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Opportunity cost of time and value of human Life in Burkina Faso and Ivory Cost

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Abstract

The monetary valuation of human life is both controversial and complex, giving rise to passionate debate and profound ethical dilemmas. This article uses a new method to measure the value of human life based on a marginal valuation of the individual's available time over her life cycle. The results of an empirical application carried out in two African countries on microeconomic data reveal a significant divergence in the valuation of human life within the population, which may illuminate discussions on the ethical issues of a differential valuation of human life. This finding calls into question the usual ethical considerations and social equity thesis and shows that this individual estimation of the value of human life may be an interesting indicator for public choice.

Keywords: Opportunity cost of time, pseudo-panel, inter-temporal substitution rate, value of human life, Ivory Cost Burkina Faso.

JEL Classification: C33, D1, D13, J22, J38

Introduction

The concept of the value of a life in economics refers to the monetary worth assigned to avoid death or to save a life. Understanding the value of human life is essential for guiding public policies, social investments, and ethical decision-making (see Dionne and Lebeau, 2010 and Anderson and Treich, 2011). However, the concept of the statistical value of life has an important limitation due to the diversity of methods and empirical results (see Gardes, 2022a). Moreover, the question of the effect of age and various socio-economic characteristics of the individual on the value of her life is not clear. Aldy and Viscusi (2008) (2008) suggest a relationship in the form of an inverted U, whereas OECD studies (2012) refute the existence of a relationship. On the other hand, income emerges as a determinant of the value of human life, yet it is rejected for ethical reasons (Thouverez, 2016). The differences between countries in this value are

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closely correlated with per capita GDP (Madeshwaran, 2007). For instance, according to Treich (2015), the value of life significantly increases with income and shows more modest values in developing countries compared to developed ones.

In light of these controversial results, this article examines the empirical results arising from the application of a new concept of the value of a life proposed by Gardes (2022), which is based on the marginal value that each individual places on his or her available time. The contribution of the paper is twofold: (i) Comparing the value of human life in two African Countries; (ii) Analysing the determinants that influence the value of human life in the African context. These two countries differ much as concern, both their economic development and the market structures (especially the labor market), independently of their particular economic, social and politic situations. It is thus difficult to disentangle all possible causes of the differences observed in households' use of their monetary and time resources. The two countries have the same average life duration (around 58 years), but the demographic structures of families may be quite different (and very variable across each population). The comparison is thus limited to the difference of the levels of being indicated by the households' income (measured by the GDP per capita).

The article is structured as follows: Section 1 describes the methodology, section 2 presents the data-sets and section 3 discusses the results.

1 Methodology

1.1 A new definition of the value of human life

Suppose an economic agent evaluates her marginal value for disposable time at ω_t in period t. This marginal value can be integrated over the agent's whole life (from birth to death: 0 to T_0) or remaining life (present age t_0 to T_0)[2] in order to obtain a monetary value of her total living time. This marginal value is applied to all types of activities, an assumption which is also made in all other methods evaluating the 'statistical' value of human life, for instance those based on the willingness to pay for an extra hour or on hedonistic wages.

The economic value of a length of time, for instance a year, lived by some individual is the product of the value of time (supposed constant during the year in the final formula (2)) with this duration (measured in yearly hours τ if the opportunity cost of time corresponds to one hour). The total value of a human life of an individual is the sum of yearly values actualized at an interest rate ρ over the life cycle from $t = 0$ (or t_0) to T_0:

$$V = \int_0^{T_0} \omega_t \tau e^{-\rho t} dt \tag{1}$$

with τ the number of disposable hours during one year. The assumption that ω is constant along the life cycle gives the following value (see Gardes,

[2] see in Gardes, 2022a, the evaluation of the VHL in this case

2022a):

$$V = \left(\frac{1}{\rho} - \frac{e^{-\rho T_0}}{\rho}\right)\omega\tau \tag{2}$$

Disposable hours are defined as those which are free to choose and which could therefore be substituted for another activity, either domestically or on the labor market. It may correspond to 24 hours a day (including sleep in this substitution) or disposable time after necessary activities (16 hours per day for instance corresponding to 5840 for one year).[3]

The value of a human life thus depends, first on the psychological interest rate ρ, second on the opportunity cost of time, third on the agent'age, fourth on life duration. This model supposes a common evaluation of time uses spent during the life cycle, either in the market or at home, which corresponds to the assumption of a perfect substitution between market work and domestic work (a possible difference between the wage rate and ω being caused by the desutility of market labor) and between periods (by means of the ISTR ρ).

