UCO Cahiers de recherche en économie-gestion
N° 2024-eco-02

UCO Working Paper Series in Economics and Business Administration
N° 2024-eco-02

Mars 2024

Inferring time preference from the value of time

François Gardes
UCO Angers

Université catholique de l'Ouest
Faculté de Droit, Économie, Gestion et Science politique
3 place André Leroy, 49008 Angers, France
Responsable : Karl-F. ISRAEL, kisrael@uco.fr
https://recherche.uco.fr/equipe/egei

Infering time preference from the value of time

François Gardes
Paris School of Economics, Université Paris 1 Panthéon Sorbonne
and Western Catholic University *

March 6, 2023

Abstract

Using a generalization of Becker's time allocation model in order to estimate the shadow price of time, we explore the relationship between it and the inter-temporal substitution rate, allowing the endogenization of the time preference from the estimation of the opportunity cost of time. Two models are developped implying a positive relationship between them and an evaluation of the inter-temporal rate at 10%.

Keywords: Time Allocation, Inter-temporal substitution rate, psychological rate of interest, Opportunity cost of time.
JEL: D31, J22.

Introduction

Actualizing the future supposes the definition of an inter-temporal substitution rate (ITSR, named here ρ) which is generally calibrated by reference to the capital market or to an anticipated rate of return for public investments when considering public expenditures. That actualization rate is often fixed at the average long term growth rate of the economy (see the discussion in Sunstein, 2014, pp. 62-63).[1] Independently from this inter-temporal rate, households value their disposable time by some opportunity cost of time ω which influences their decisions for market work and domestic production. A natural idea is that there may exist some relationship between these valuations of present and future time, but it seems that no model exists up to now exploring that link. It can be expected that an exogenous increase of the value of time may accelerate monetary expenses by way of substitution with time use in home production, which could develop the preference for present money over future money, thus increasing the psychological rate of interest. Also, a natural relation between ρ and ω could be extracted from their complementary relations with the household's saving rate. The household's time preference determines its saving rate, while the value of time is correlated with its expenditures and labor supply, so

*François Gardes, Centre d'Economie de la Sorbonne 106 - 112 Boulevard de l'Hôpital 75013 Paris, francois.gardes@univ-paris1.fr. Thanks are due to Christophe Starzec for his collaboration to the preparation of the dataset.

[1] see Frederick et al., 2002, for a survey of empirical and experimental estimations of time discounting and time preference.

that a relationship can be established between them equalizing the values of its household's savings depending on these two variables.[2] This method can be critized since it relies on the assumption that the decision to save part of income is taken in relation with an interest rate independently from the marginal propensity to consume, which is a heroic hypothesis whence it applies to one agent (while it may be more naturally applied to aggregates) since a change in the opportunity cost of time implies a change in full income and full prices, and consequently in total expenditure.

This article explores a relationship between the changes of these parameters based either on the assumption of a constant household's permanent wealth or on a specific direct utility function depending on monetary expenditures and time use. The second model gives also rise to an estimation of the level of the inter-temporal rate conditional to the value of time.

In order to estimate the opportunity cost of time, I use a home production model where the consumer combines time with market goods to produce activities that generate utility. Utility maximization implies that the value of time is given by the ratio of the marginal utility of time over the marginal utility of income. Previous papers (Gardes 2018 and 2019) show that this ratio can be structurally estimated at the individual level provided that data on households' time and monetary expenditures are available (see Appendix A). To overcome the lack of this type of data, I combine, using a statistical matching procedure described in Appendix B, a french survey on household expenditures with a survey on time use made in the same year (2000).

Section 1 presents a model based on the constancy of the present value of the household's permanent full wealth and its application to the french dataset, section 2 develops another model based on a specific utility.

