave ovens. Nevertheless, in that period U.S. fertility collapsed.

Even so, surely the most important lesson from Greenwood *et al.* (2002) and Greenwood and Seshadri (2002) is that technological progress does not show its effects in a unique field of economic activity. As a direct consequence of this idea, we could go even

[83] Conventionally dated between 1946 and 1964.

further and study how technological progress affects the efficiency in other alternative uses of time not related to market work and household production like the time we devote to recreate. Besides, technological progress does not only reveal as an increased productivity in market work and household production, but it also shows up as an expansion in the number of varieties of consumer products.

Juster and Stafford (1991) and Gronau and Hamermesh (2003) report that individuals residing in developed economies devote around forty hours per week to recreate, what represents a significant proportion of our waking time. Although it could be argued that the only effect of technological progress regarding recreation consists in lowering the price of those goods consumed in conjunction with leisure time—recreation goods—, and that this effect is already taken into account in existing models of fertility choice, we think this view could be hidden a twofold phenomenon. Firstly, the consequences for fertility of reductions in the price of different categories of consumption goods need not be the same: Gronau and Hamermesh (2003) show that what they call “leisure” is the activity, apart from “sleep”, in which more time is combined with every dollar spent in goods consumed as the activity takes place, what suggests that changes in the prices of recreation goods could entail non-trivial alterations to the allocation of time devoted to enjoy recreation and, as a consequence, to the time allocated to other pursuits like rearing children. Secondly, technological progress gives rise to innovations usually associated to pleasant or recreational activities—such as photographic equipment, television sets, amusement parks, or even the Internet—, that could entail significant consequences regarding the amount of time devoted to rear children.

We propose a model in which the economic agent optimally allocates time among working in the market, enjoying recreation, and rearing children. Exogenous technological progress raises the efficiency of market time—making more affordable the consumption of existing goods—and of household production—reducing the time needed to produce a child. Besides, it also increases the number of varieties of recreation goods available to the individual. This enhanced yet parsimonious model reveals new channels of causation that would allow us to simultaneously explain the secular decline in fertility rates and other out of trend movements like the baby boom.

The rest of this chapter is organized as follows. Section 3.2 formalizes the assumptions about the determinants of the allocation of time presented earlier, and incorporates them into a static model of choice. The main predictions of the model regarding the allocation of time and fertility are derived in Section 3.3. Section 3.4 applies some insights of the model to study the evolution of U.S. fertility during the twentieth century. Section 3.5 concludes.

3.2 Setup of the Model

3.2.1 Preferences and Constraints

Let the economy be populated by a representative household who is made up of a single parent. This economic agent wishes to maximize the utility derived from the consumption of recreation activities, children, and other consumption goods—henceforth denoted by s,

b, and c^*, respectively. For analytical tractability, we follow Jones (2001) and we assume that the utility function is represented by

$$u\left(\tilde{c}^*, s, b\right) \equiv \alpha_1 \frac{\tilde{c}^{*1-1/\theta} - 1}{1 - 1/\theta} + \alpha_2 \frac{s^{1-1/\gamma} - 1}{1 - 1/\gamma} + \alpha_3 \frac{b^{1-1/\eta} - 1}{1 - 1/\eta}, \tag{3.1}$$

where $\tilde{c}^* \equiv c^* - \bar{c}^*$. The parameter $\bar{c}^* > 0$ stands for the subsistence level of consumption of other consumption goods in this economy, while the α's ($\alpha_i > 0$, $\forall i$) capture the intensity of the taste for each object of choice. The parameters θ, γ, and η are assumed to be strictly positive, and they denote the elasticities of intertemporal substitution of $\tilde{c}^*$, s, and b, respectively. Although an elasticity of intertemporal substitution may seem foreign to the static structure of this model, the decision making process here analyzed may be re-interpreted as a stage of a dynamic model in which there are no asset links across periods of time. For instance, the choices analyzed in this model may be viewed as carried out by the head of a generation in a Barro (1974) extended family under the assumption of missing financial and capital links across generations. With these parameter restrictions, this utility function is assured to be strictly concave.

It is assumed that the economic agent has T units of time available every period that are distributed among market work, leisure time, and child rearing. The amount of time devoted to each of these pursuits is henceforth denoted by n, l, and d, respectively.

The enjoyment of recreation requires not only the allocation of leisure time by part of the individual, but also the purchase of recreation goods. It is assumed that, as a consequence of technological progress, the variety of recreation goods available to the economic agent increases across periods of time. We follow Spence (1976), Dixit and Stiglitz (1977), and Oulton (1993) by writing the production function for recreation as

$$s = \left[\sum_{i=1}^{N} z_i^{\rho} \right] l^{1-\rho}, \tag{3.2}$$

where $0 < \rho < 1$, N denotes the number of recreation goods available in the current period, and z_i represents the number of units consumed of recreation good i. As discussed by Barro and Sala-i-Martin (1995, Ch. 6), the additive separability form for the z_i^{ρ} means that, in the production of recreation, the marginal product of recreation good i is independent of the quantity consumed of recreation good i', an specification that may hold on average for breakthrough innovations. As an example, photographic equipment has to be neither a direct substitute nor a direct complement with television sets. At this stage of the analysis, we do not care about how N evolves across periods of time, and we just highlight the decision-making consequences emerging from the availability of a different variety of recreation goods.