1.2 The estimation of the opportunity cost of time

In the Becker's original allocation of time model, the same opportunity cost of time applies for the time factor of the home production and on the labor market. Gardes (2019) proposed a model where the value of time in domestic production can differ from the wage rate and where the agent maximizes a direct utility function depending on the quantities of a set of activities given by domestic production functions. This model gives rise to an estimation of the opportunity cost of time depending on the parameters of the utility and domestic production functions and on geometric means of household's monetary expenditures and time uses for all domestic activities (Gardes, 2019, equation 5). This value of time is estimated at the individual level (that is for each individual or household in the data-set). This model is presented in Ango and Gardes (2025, Appendix A).

2 Datasets

2.1 Burkina Faso: the Agricultural Family survey

The RGA Survey[4] (Recensement Général de l'Agriculture, 2008) covers 71 villages in the 45 provinces, with a total of 6941 households surveyed. It contains information on family characteristics (incomes from agriculture or other activities, age of the head and the spouses, number and age of children, education level, accessibility to social services, income, financial situation, equipment...),

[3] Considering that the opportunity cost of time depends on age and various socio-economic characteristics of the household gives an alternative formula but rather concordant final average results, see Gardes (2022, section 2.1, equation 8) and Aldy and Viscusi, 2008.

[4] Acknowledgment to the General Directorate for the Promotion of the Rural Economy (DGPER) and the University of Ouaga II and to INSEE for the disposition of its Family Expenditures and Time-Use surveys.

households' expenditures (over 40 goods and services) and time use over 14 activities: unproductive activity, agriculture in rainy periods, gardening, culture of trees, cattle breeding, fishing, gathering, wood harvesting for selling on a market, wood harvesting for family needs, search for water, market work, other domestic activities, personal activities, other activities.

The monetary expenditures and the time use have been grouped into three common domestic activities (activity 11 being excluded since it concerns market work): food (time activities 2 to 7, 9 and 10), domestic activities (12), other (13, 14). Detailed information on the country and the dataset can be found in Gardes and Thiombiano, 2017, Appendix A and Angbo-Gardes, 2025).

2.2 Ivory Cost

We use two annual family budget surveys: BdF (2008) and BdF (2015). As these surveys do not provide data on the use of time for activities, we use a daily time budget survey: BdT (2013). This allows us to attribute the time spent on each activity in the family budget surveys, but only in urban areas, as the BdT (2013) survey was limited to these regions. All survey data were previously converted to monthly data for a consistent comparison.

The statistical matching is based on the definition of four groups of activities that are compatible with the data available in the two family budget surveys and the time budget survey: food, housing, domestic activities, leisure and miscellaneous. The statistical matching process between the BdT (2008) or the BdF (2015) and the BdT (2013) is conducted by the cell-matching method (Deaton, 1985), leveraging a shared set of household characteristics present in all three surveys. These household characteristics, assumed to be invariant over time, are the head's cohort (date of birth by forming 10 age modalities in 10-year increments per survey year), household demographic type (4 modalities) and the head's gender (2 modalities). After grouping households into cells, we established a temporal relationship between them. For example, a household with modality 1 for gender, 1 for typology, and aged 14 in 2008 is linked to the household with modality 1 for gender, 1 for typology, but aged 19 in 2013, which in turn is linked to the household with the same characteristics (gender and typology), but aged 21 in 2015. The variables of interest (monetary expenditure or use of time in each activity) for a household result from an imputation of the intra-cohort average of observations from all households within the same cohort. We control the size and homogeneity of the cohorts formed by retaining only those whose size (in number of households) is at least equal to 100 (according to the methodology proposed by Verbeeck and Nijman, 1992: two neighboring cells will only be grouped into one if the sum of their sizes is at least 100, otherwise they will be deleted from the database). We define "two neighbouring cells" if they differ only in the gender of the head of household. In conclusion, we have built a pseudo-panel made up of 11743 households observed at two separate times (in 2008 and 2015), divided into 27 cells, representing an average of around 435 households per cell.