I Model based on the constancy of the present value of the permanent full income

The first general method I propose relies on the assumption that the ITSR and the opportunity cost of time both influence the present value of the household's permanent full wealth (equal to the discounted sum of all future full incomes y^f).[3] Following the assumption made in the permanent income theory, the present value of the stream of future full incomes is supposed to remain constant over the household's life cycle, in spite of changes in the opportunity cost of time due to age, family structure or income (all being supposed to be well anticipated

[2]Suppose for instance that an increased household's income in the first period t_0 is partially (for instance at 80%) devoted to an instantaneous consumption and the residual (20%) to deferred consumption in $t_0 + 1$, so that the ratio of instantaneous indirect utilities of expenditures in t_0 and $t_0 + 1$ decreases, which corresponds to a smaller value of future incomes or an increase of the inter-temporal rate ρ. On the other hand, the opportunity cost of time depends positively on the household's monetary expenditures (according to equation 10 in Appendix A), so that the income change implies both increased ρ and ω. A more complete model where saving depends on the ratio of the market interest rate over the ITSR and over the household's full income is presented in Gardes, 2022b.

[3]A model restricted to two periods is presented in Gardes, 2022b.

by the household). This supposes that the inter-temporal rate of substitution varies accordingly to the opportunity cost of time in order to maintain the permanent income constant through the life cycle. Therefore, it is possible to calculate the change between two consecutive periods of the inter-temporal rate of substitution which corresponds to a change in the opportunity cost of time. The present value of the permanent income stream can be written for a full income flow y^f and an ITSR ρ:

$$v\left(y^f\right) = \int \left[y_t^f \exp\left(-\rho t\right)\right] dt \tag{1}$$

The definition of full income is presented below.

Definition of the household's full income

Two possible indicators of full income

The usual full income concept y_0^f is the maximum monetary income which could be earned when working during all disposable time T, valued at the market wage rate W net of taxes:

$$y_0^f = WT + V. \tag{2}$$

with V other incomes unrelated to market work (financial revenues, social redistribution...). Another indicator of household's full resources, adding the value of domestic production to monetary income from market work and other sources, can be defined, first valuing the time used in home production by an estimated opportunity cost ω and second, considering that only a part of domestic production could be afforded by market goods and services. The non-substituable component of domestic production (speaking with one's spouse for instance) would not be added to the full estimate of household's resources. Indicating by π_i the proportion of a semi-aggregate home product i (such as expenditures for private transportation) which can be replaced by a market product or service, this indicator of full resources writes:

$$y^f = Wt_w + V + \omega \sum \pi_i t_i. \tag{3}$$

The next sub-section proposes a method to calculate these proportions π_i.

Substituable chores

Chores (domestic dayly works) are generally defined as the minimum amount of home production the value of which could be added to the value of the agent's production working on the labor market. Pure leisure activity would for instance be excluded. Home production related to food would be considered as a chore only if it corresponds to the normal amount of food for a typical similar agent, the individual surplus of a given agent being considered as linked to its particular constraints or preferences to be excluded from the chores. But measuring this minimum amount is difficult, either directly on a survey (choosing for instance the first tercile of the distribution of time use for food among similar individuals) or by an estimation of a demand system such as the Linear

Expenditures System.

I propose a new method estimating the proportion of time devoted to some home activity which can be considered as a chore, by means of the degree of substitution with market alternative goods or services since the value of chores for a given domestic production (for instance of transport) is the cost to acquire a substitute on the market. The integration of that value in the market production thus proceeds from the possibility to obtain the same final good on the market at a given price which is attributed to that component of the domestic production. This requires that the elasticity of substitution between market factors of production and time must be large, so that it is possible to produce the same amount of final good with these market factors substituted to time use.

Suppose that the domestic production of some final good i is divided between 'substituable' chores 1 produced with complete substituability with market goods or services (therefore supposed to be governed by a unitary elasticity of substitution between monetary and time inputs, corresponding to a Cobb-Douglas domestic production function: : $\sigma_{i,1} = \frac{\frac{\partial[(t_{i,1})/m_i]}{\partial(\omega)}}{[(t_{i,1})/m_i]/\omega} = 1$) and non-substituable chores 2 characterized by a zero elasticity of substitution with market goods ($\sigma_{i,2} = 0$). The same division applies to the total time devoted to the home production of the final good: $t_i = t_{i,1} + t_{i,2}$, with $t_{i,1}$ and $t_{i,2}$ the times spent in substituable (respectively non-substituable) home work producing the final good i. The elasticity of substitution of the aggregate time t_i over the opportunity cost of time ω writes, with m_i the expenditure made for market goods and services used producing the final good:

$$\sigma_i = \frac{\frac{\partial[(t_{i,1}+t_{i,2})/m_i]}{\partial(\omega)}}{[(t_{i,1}+t_{i,2})/m_i]/\omega} = \frac{\frac{\partial[t_{i,1}/m_i]}{\partial(\omega)}}{(t_{i,1}/m_i)/\omega}\frac{t_{i,1}}{(t_{i,1}+t_{i,2})} = \sigma_{i,1}\frac{t_{i,1}}{t_{i,1}+t_{i,2}} = -\frac{t_{i,1}}{t_{i,1}+t_{i,2}} = -\pi_i \tag{4}$$

The proportions π_i of chores in this domestic activity can then be measured by the absolute value of the elasticities of substitution, which are smaller than one for all activities in our french dataset : 0.37 for food, 0.40 for clothing, 0.96 for leisure activities and 0.74 for All other activities, with an overall average 0.72 (see Canelas et al., 2018, Tables 2 and 3). The time value of chores[4] v_i in each domestic activity will be calculated by means of these elasticities of substitution and added to the monetary value of expenditures made to produce the corresponding final good: $v_i = \omega_i.t_{i,1} = |\sigma_i|.\omega_i.t_i$. A generalization to the case of multiple components of chores with different elasticities of substitution is straightforward.

The household's full resources can therefore be defined as the sum of its monetary income and of that component of substituable chores valued by the estimated opportunity cost of the household:

$$y^f = Wt_w + V - \omega\sum \sigma_i t_i = Wt_w + V + \omega|\sigma|(T - t_w) \tag{5}$$

[4]The total economic cost of these chores include all monetary goods and service used for their production, the value of which is already included in the household's total monetary expenditure

with σ the weighted average (weighted by the time budget shares) of the elasticities of substitution σ_i.[5]

This full income is estimated at the households' level, then aggregated over the population.

Calculus of the elasticity of the inter-temporal rate over the opportunity cost of time

The derivative over ω of this integral equals, under usual conditions, the integral of the derivative of the full income y^f, which is, with ρ depending on ω:

$$\phi = \frac{\partial y^f}{\partial \omega} = W\frac{\partial t_W}{\partial \omega} + (T - t_W) - \omega\frac{\partial t_W}{\partial \omega} = \left(\frac{W}{\omega} - 1\right) E_{\frac{t_w}{\omega}} + \sum |\sigma_i| t_i \qquad (6)$$

with σ_i the elasticity of substitution between the household's time and monetary expenditures.

The integration over time (from 0 to infinity[6]) of this derivative is equal to zero since permanent full income remains constant:

$$\int \left\{ \frac{\partial y_t^f}{\partial \omega} \right\} \exp(-\rho t)\, dt = \frac{\phi}{\rho} - y_t^f \frac{1}{\rho^2}\frac{\partial \rho}{\partial \omega} = 0 \qquad (7)$$

Under the assumption that the household's permanent income does not change for simultaneous changes of the inter-temporal rate and the opportunity cost, the marginal propensity and the elasticity of the ITSR over the opportunity cost of time write:

$$\frac{\partial \rho}{\partial \omega} = \frac{\left(\frac{W}{\omega} - 1\right) t_W El_{\frac{t_W}{\omega}} + \sum |\sigma_i| t_i}{W t_W + V + \omega \sum |\sigma_i| t_i}\rho \qquad (8)$$

$$El_{\frac{\rho}{\omega}} = \frac{(W - \omega)\, t_W El_{\frac{t_W}{\omega}} + \omega \sum |\sigma_i| t_i}{W t_W + V + \omega \sum |\sigma_i| t_i} \qquad (9)$$

This elasticity can be calculated for average values of W, t_W, V and t_i and estimates of the opportunity cost of time, and the elasticities of substitution and of the market work household's supply.

[5] Note that, as the opportunity cost of time (Gardes, 2019) and income both increase in the middle of the household's life cycle, domestic times and the market work may decrease by means of the substitution effect (measured through the elasticities of substitution) and by means of the price effect of the ratio of the market wage over the opportunity cost of time over the household's market work supply. By these correlated changes, households' full income may be more stable than their monetary income through the life cycle.