To see the effect on the production of recreation from an increase in N, suppose that recreation goods can be measured in a common physical unit and that all are consumed in the same amount, $z_i = z$ (which turns out to be true in the equilibrium). Hence

$$s = N z^{\rho} l^{1-\rho} = N^{1-\rho} (Nz)^{\rho} l^{1-\rho}, \tag{3.3}$$

with Nz being the total quantity of resources embodied in recreation goods. By analogy with a production function in which the inputs are given by Nz and l, $N^{1-\rho}$ represents an index of technological advance in recreation in the sense of inventions or adaptations that permit the production of new kinds of recreation goods. Thus, for given quantities of Nz and l, the term $N^{1-\rho}$ in Eq. (3.3) indicates that s increases with N. The benefit from spreading a given total of resources, Nz, over a wider range, N, arises because of the diminishing marginal product of each individual z_i in the production of recreation.

The production function for children is assumed to exhibit constant returns to scale in the time devoted to child rearing:[84]

$$b = \lambda d, \tag{3.4}$$

in which $\lambda > 0$ is a measure of the level of productivity in household production.

The budget constraint of the household is given by

$$c^* + \sum_{i=1}^{N} p_i z_i = wn, \tag{3.5}$$

where p_i and w denote, respectively, the price of recreation good i and the price of a unit of time both expressed in terms of other consumption goods.

3.2.2 Production

The production side of this model will be admittedly simple, but we do so in order to concentrate the attention on the time allocation decisions made by the representative consumer. We assume the existence of $N+1$ sectors of production that use labor as the sole input: one is in charge of producing other consumption goods, and each one of the other N produces a particular variety of recreation goods. Let this setup be represented by

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84 This assumption simplifies the algebra without radically changing the results. Under varying returns to scale in the production of children, the predictions of the model would be the same if the elasticity of intertemporal substitution of children, η, was not larger than one, or if—when $\eta > 1$—the returns to scale in producing children were lower than $\frac{\eta}{\eta-1}$.

$$Y_i^z = A\tau_i n, \;\; i = 1, ..., N, \tag{3.6}$$

and

$$Y^{c^*} = B\,(1-\tau)\,n. \tag{3.7}$$

Y_i^z and Y^{c^*} represent—respectively—the output of the ith recreation good and the output of other consumption goods available in this economy. The total time devoted to market activities by part of the economic agent, n, is splitted up into the $N+1$ sectors. "τ_i" denotes the proportion of market time devoted to the production of recreation good i and, thus, $\tau_i n$ is the amount of labor services hired to produce the ith recreation good. It is assumed that $\sum_{i=1}^{N} \tau_i = \tau$, $0 < \tau < 1$. Therefore, τ stands for the proportion of market time utilized in the production of recreation goods, while $(1-\tau)$ stands for the proportion of market time employed in obtaining other consumption goods.

The productivity of the labor effort in these sectors is represented by the parameters A and B. For simplicity, it is assumed that the N sectors producing recreation goods share the same productivity level. The existence of different levels of productivity across the sectors producing other consumption goods and recreation goods would be reflecting the presence of unequal technological developments in the production of different consumption goods. As will become clear in the next subsection, these technological imbalances will be reflected in the relative price of the goods consumed by the economic agent.

3.2.3 Equilibrium

We assume that product and labor markets are characterized by pure competition and that all markets clear. Thus, assuming an interior solution, the economic agent takes prices as given and solves[85]

$$\max_{\left\{(z_i)_{i=1}^N, l, d\right\}} \alpha_1 \frac{\left(w\left(1-l-d\right)-\sum_{i=1}^N p_i z_i-\bar{c}^*\right)^{1-1/\theta}-1}{1-1/\theta}$$
$$+\alpha_2 \frac{\left(\sum_{i=1}^N z_i^\rho l^{1-\rho}\right)^{1-1/\gamma}-1}{1-1/\gamma}+\alpha_3 \frac{(\lambda d)^{1-1/\eta}-1}{1-1/\eta}.$$

Consumption behaviour is therefore governed by the next set of first order conditions plus the budget and time constraints:

$$\alpha_1 \tilde{c}^{*-1/\theta} p_i=\alpha_2 s^{-1/\gamma} l^{1-\rho} \rho z_i^{\rho-1}, \quad i=1,...,N, \tag{3.8}$$

$$\alpha_1 \tilde{c}^{*-1/\theta} w=\alpha_2 s^{-1/\gamma}\left(1-\rho\right) l^{-\rho} \textstyle\sum_{i=1}^N z_i^\rho, \tag{3.9}$$

and

$$\alpha_1 \tilde{c}^{*-1/\theta} w=\alpha_3 \lambda b^{-1/\eta}. \tag{3.10}$$

From Eq. (3.8) we may obtain an expression for the demand of the ith variety of recreation goods:

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85 Since the utility function is strictly concave the optimum will be unique.

$$z_i = \left[\frac{\alpha_2 \tilde{c}^{*1/\theta} \rho l^{1-\rho}}{\alpha_1 s^{1/\gamma}} \right]^{\frac{1}{1-\rho}} p_i^{-\frac{1}{1-\rho}}, \tag{3.11}$$

where the terms in square brackets are evaluated at equilibrium values. Thus, the demands for recreation goods are downward sloping and with common price elasticity of size $\frac{1}{1-\rho}$.