3 Empirical analysis

3.1 Table 1: Value of time and GDP

Country	V, ρ=0.03	V, ρ=0.05	ω/w	GDP pc	$V/GDP*$	$V/GDP**$
Burkina Faso	21 382	14 809	0.30	619	1.25	0.63
s.e.	24 756	17 146	-	-	-	-
Ivory Cost	93089	64016	0.90	1942	1.74	0.87
s.e.	(6420)	(4415)	-	-	-	-

Note: $\tau = 16$ disposable hours per day (5840 per year). ω/w: on the minimum wage rate in Ivory Coast; on the average wage rate in Burkina Faso. Ratio V/GDP: V calculated for $\rho = 0.03$; GDP*: GDP per capita accumulated over the household's life cycle ($\rho = 3\%$)); GDP**:GDP per capita accumulated over the household's life cycle with equivalence scale for the VHL.

First, the value of human life of much greater in Ivory Coast (in absolute value and also compared to the GDP per capita), which could be inferred considering their respective levels of being (as informed for instance by their GDP per capita in Table 1). These values are somewhat greater from the accumulated GDP per capita, which is here actualized at a real rate of 3% (generally used in public investment). In order to equalize the value of human life with the GDP per capita, it would be actualized at a rate of 4.6% in Burkina Faso and 6% in Ivory Coast. Note that fixing the number of disposable time at 24 hours per day instead of 16 would increase the ratio of the VHL over the accumulated GDP to 1.88 in Burkina Faso and 2.81 in Ivory Coast.[5]

Second, changing the Inter-temporal Substitution rate in the actualization of yearly time values changes a lot the evaluations. It could be therefore important to estimate the endogenous ISTR linked to the opportunity cost of time as suggested in Gardes (2021 and 2022).

Third, comparing the value of human life and the corresponding accumulated GDP per capita supposes that all households have a similar weight in the national product, thus eliminating the necessity to aggregate income and values of time per unit of consumption using an equivalence scale. Evaluating units of consumption from the demographic structure in Ivory Coast and an equivalence scale (valuing 1 the first adult, 0.7 other adults and 0.5 children), gives rise to an average number of units of consumption per family equal to 2.76. But the value of time is measured only for two adult in the family while consumption concerns all members of the family, so that a smaller demographic scale (averaging units of consumption of time use and U.C. of monetary expenses), equal to 2, is used to evaluate the value of time per capita. The VHL is of the same magnitude of the accumulated GDP, being smaller than 1 when the VHL is computed per capita (0.625 for Burkina Faso and 0.87 for Ivory Coast) and slightly greater than 1 for no equivalence scale of the VHL (1.25 and 1.74). It is significantly greater in Ivory Coast, perhaps because of a more liberal labor market which allows individuals to compare the value of their domestic time to

[5]These figure correspond approximatly to the ratio of an enlarged GDP integrating the value of domestic work into the official GDP, see Gardes, 2022b

the opportunity value of market labor (i.e. its wage rate). [6]

The value of disposable time depends on the possibility to use disposable time for an activity which gives rise to a monetary counter-part, especially working on the market (either official or informal). This possibility to spend time on the labor market may bring together the OCT to the wage rate of the individual on the market, so that the degree of substitution between time and money resources (as it can be measured by the elasticity of substitution between them) may influence the level of the OCT (or more precisely its ratio with the wage rate). An economy which is more liberal (that is more based on market mechanisms) may therefore have an average opportunity cost of time closer to the average wge rate, and therefore probably magnified compared to the value which would appear if the substitution between the time and money resources disappears. This is probably an important factor of the higher ratio of the value of time to the wage rate in Ivory Coast.

Fourth, the differences in the opportunity cost of time is not very significant, being smaller than 20%, between different socio-economic groups in Ivory Coast (young vs old, poor vs non-poor, singles vs couples...), so that the average evaluation which have been made can be considered as applying to each household in the population. This point necessitates a supplementary analysis.