[6] Households are supposed to leave their permanent wealth to their inheritants. Considering the life cycle from birth to age T multiplies the derivative of ρ over ω by the fraction $\frac{\exp(-\rho T)-1}{\rho \exp(-\rho T)}\left(T + \frac{1}{\rho}\right) - 1$ which is for instance 0.925 for $\rho = 5\%$ and T=80 years (corresponding to the average life duration in developed countries) or 0.418 for T=20 (corresponding to an evaluation at age 60 till 80).

In order to estimate the shadow price of time ω, I assume that the consumer combines time with monetary expenditures to produce activities that generate utility in a model where the market work time is valued by the consumer's wage rate while the remaining time (e.g., time allocated to leisure or non-market work) is valued by the shadow price of time that may differ from her wage rate. It is assumed here that the consumer's utility function is a Cobb-Douglas function of domestic productions, which are themselves Cobb-Douglas functions of the monetary and time expenditures corresponding to the given activity.[7] Combining the utility and the production functions allows to write the utility in terms of monetary and time inputs and to calculate the endogenous value of time as:

$$\omega = \frac{\frac{\partial u}{\partial t'}\frac{\partial t'}{\partial(\sum t_i)}}{\frac{\partial u}{\partial m'}\frac{\partial m'}{\partial Y}} = \frac{m'\sum \beta_i\gamma_i\frac{\partial t'}{\partial(\sum t_i)}}{t'\sum \alpha_i\gamma_i\frac{\partial m'}{\partial Y}} \tag{10}$$

with α, β and γ the coefficients of the utility and domestic production functions and m', t' geometric means of monetary and time expenditures (see Appendix A and Gardes, 2019, sections 2.3 and 2.4).

Equation (9) shows that, generally speaking, the ITSR increases with the opportunity cost of time with an elasticity positive and smaller than 1, for instance whence $V \geq 0$, $0 \leq El_{\frac{t_W}{\omega}} \leq 1$ and $W \geq \omega$. It is for instance equal to 0.25 for a direct estimation of these parameters on the french dataset (see Table 1 below). This elasticity may vary between households, which implies different inter-temporal rates across the population. If for instance the average household has an inter-temporal Substitution rate at 3% and an opportunity cost of time at 7.32 US dollars (the average for the french survey), the ITSR of a household characterized by an opportunity cost equal to ω is given by: $log(\rho) = -4.0 + 0.25 * log(\omega)$. As ω is positively related to income, ρ increases along the income distribution.

In Gardes (2022d), I modify the definition of a textitpsychological time parallel to the calendar time proposed by Allais (19) in order to stabilize the macroeconomic demand for money in this time scale. In this model, the new version of textiteconomic (rather than psychological) time depends positively on the opportunity cost of time *omega*, which shows that this time scale is extended in terms of calendar time when *omega* increases. Therefore, that extension of the economic time scale can be supposed to increase the time preference (corresponding to the calendar time) indicated by *rho* as soon as the time preference is supposed to remain constant on the economic time scale. This relation between the opportunity cost of time and the economic time scale therefore implies a positive relation between *rho* and *omega* concordant with formula (9).

Empirical Results

In this application, household's income is proxied by its total expenditures, in order to take care of the proportions π_i differeing between partial expenditures,

[7] A generalization with more general CES functions is developped in the 2022 version of Gardes, 2018

and of the errors of measurement of households' income in Family Expenditures surveys.The parameters which must be estimated in equations (8) and (9) are the elasticity of market labor over the opportunity cost and the elasticities of substitution σ_i. Market labor time can be considered as the residual of domestic production time over the total disposable time T (supposed to be exogenous), so that this elasticity can be estimated by means of the elasticities of domestic production times t_i over the opportunity cost of time ω. Estimation of that elasticity of the market labor time using the french dataset (Gardes and Margolis, 2014) provides an estimate 0.861 for the whole population, with significant changes for different sub-populations, as indicated in Gardes and Margolis, Table 1. A direct estimation of the regression between $T - \sum t_i$ and ω, reported in this Table 1, gives positive but smaller estimates which are more in line with the usual estimations of the elasticity of market work over the wage rate. These estimations are used in the calculus of the marginal propensity and the elasticity of ρ over ω.[8]