In any market there exist many competitive firms with free access to the technologies established in Eqs. (3.6) and (3.7). As a consequence of the pure competition, producers equalize the given market price of their output to marginal costs. Regarding the production of recreation goods, the cost function associated to the technology in Eq. (3.6) is

$$c\left(w, Y_i^z\right) = \frac{w}{A} Y_i^z, \tag{3.12}$$

where w is the price of a unit of labor services. Therefore, the selling price of a unit of recreation good i expressed in terms in other consumption goods is

$$p_i = \frac{w}{A}. \tag{3.13}$$

The common price for the N varieties of recreation goods emerges from the common technology available to produce them and the common price of labor services. Given the form of the demand for the ith recreation good established in Eq. (3.11),

$$z_i = z = \left[\frac{\alpha_2 \tilde{c}^{*1/\theta} \rho l^{1-\rho}}{\alpha_1 s^{1/\gamma}} \right]^{\frac{1}{1-\rho}} (w/A)^{-\frac{1}{1-\rho}}. \tag{3.14}$$

Hence, in the equilibrium recreation goods can be measured in the same physical unit and are consumed in the same quantity.

To calculate the wage rate paid in this economy, notice that if the economic agent increases in one unit the time devoted to market work, n, the marginal returns would be given by the aggregation across the $N+1$ sectors of production of the marginal products measured in a common physical unit. That is,

$$\begin{aligned} w &= B(1-\tau) + \textstyle\sum_{i=1}^{N} p_i A \tau_i \\ &= B(1-\tau) + \textstyle\sum_{i=1}^{N} w \tau_i \\ &= B(1-\tau) + w\tau, \end{aligned}$$

where we made use of Eq. (3.13) and of $\sum_{i=1}^{N} \tau_i = \tau$. Solving for w, we obtain that

$$w = B \tag{3.15}$$

and, therefore,

$$p_i = \frac{B}{A}. \tag{3.16}$$

In this economy, the price of a unit of time expressed in terms of other consumption goods, w, depends exclusively on the level of productivity available in the sector producing other consumption goods, B. An increase in B raises the opportunity cost of time because labor effort becomes more productive in producing c^*. "w" depends neither on the level of productivity available in the sectors producing recreation goods, A, nor on the distribution of time across sectors of production, τ_i ($i = 1, ..., N$) and τ. It does not depend on A because, although increases in this parameter raise the marginal product of labor in producing recreation goods, they simultaneously reduce the price of a unit of recreation goods expressed in terms of c^*. Both effects are of the same magnitude and cancel each other out. On the other hand, the price of time does not depend on how market time is distributed across sectors of production because of the constant returns to scale assumption over labor input in the $N + 1$ sectors. The values for τ_i and τ are determined by demand conditions. In the case of τ_i, since $z_i = z$, the market clearing condition forces the quantity produced of each recreation good to be the same and, therefore, $\tau_i = \tau/N$. The value of τ is determined by the relative demands of other consumption goods and recreation goods derived from Eqs. (3.8)-(3.10).

The common price for the N varieties of recreation goods is directly proportional to the level of productivity available in the sector producing other consumption goods, and inversely proportional to the level of productivity in their own sectors of production. Increases in B raise the price of recreation goods because the labor input employed in producing them would obtain a higher return in producing c^*. The opposite effect occurs when the economy experiences an increase in A.

Substituting back Eqs. (3.15) and (3.16) in the first order conditions leading the economic agent's behaviour, we obtain a set of equilibrium relationships depending—among others—on the parameters B, A, λ, and N that are given by

$$\alpha_1 \tilde{c}^{*-1/\theta} \frac{B}{A} = \alpha_2 s^{-1/\gamma} l^{1-\rho} \rho z^{\rho-1}, \tag{3.17}$$

$$\alpha_1 \tilde{c}^{*-1/\theta} B = \alpha_2 s^{-1/\gamma} \left(1-\rho\right) l^{-\rho} N z^{\rho}, \tag{3.18}$$

and

$$\alpha_1 \tilde{c}^{*-1/\theta} B = \alpha_3 \lambda b^{-1/\eta}. \tag{3.19}$$

In the next section, we utilize these relationships to assess the sign of the partial effects caused by parametric changes on the allocation of time to different pursuits.