On the french dataset, equation (8) gives a derivative of ρ over ω equal to 0.00221 for the whole population implying an elasticity $El_{\frac{\rho}{\omega}} = 0.246$.[9] It can be concluded that the inter-temporal rate of substitution ρ increases with the opportunity cost of time ω, with an elasticity which is smaller than one. These parameters change a lot on sub-populations : results in Table 1, in accordance with other studies (Gardes, 2019), show that the opportunity cost of time is greater for households having a more constrained time budget (families with children, middle aged households) and much smaller for singles. The elasticity of market work over the opportunity cost of time diminishes with age and is larger for families with children. These changes imply that the elasticity $El_{\frac{\rho}{\omega}}$ increases with age and the presence of children and is one half smaller for singles compared to families with children. This shows that the effect of the value of domestic time over the rate of substitution differs much across the population. The resulting change of the inter-temporal substitution rate due to income (in the cross-section dimension) is a relative increase by one third to two thirds from the 5th centile to the 95th centile of the income distribution (for instance from 3.77% to 6.23% for families with children, which corresponds to a cumulated actualized full income over the life cycle equal to 26.5 times the yearly income for 3.77% and only 16.0 for 6.23%). That change is somewhat contrary to the assumption that the poor are obliged to be short-forsighers (but in line with the idea that the opportunity cost of time is larger for the rich and perhaps more sensitive to income changes).

Note finally that the increase of yearly full income has a proportional positive direct effect on the cumulated income over the life cycle, but also a negative indirect effect through the increase of the inter-temporal substitution rate: for instance, an increase of yearly income (over the whole life cycle) by +10% increases the ITSR (supposed calibrated at its mean 5%) by 0.114% , which implies a reduced total positive effect on cumulative income +7.7%.

[8]Estimates using the higher elasticities of market work obtained by the indirect method based on domestic work in Gardes and Margolis are not so different.

[9]Remind that, in this estimation, the domestic times are reduced by a factor $|\sigma_i|$ which measures the component in the domestic activity i which can be substituted to market goods and services as discussed in the previous section. Computed on total domestic times, the corresponding $\frac{\partial \rho}{\partial \omega} = 0.00559(0.00237)$ and the elasticity are doubled.

	ω	$El_{\frac{t_W}{\omega}}$	$\frac{\partial \rho}{\partial \omega}$	$El_{\frac{\rho}{\omega}}$	$\rho 5^{th}(\%)$	$\rho 95^{th}(\%)$
Whole Population	6.23	0.281	0.00221	0.246	4.26	5.74
s.e.	2.02	0.017	0.00197	0.171	-	-
Singles	5.82	0.093	0.00184	0.184	4.53	5.47
s.e.	1.56	0.035	0.00145	0.126	-	-
Couples without children	6.23	0.213	0.00222	0.265	4.14	5.86
s.e.	2.36	0.027	0.00179	0.148	-	-
Couples with children	6.62	0.356	0.00279	0.338	3.77	6.23
s.e.	1.87	0.031	0.00143	0.126	-	-
Age till 35	6.02	0.413	0.00174	0.194	4.50	5.50
s.e.	1.73	0.036	0.00329	0.307	-	-
Age 36-55	6.46	0.268	0.00223	0.250	4.16	5.84
s.e.	2.30	0.019	0.00157	0.122	-	-
Age after 56	6.09	0.127	0.00321	0.358	4.04	5.86
s.e.	1.81	0.065	0.00203	0.182	-	-

Table 1: Estimates of the Elasticity of Labor Supply, the derivative of ρ over ω and of the corresponding elasticity

Another way to obtain a relation between ρ and ω could rely on the maximization of a specific utility depending both on monetary and time expenditures, but this needs specifying a particular utility and estimating its coefficients. Moreover, that modelization requires to make assumption on the dynamic effects of a change in the value of time over the the variables defining the utility, for instance the expenditures and time uses in our specification of a direct utility. That difficult study is left to a future research.

Conclusion

This paper provides an estimate of the inter-temporal substitution rate depending on the value of time experienced by the household. This relation serves as an endogeneisation of the psychological inter-temporal rate which is generally supposed in the literature to be the same for all households or which is calibrated for different typical economic agents at a priori amounts which are rarely justified by some reasoning. It gives also a micro-economic explanation, based on the theory of the allocation of time, of the positive value and the level of the primary interest rate central to the Austrian school (see von Mises, 1949, chapters 18 and 19, Herbener, 2011, and Gardes, 2022c) and to Allais' psychological rate of interest (Allais, 1974).

The empirical analysis of the model based on the household's permanent full wealth shows that this psychological rate of interest is positively correlated

to the value of time, depends on the elasticity of market labor supply and varies significantly across the population. The increase of the inter-temporal rate with the household's level of being reveals that the inter-temporal rate may not be interpreted as an information on the time horizon of the agent but rather as the cost of the displacement of money to the future, which is related to the value of time [10]. The evolution of the inter-temporal rate along the income distribution (or its changes for different sub-populations) must be challenged looking precisely at the evolution of all parameters along the income distribution.

Appendix A: Estimation of the opportunity cost of time[11]

The opportunity cost of disposable time for home production and leisure (total time less market working time and necessary uses, such as sleeping time) can be derived from the households' allocation of time among market and domestic activities according to Becker's model of the allocation of time (Becker, 1965). This opportunity cost (named ω) is generally calibrated at the level of the household's wage rate (net of all taxes and costs involved by market labor), or at a minimum wage level if the domestic production is considered as substituable to market services characterized by a low productivity and thus a cost equal to the minimum wage rate. A model of domestic production with an endogenous opportunity cost of time generalizing Becker's theory allows to estimate this opportunity cost of time at the household level. In order to estimate the opportunity of time, I use a home production model (presented in (Gardes, 2019 and 2022a) where the consumer combines time with market goods to produce activities that generate utility. Utility maximization implies that the value of time is given by the ratio of the marginal utility of time to the marginal utility of market goods. It is assumed that the consumer's utility function is given by $u(z) = \prod_i a_i z_i^{\gamma_i}$ where a_i is a positive parameter and z_i is the quantity of the activity i produced by the combination of monetary and time inputs denoted m_i and t_i, respectively: $z_i = b_i m_i^{\alpha_i} t_i^{\beta_i}$ where $m_i = x_i p_i$ with x_i the quantity of the market goods i, p_i its monetary price, and b_i a positive parameter.[12] The choice of the Cobb-Douglas forms[13] allows the parameters to be identifiable assuming that $\alpha_i + \beta_i = 1$ (no economy of scale in the domestic productions). As we estimate the parameters locally (i.e., for each observation in the dataset), the Cobb-Douglas specifications imply simply constant substitution between time and monetary resources only in the neighborhood of each individual's equilibrium point.

[10] However, the negative correlation between the time horizon of the agent and the inter-temporal rate is well in line with the negative relation between the opportunity cost of time and the definition of economic time (defined as such rather than psychological with reference to the opportunity cost of time in Gardes, 2022d)

[11] Based on Gardes, 2019, sections 2.3 and 2.4.

[12] z_i is assumed to depend on expenditures m_i (rather than quantities x_i) because the dataset informs only expenditures. This approach yields consistent results when all households face the same prices.

[13] A more general model based on CES utility and domestic production functions allows to estimate specific opportunity costs for different activities, see Gardes 2018, sections 1.4 and 3.1

Rewriting the utility in terms of (geometric) averages m' and t' of monetary and time expenditures, gives the following function:

$$u(m,t) = \Pi_i(a_i b_i^{\gamma_i}) \left(\prod_i m_i^{\frac{\alpha_i \gamma_i}{\sum \alpha_i \gamma_i}} \right)^{\sum \alpha_i \gamma_i} \left(\prod_i t_i^{\frac{\beta_i \gamma_i}{\sum \beta_i \gamma_i}} \right)^{\sum \beta_i \gamma_i} \tag{11}$$

$$= A\ m'^{\sum \alpha \gamma_i}\ t'^{\sum \beta_i \gamma_i} \tag{12}$$

This implies that the shadow price of time, denoted ω, is given by equation (10):

$$\omega = \frac{\frac{\partial u}{\partial t'} \frac{\partial t'}{\partial (\sum t_i)}}{\frac{\partial u}{\partial m'} \frac{\partial m'}{\partial Y}} = \frac{m' \sum \beta_i \gamma_i \frac{\partial t'}{\partial (\sum t_i)}}{t' \sum \alpha_i \gamma_i \frac{\partial m'}{\partial Y}} \tag{13}$$