3.3 Analysis

We now turn to analyze the main predictions of the model regarding the optimal allocation of time by part of the representative individual. The simplified structure of the model discussed so far, allows us to algebraically assess the sign of the partial responses of the amount of time devoted to market work, n, recreation activities, l, and child rearing, d, with respect to changes in the parameters of the economy. Starting from the first order conditions rewritten in Eqs. (3.17)-(3.19) plus the budget and time constraints, we can construct algebraic expressions equalized to zero of the form

$$F_1\left(d, B, A, \lambda, N\right) = 0,$$

and

$$F_2\left(l, B, A, \lambda, N\right) = 0.$$

By applying the Implicit Function Theorem,[86] we are provided with the opportunity to assess the partial effects motivated by parametric changes on d and l. Once we know how

[86] The sufficient conditions of the theorem—see, for instance, Chiang (1984)—are met since every F_j has continuous partial derivatives and, when evaluated at the interior solution, the partial derivative of F_j with respect to the corresponding endogenous variable is nonzero.

these endogenous variables react, we may assess the partial effect of the parameters on n by means of the time and budget constraints.

3.3.1 Child Rearing Time

The form of the production function for children given in Eq. (3.4) entails that the sign of the partial responses of time devoted to child rearing with respect to changes in the parameters of the economy is, with only one exception, the same as the sign of the partial responses of fertility. The exception has to do with the level of technology in household production, λ: although the partial derivative of fertility with respect to λ is, as in Greenwood *et al*. (2002) and Greenwood and Seshadri (2002), unambiguously positive, the sign of the partial derivative of child rearing time with respect to λ coincides with the sign of $\{1 - 1/\eta\}$. Therefore, if the elasticity of intertemporal substitution of children, η, was lower than one, the economic agent would have *more* descendants and would devote *less* time to raise children in time periods characterized by high efficiency in home production.

The sign of the partial response of child rearing time with respect to a change in the level of productivity in the sector producing other consumption goods, $\frac{\partial d}{\partial B}$, is the same as the sign of

$$\{\bar{c}^* + c^* (1/\theta - 1)\} . \tag{3.20}$$

The first term in (3.20) is positive, and captures what Jones (2001) designates as a subsistence effect: the market time needed to obtain the subsistence level of consumption of other consumption goods becomes lower as B increases and, therefore, the individual would have more time available to be devoted to, say, child rearing, once the subsistence level of consumption had been satisfied. The traditional income and substitution effects caused by changes in B are reflected in the second term. As the level of productivity in producing other consumption goods goes up, the income effect would lead the economic agent to increase the consumption of other consumption goods, recreation activities, and children, while, on the other hand, the substitution effect would lead the individual to substitute toward consumption and away from fertility. Which of both dominates depends on the magnitude of the elasticity of intertemporal substitution of other consumption goods, θ. Since the relationship between fertility and the wage rate after the Malthusian Regime has been $\cap$-shaped,[87] we might conclude that, from a given level of development (represented in [3.20] by c^*), the substitution effect swamps the income and subsistence effects, therefore evidencing that θ should be greater than one. Nevertheless, this is not the only channel of causation affecting fertility considered in our model, and thus the value of θ could differ from what previous contributions have suggested to be.

The sign of the partial response of child rearing time with respect to both the level of productivity available in the sectors producing recreation goods, $\frac{\partial d}{\partial A}$, and the number of varieties of recreation goods, $\frac{\partial d}{\partial N}$, coincides with the sign of $\{1/\gamma - 1\}$. Again, a change either in A or in N, brings forward income and substitution effects: on one hand, since recreation goods have become either cheaper or more varied, the economic agent would increase the consumption of other consumption goods, recreation activities, and children, but, on the other hand, the economic agent would be incentivated to substitute toward recreation

[87] See Galor and Weil (2000) and Jones (2001).

and away from, say, fertility. It is the magnitude of the elasticity of intertemporal substitution of recreation activities, γ, what determines which of both effects dominates: if γ was greater than one—that is, if individuals were inclined to deviate from the consumption of a uniform pattern of recreation activities across periods of time—, the substitution effect would dominate, giving rise to an inverse relationship between fertility—or child rearing time—and both the level of productivity in producing recreation goods and their number of varieties available.

In the previous chapters of this thesis we had found point estimates for the parameter γ that were clearly below unity. This finding would suggest the existence of a direct relationship between fertility and both A and N. Nevertheless, we must take into account that the estimated values of γ were obtained in a framework different in at least two respects to that considered in this paper: on one hand, we studied life-cycle choices, in which the period of analysis coincided with the natural year, and, on the other hand, we dealt with only two uses of time—market work and leisure time. We think that the period of analysis in the current model suits better to a generation of a Barro (1974) extended family, and therefore the previous estimates of γ could be misleading.[88] Besides, our estimates of γ were directly proportional to the ratio of market time to leisure time, the latter including all time not devoted to work in the market. Since in this contribution we are considering alternative uses of time—in particular, time devoted to child care—, the ratio of market time to leisure time and, as a consequence, the estimated value of γ, would have now to be larger.