The shadow price of time differs from the market wage rate when, for instance, there exist some market imperfections, transaction costs, and constraints on the labor market or in the home sector. The shadow price of time can be estimated provided that estimates of α_i, β_i, and γ_i are available, which is obtained considering the substitutions between monetary and time expenditures in the production of each final goods and by the substitution of time or money between activities (see Gardes 2019, section 2.4).

Appendix B: Datasets[14]

The computation of the opportunity cost of time ω necessitates to measure both households' monetary expenditures and time uses. In order to dispose of this statistics, I use a French dataset from INSEE which combines at the individual level the monetary and time expenditures into a common, unique goods and services consumption structure by a statistical match of the information contained in two surveys: the Family Expenditure Survey (FES, INSEE BDF 2001) and the Family Time Budget (FTB, INSEE BDT 1999).
The definition of comparable good and time groups of expenditure is a difficult and sometimes arbitrary operation. This rather difficult exercise needs some arbitrary assumptions about the substitution between time use and monetary expenditures (see Gronau and Hamermesh 2006 for a discussion). The commodity consumption structure does not correspond exactly to what is often used as a standard classification of time uses even if differences can be limited. The reason is that not all time use activities can have a clear work equivalent. This is particularly the case of the leisure time. However, comparing our classification with other similar approaches (Gronau and Hamermesh, 2006) we obtain similar patterns of what these authors call "relative goods/time intensity" defined as a ratio of good to time inputs relative to total amount of goods and time allocated to the production of final goods.

The French dataset from INSEE combines at the individual level the monetary and time expenditures into a common, unique goods and services consumption structure by a statistical match of the information contained in two surveys: the Family Expenditure Survey (FES, INSEE BDF 2001) and the Family Time Budget (FTB, INSEE BDT 1999). I define 8 types of activities or time use

[14] Matched Dataset prepared by Christophe Starzec

types compatible with the available data both from FES and BDT: Eating and cooking time (FTB) and food consumption (FES), cleaning and home maintenance and dwelling expenditures (including imputed rent), clothing maintenance and clothing expenditures, education time and education expenditures, health care time and health expenditures, leisure time and leisure expenditures, transport time and transport expenditures, miscellaneous time use and miscellaneous goods and services. Time uses for all selected activities are regressed on households' characteristics using common covariates observed in the two surveys (such as education level and the age of the head, the family demographic structure and location) for all observation units in the FTB survey and these estimations serve to predict the time spent on these activities for the corresponding units in the FES survey.[15]

[1.5pt]	σ food	σ non-food	$El_{\frac{t_W}{\omega}}$	t food	t non-food	t_w	W
Whole Population	0.620	0.692	0.861	31.0	101.1	56.3	10.13
s.e.	0.017	0.009	0.0038	13.6	32.4	24.9	15.87
Singles	0.685	0.741	1.336	18.1	67.6	38.5	9.04
s.e.	0.047	0.023	0.0116	7.1	15.6	13.3	5.80
Couples without children	0.558	0.644	1.043	39.1	122.4	59.5	10.92
s.e.	0.022	0.011	0.0096	13.5	29.7	26.1	22.35
Couples with children	0.905	1.097	0.590	33.3	106.4	62.5	10.10
s.e.	0.034	0.017	0.064	8.4	18.9	24.3	13.6
Age till 35	0.619	0.902	-	21.4	91.3	57.4	7.72
s.e.	0.063	0.030	-	9.9	28.5	24.3	3.77
Age 36-55	0.596	0.711	-	29.6	93.0	57.4	10.67
s.e.	0.023	0.012	-	11.1	27.3	24.5	10.8
Age after 56	0.764	0.768	-	37.9	115.4	46.8	13.64
s.e.	0.029	0.014	-	14.23	34.37	26.5	39.88

Table 2: Estimates of elasticities of substitution and labor supply

Note: $El_{\frac{t_W}{\omega}} = A_i$; $\alpha_i = 1 - \beta_i$; σ_i: elasticity of substitution between monetary expenditures and time uses for activity i: estimation on the estimated opportunity cost of time (Canelas et al, 2018; direct estimation of E_{z_i/y^f} and E_{z_i/π_i} on the dataset (this compensated price-elasticity is estimated on full prices p_i^{f1} since the second definition depends on monetary prices which are not observed).