[88] It is not difficult to imagine a generation of an extended family working a lot and enjoying very little recreation, while its children consuming a lot of recreation. This would suggest a high elasticity of intertemporal substitution of recreation activities.

3.3.2 Leisure Time

We now comment on the main predictions of the model regarding the time devoted to enjoy recreation, l. As we will see, the sign of the partial responses of l with respect to changes in the parameters of the economy will depend crucially on intertemporal substitution parameters. This feature owes to the equilibrium form of the production function for recreation activities (see Eq. [3.3]): its Cobb-Douglas shape implies a contemporaneous elasticity of substitution between the resources embodied in recreation goods, Nz, and leisure time, l, equal to one. Therefore, the contemporaneous income and substitution effects brought about by parametric changes will cancel each other out. To assess how the predictions of the model would become modified in presence of contemporaneous substitutability, we would need a more general production function for recreation activities. However, this is no without cost and, at this stage of the analysis, we prefer to gain intuition by keeping the structure of the model as simple as possible.

The sign of the partial response of leisure time with respect to a change in the level of productivity in the sector producing other consumption goods, $\frac{\partial l}{\partial B}$, coincides again with the sign of the expression given in (3.20). This should not surprise us: leisure time is treated on an equal footing with child rearing time when the only change in the economy is a change in a variable that makes more productive the labor effort. If we think that θ is greater than one, then the substitution toward the consumption of other consumption goods and away from the consumption of recreation activities dominates the income and subsistence effects. The model would predict a reduction in our leisure time as the economy develops if this were the only parametric change. Nevertheless, we must pay attention to other possible sources of movements in l.

The sign of the partial derivative of leisure time with respect to a change in the level of technology available for household production, $\frac{\partial l}{\partial \lambda}$, is the same as the sign of $\{1/\eta - 1\}$. Thus, if the elasticity of intertemporal substitution of children, η, was lower than one, the time devoted to leisure would rise as the household production technology developed.

Finally, the sign of the partial response of leisure time with respect to both the level of productivity available in the sectors producing recreation goods, $\frac{\partial l}{\partial A}$, and the number of varieties of recreation goods, $\frac{\partial l}{\partial N}$, coincides with the sign of $\{1 - 1/\gamma\}$. As in the case of child rearing time, assessing the sign of this effect requires an estimate of γ. If recreation activities were highly substitutable across periods of time, the time devoted to leisure would go up with increases in the level of technology available for producing recreation goods and their number of varieties.

3.3.3 Market Time

We now discuss the main predictions of the model regarding market time, n. To assess the sign of the partial responses of n with respect to the parameters of the economy, we will use the equilibrium version of the budget constraint in Eq. (3.5) and the fact that the T units of time available have only three possible uses: market time, leisure time, and child rearing time.

Since the partial derivatives of d and l with respect to the level of productivity in the sector producing other consumption goods have the same sign, the sign of the partial derivative of market time with respect to B has to be the opposite. Therefore, we may claim that the sign of $\frac{\partial n}{\partial B}$ is the inverse of the sign of $\{\bar{c}^* + c^* (1/\theta - 1)\}$. If we think the subsistence effect dominates at low levels of development, then individuals would work less in the market as B increases, but if from a given threshold of development the substitution effect becomes the stronger, individuals would work more as B goes up, giving rise to a $\cup$-shaped pattern for the labor effort after the Malthusian Regime that seems to suit better the labor market behaviour of females.[89]

To know the sign of the partial response of market time with respect to the level of productivity in household production, we made use of the equilibrium version of the budget constraint given in Eq. (3.5). Thus, we may derive an expression for market time equal to[90]

$$n = \frac{c^*}{B} + \frac{N}{A} z.$$

Since the signs of $\frac{\partial c^*}{\partial \lambda}$ and $\frac{\partial z}{\partial \lambda}$ coincide with the sign of $\{1/\eta - 1\}$, this expression determines the sign of $\frac{\partial n}{\partial \lambda}$ too. As a consequence, if the representative individual is averse to substitute children across periods of time ($0 < \eta < 1$), the model predicts that market time increases as the level of productivity in household production increases.

We may offer again a common prediction regarding the sign of $\frac{\partial n}{\partial A}$ and $\frac{\partial n}{\partial N}$. Since the partial derivatives of child rearing time and leisure time with respect to either A or N moved in opposite directions, we had to quantitatively evaluate them to see which of both dominated. We may conclude the following: if

89 See Galor and Weil (1996).

90 In what follows, notice that, since A and B are rates of goods per unit of time, $\frac{c^*}{B}$, $\frac{Nz}{A}$, and $\frac{\bar{c}*}{B}$ represent amounts of time.

$$n > \frac{\bar{c}^*}{B} + \frac{\rho}{1-\rho}\left(l + \frac{\eta}{\theta}d\right), \tag{3.21}$$

then the sign of $\frac{\partial n}{\partial A}$ and $\frac{\partial n}{\partial N}$ is the opposite to the sign of the partial response of leisure time with respect to A or N. If, however,

$$n < \frac{\bar{c}^*}{B} + \frac{\rho}{1-\rho}\left(l + \frac{\eta}{\theta}d\right), \tag{3.22}$$

the sign of $\frac{\partial n}{\partial A}$ and $\frac{\partial n}{\partial N}$ is the opposite to the sign of the partial response of child rearing time with respect to A or N. Finally, if

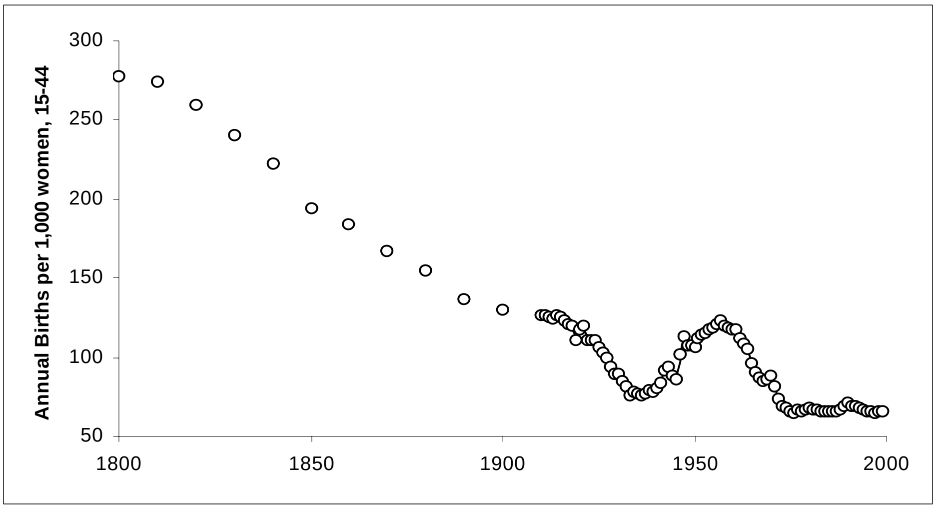
$$n = \frac{\bar{c}^*}{B} + \frac{\rho}{1-\rho}\left(l + \frac{\eta}{\theta}d\right), \tag{3.23}$$

then market time is unaffected by changes in either A or N.

What this series of claims suggests is that, for individuals highly involved in the labor market, we expect to see market time and leisure time moving in opposite directions as either A or N changes. In particular, if the intertemporal substitution of recreation was relatively elastic ($\gamma > 1$), then we should see simultaneous increases in l and reductions in n as either A or N goes up. Nevertheless, for individuals relatively less involved in the labor market, the same assumption for γ would lead to a different prediction: in an economy with rising A or N, we should find reductions in d simultaneously accompanied by increases in n. If we think that the division by gender of an economy's population gives rise to two different groups regarding labor market involvement with females less involved than males, then, under the assumption of $\gamma > 1$, the model predicts that males would simultaneously increase their leisure time and reduce their market time when faced with higher A or N, while females would simultaneously reduce their child rearing time and rise their market time as either A or N goes up.

FIGURE 3.1

FERTILITY IN THE U.S., 1800-1999.



SOURCE.— Hernandez (1993, Table 2.1) and National Center for Health Statistics (2000, Table 1-1).

3.4 A Case Study: Twentieth Century U.S. Fertility

The model developed so far is now utilized in the study of the evolution of U.S. fertility during the twentieth century. Figure 3.1 displays the evolution of the general fertility rate in the U.S. economy from—roughly speaking—the beginning of its Modern Growth Regime until recently.[91,92] Although the observable evolution for the nineteenth century is limited

[91] The sources for the data used are Hernandez (1993, Table 2.1) and National Center for Health Statistics (2000, Table 1-1).

[92] The general fertility rate is the total number of live births, regardless of age of mother, per 1,000 women

by the decennial frequency of the data, it may be depicted by a downward trend without significant out of trend movements. The first forty years of the twentieth century seem to respond to the same trend but, between the mid 1940's and mid 1960's, fertility showed a surprising recovery—a baby boom—, followed, again, by an abrupt downward movement that stabilized from the mid 1970's on.

As we explained in the motivation to this chapter, theories that rely exclusively on technological progress in the market to explain fertility decisions, can not account for the U.S. baby boom, since neither real wage nor productivity in the market revealed any symptom of technological reversal during the baby boom period.[93] Besides, the theories tackled to specifically account for the baby boom are not free of shortcomings. We think the theory developed in this chapter could offer new insights regarding fertility, and we now concentrate in discussing one possible channel of causation: that suggested by the evolution of the price of recreation goods.

Figure 3.2 displays the evolution of an index for the relative price of recreation goods in the U.S. economy during the twentieth century.[94] It is constructed by dividing the recreation component of the Consumer Price Index (CPI)—including items like motion picture admissions, newspapers, radio and television sets, toys, and sporting goods, among others—by the CPI itself.[95] Although the scarcity of data for the first quarter of the last

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of reproductive age, 15-44 years.

[93] See, for instance, Goldin (2000, Figures 1 and 2).