[15] Another more general matching procedure (based on Rubin's Multiple Imputation method (Rubin, 1986) which takes into account the correlations (conditional to covariates) for each variable which is matched between the two surveys, with the set of matching variables) is presented in Alpman, 2016. Alpman et al., 2017 shows that this procedures gives estimates to the regression method.

References

Aguiar, M., and Erik Hurst (2007). Measuring Trends in Leisure: The Allocation of Time over Five Decades. *Quarterly Journal of Economics*, 122, 969−1006.

Allais, M. (1974), The Psychological Rate of Interest. *Journal of Money, Credit and Banking*, August, 285-331.

Alpman, A. Implementing Rubin's Alternative Multiple-Imputation Method for Statistical Matching in Stata. *Stata Journal* 16 (2016): 717−739.

Alpman, A., Francois Gardes, and Noel Thiombiano (2017) "Statistical Matching for Combining Time-Use Surveys with Consumer Expenditure Surveys: An Evaluation on Real Data." *Cahiers du Centre d'Economie de la Sorbonne , University Paris I Panthéon Sorbonne* (2017.24).

Becker, G. (1965) A Theory of the Allocation of Time. *The Economic Journal*, 75, 493−517.

Canelas, Carla, Gardes, François, Merrigan, Philip and Salazar, Silvia (2018), Are Time and Money Equally Substitutable for All Commodity Groups in the Household's Domestic Production? *Review of Economics of the Household*, 17, 267-285.

Frederick, S., Loewenstein, G. and O'Donoghue, T. (2002), Time Discounting and Time Prefernce: A Critical Review, *Journal of Economic Literature*, vol. XL, June, 351-401.

Gardes, F. (2018), On the Value of Time and Human Life, *Cahiers du Centre d'Economie de la Sorbonne 2018.28, new version 2022, University Paris I Panthéon Sorbonne.*

Gardes, F. (2019) The Estimation of Price Elasticities and the Value of Time in a Domestic Production Framework: an Application Using French Micro-Data. *Annals of Economics and Statistics*, 135, September, 69-100.

Gardes, F. (2022a), A solution to the estimation of an enlarged GDP including domestic production: an estimation on individual data, *Cahiers du Centre d'Economie de la Sorbonne 2022.24, University Paris I Panthéon Sorbonne.*

Gardes, F. (2022b), Infering Time Preference from the Value of Time: three models, *Working Paper, University Paris I Panthéon Sorbonne.*

Gardes, F. (2022c), An Austrian Trade Cycle model with an Endogenous Value of Time, *Cahiers du Centre d'Economie de la Sorbonne 2022.25, University Paris I Panthéon Sorbonne.*

Gardes, F. (2022d), On Allais' 'Psychological Time', *w.p., Journées de Microéconomie Appliquée, Rennes, June.*

Gardes, François and Margolis, David (2014), Labor Supply, Consumption and Domestic Production, *w.p. CES 2014, Paris School of Economics, University Paris I Panthéon Sorbonne.*

Gronau R and D.S. Hamermesh (2006). Time vs. Goods: the Value of Measuring Production Technologies. *Review of Income and Wealth*, 52.1, 1-16.

Herbener, J.M. (2011) *The Pure Time-Preference Theory of Interest.* Ludwig von Mises Institute.

Sunstein, C.R. (2014) *Valuing Life.* University of Chicago Press.

Mises, Ludwig von (1949) *Human Action: A Treatise on Economics.* Yale University Press.

Rubin, D. B. Statistical Matching Using File Concatenation with Adjusted

weights and Multiple Imputations. *Journal of Business and Economic Statistics*, 4 (1986): 87-94.