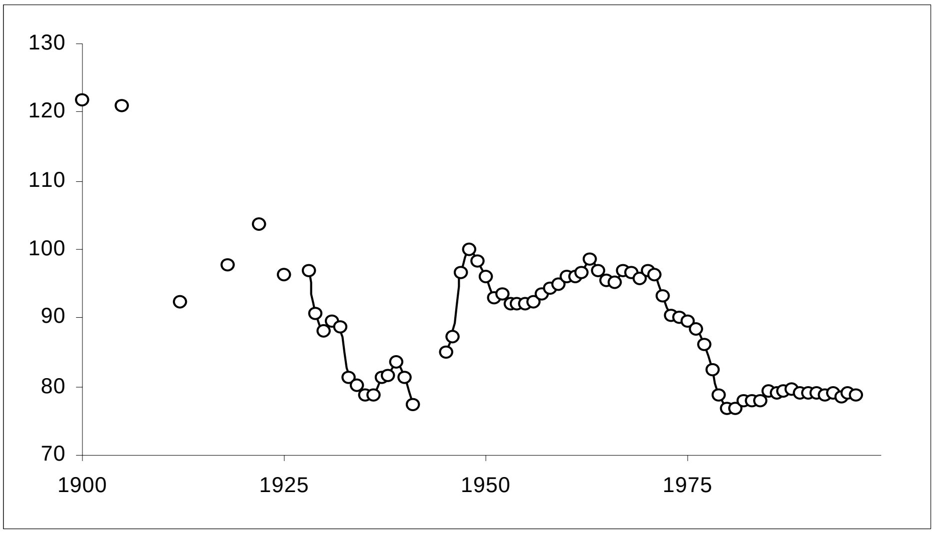
[94] The data sources for this index are Owen (1971), U.S. Bureau of the Census (1975), and series MWUR0000SA0 and MWUR0000SA6 provided by the U.S. Bureau of Labor Statistics as part of the *CPI-Urban Wage Earners and Clerical Workers* and downloadable at ftp.bls.gov/pub/time.series/mw/.

[95] Even though we would be more consistent with the theoretical model if the index for the price of recreation goods was divided by an index of commodities not including them, we resort to the definition of the index given in the text since, because of limited data availability, was the one utilized by Owen (1971).

century limits the scope of our conclusions, we observe a tendency in the index to go down during the first forty years or so, followed by an increase of about 20 or 25 percent coinciding with the baby boom years. The oil shocks in the 1970's caused a sudden reduction in the index, that stabilized its value from the beginning of the 1980's. Thus, the time series for the general fertility rate and the relative price of recreation goods exhibit a high correlation between them.[96]

FIGURE 3.2

PRICE OF RECREATION GOODS
U.S. (1949=100)



SOURCE.— Owen (1971), U.S. Bureau of the Census (1975), and series MWUR0000SA0 and MWUR0000SA6 provided by the U.S. Bureau of Labor Statistics (downloadable at ftp.bls.gov/pub/time.series/mw). The index for the price of recreation goods depicted here is constructed by dividing the recreation component of the Consumer Price Index by the CPI itself.

96 The correlation coefficient amounts to 0.70.

Before discussing the predictions of the theoretical model developed previously regarding the influence of the relative price of recreation goods on fertility, we must make two caveats. Firstly, in our framework of analysis the sign of the partial derivative of fertility with respect to the price of recreation goods, $p = \frac{B}{A}$, is the opposite to the sign exhibited by the partial derivative of fertility with respect to A, since, by definition, the wage rate, B, must be kept constant. This feature motivates the rather controversial conclusion that *ceteris paribus* increases in the relative price of recreation goods are caused by technological reversals in the sector in charge of producing them. Nonetheless, we do not take too literally this consequence, motivated as it is by the simplified structure of the model, and we prefer to think about p as a tractable proxy for the *relative* rather than the *absolute* technological development of the sectors producing recreation goods. Secondly, although we have assessed the qualitative responds of fertility to changes in the parameters of the economy, we have said anything regarding quantitative responses, what will limit the scope of the following discussion.

Under the assumption of a relatively elastic intertemporal substitution of recreation activities ($\gamma > 1$), there would exist a direct relationship between the price of recreation goods and fertility: increases in p—or, equivalently, reductions in A—would be accompanied by higher levels of fertility, and vice versa. Thus, given the actual evolution of the price of recreation goods, it would be contributing to the downward trend in U.S. fertility during the first forty years of the twentieth century and immediately after the baby boom, while, on the other hand, the baby boom itself might be influenced by the increase in the price of recreation goods observed after World War II: consumers could have substituted toward the consumption of other consumption goods and fertility and away from the consumption of recreation activities during the years of the U.S. baby boom.

We might argue a piece of evidence consistent with such prediction if the prime-age female behaviour found in the previous chapter under a life-cycle model of time allocation was also valid for the period of analysis considered in this chapter. We are only speculating, but if the negative relationship between the price of recreation goods and the time devoted to work in the market by part of prime-age females found before applied to this framework, it would bear out the existence of a positive relationship between the price of recreation goods and fertility since, as we claimed before (see the inequality [3.22] and the related discussion), if the representative individual was not too involved in the labor market—what might suit the situation of prime-age females in the 1950's and 1960's—, the sign of $\frac{\partial d}{\partial A}$ must be the opposite to $\frac{\partial n}{\partial A}$. Thus, should a prime-age female works less as p rises (that is, as A decreases), our model would predict that she would devote more time to rear children and would increase her number of descendants.

3.5 Concluding Remarks

This chapter has developed a model of optimal allocation of time in which children are considered consumption goods whose production requires time. We discussed a series of channels of causation through which technological progress in the economy could be determining the allocation of time across activities and, thus, affecting the level of fertility. Apart from the usual sort of technological progress consider in models explaining the evolution of human fertility after the Malthusian Regime in the process of economic development, the model laid out in this chapter emphasizes the roles of the expansion in the variety of recreation goods and of the existence of technological imbalances across sectors of production as new sources of movements in fertility.

We utilized some of the predictions emerging from the model to study the evolution of the U.S. fertility during the twentieth century. In particular, we study fertility in relation to the evolution of the relative price of those goods consumed in conjunction with leisure time, finding that, for a plausible range of parameter values, the price of recreation goods might contribute to the explanation of the downward trend in U.S. fertility during the twentieth century and, more importantly, to the explanation of its surprising recovery from the mid 1940's to the mid 1960's—the U.S. baby boom.

Lessons and Future Research

We think the two main contributions of this thesis are the following. Firstly, in contrast to what is usually sustained in life-cycle studies of the allocation of work effort, we have found evidence against the hypothesis of contemporaneous separability between goods and time in the preference ordering of the individual. Secondly, we have suggested new channels of causation through which technological progress in the economy could be affecting the allocation of time and that might contribute to the explanation of secular and out of trend movements in fertility after the malthusian era.

On the contrary to previous findings in Browning *et al.* (1985), Mankiw *et al.* (1985), and Altonji and Ham (1990), we have found the price of goods as a significant determinant of the allocation of time for both prime-age males and females. The main difference between those previous studies and ours is that, instead of studying whether the price of an aggregate of goods and services influenced the intertemporal allocation of market time, we have analyzed the influence caused by the price of a particular category of goods: those consumed in conjunction with leisure time. Regarding the observed behaviours, it is worth noting that prime-age males work, on average, more in those years in which the price of recreation goods is relatively higher, while prime-age females do exactly the opposite. These different gender responses to anticipated changes in the price of recreation goods evidence that prime-age males change the age at which they recreate more readily than they change the sort of recreation activities consumed, while prime-age females are more propense to contemporaneously substitute goods and leisure time in the enjoyment of recreation than to intertemporally substitute the consumption of recreation activities. Thus, for instance, if both populations anticipate that admissions to the cinema are going to be more expensive in the next period, males would go to the cinema this period, while females would prefer to, say, read a book the next period.

In the light of the theory unfolded in Chapter 3, the largely unexplained out of trend movements in fertility after the Malthusian Regime may be looked at now from alternative points of view. As a difference with the previous literature, we have emphasized the roles of the expansion in the variety of recreation goods and of the existence of technological imbalances across sectors of production as new sources of movements in fertility. Besides, these technological imbalances, caused, for instance, by the different diffusion of technology across productive sectors of an economy, may alter the relative price of consumption goods and generate the kind of movements studied in the first two chapters.

A lot of work remains to be done, however. If the life-cycle allocation of work effort is insensitive to alterations in the price of the whole set of goods and services, it must be due to the existence of other categories of commodities whose price changes generate—regarding market time—the opposing movements to those caused by price changes in recreation goods. The explanation of the different recreational behaviours observed by gender also deserves more research. For instance, as suggested in other previous studies,[97] we could analyze whether males' recreational behaviour is more influenced by habits than the females' one. The empirical findings in the first two chapters were obtained from samples with a high proportion of observations coming from married people. If the implicitly

[97] See Robinson and Godbey (1997, Ch. 13) and Coile (2003).

assumed exogeneity of spouse's labor market decisions was not appropriated, we would have to extend the model to be able to cope with the interrelated labor market behaviour of both spouses. Apart from this, it could be necessary to depart from the static framework of analysis, since the sizeable serial correlation detected in the idiosyncratic error of the structural equation calls into question the dynamic completeness of the conditional mean that is modeling labor supply behaviour.

In order to emphasize a series of mechanisms through which technological advances in the economy may be affecting time allocation and fertility, the model presented in Chapter 3 was highly stylized. We could make it more sophisticated by adding dynamics and by endogeneizing technological progress. For a better understanding of the partial responses of fertility to parametric changes in the economy, a more comprehensive production function for recreation would be necessary. Last, but certainly not least, a non-trivial amount of empirical research is needed to estimate the values of the model's parameters that are shaping the responses of the time-use categories and fertility to parametric changes in the economy. All these topics are outlined in our research agenda.

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