Fifth, one may suspect a dependency of the VHL on age (as revealed by the study on developed countries in Gardes, 2022a), so that the method proposed in Gardes (2022) to take care of the dependency of the value of time on the household's life cycle must be considered, which necessitates to estimate the influence of the age of the head (and possibly the difference of ages between the man and his spouse) on the household's average value of time.

Conclusion

The results obtained applying the domestic production framework to the computation of the value of time show that it differs from the accumulated value of the GDP per capita and that it is clearly linked to the levels of being of the two countries and possibly the development of their labor market. It can also depend on the specific political problems encoutered recently by these countries. It seems important to consider that National production (as measured by the GDP) and the level of being of the population (measured by the GDP per capita or per unit of consumption - depending on a specific equivalence scale) are only a partial indicator of the well-being of individuals: *first*, these indicators, based on National income, must be accumulated over the whole life of individuals in order to represent the entire wealth proceeding from households monetary income. *Second*, they must be augmented by the effects of other determinants of well-being such that life expectancy, health status...) the effects of which are partially conveyed by the valuation of free time by individuals. Policy recommendation must therefore: *first*, try to increase the life duration through an improvement of life duration. *Second*, to diminish the economic and political

[6] Note that an equivalence scale equalizing the VHL to the accumulated GDP per capita would be 1.25 in Burkina Faso and 1.74 which are slightly smaller than official equivalence scales.

uncertainty in order to lower the weight of the Inter-temporal Substitution in the valuation of life, which depends on the future achievements of the individual. *Third*, to increase the substitution between time for domestic production and market labor in order to increase the value of domestic time.

Note finally that infering the inter-temporal rate of substitution from the opportunity cost of time (as discussed in Gardes, 2021 and 2022) results in comparable but much less dispersed evaluations of the value of human life across the population. Moreover, it allows the computation of the value of human life for different types of households or individuals. This is an interesting feature of that indicator for public choices.

Appendix: Descriptive Statistics

Table A1: Monetary expenditures and time use in Burkina Faso

Activities	Monetary b.s. (%)	Time b.s. (%)	Mon. exp.	Ratio mon. to time value
Food	0745	0.459	2472	16.41
Housing	0.079	0.274	259	2.60
Leisure and Other	0.176	0.267	588	6.14
Total	1	1	3319	9.58

Note: Monetary expenditures in 2008 CFA francs (1000 FCFA (2008) correspond approximatively to 2.65 USD (2015)).

Table A2: Monetary expenditures and time use in Ivory Cost

Activities	Monetary expenditures (US dollars 2015 per month)		Time use	
	Whole sample	%	Whole sample	%
Food	166.42	45.55	115.82	8.96
s.e.	(27.10)	-	(66.41)	-
Housing	52.31	21.65	240.36	18.59
	(23.87)	-	(109.11)	-
Domestic activities	61.04	24.94	180.35	18.59
	(25.89)	-	(61.12)	-
Leisure and Other	18.12	7.86	756.24	58.50
	(4.92)	-	(246.44)	-
Total	237.89	100	1292.78	100
	(73.56)	(100)	(428.68)	-

Note: 12066 observations.

Appendix A: Estimation of the opportunity cost of time (Gardes, 2019

To estimate the shadow price of time, 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 the wage rate. It is assumed that the consumer's utility function is given by $u(Q) = \prod_i a_i Q_i^{\gamma_i}$ where a_i is a positive parameter and Q_i is the quantity of the activity i produced by the combination of monetary and time inputs denoted m_i and t_i, respectively: $Q_i = b_i m_i^{\alpha_i} t_i^{\beta_i}$ where $m_i = x_i p_i$ with x_i the quantity of the market goods i, p_i its price, and b_i a positive parameter.[7] The choice of the Cobb-Douglas forms allows the parameters to be identifiable. 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. As discussed in Gardes (2018), the Cobb-Douglas specification allows identifying a unique shadow price of time for all activities while a more general model based on CES household production functions allows identifying only activity-specific shadow prices of time.

Combining the utility and the production functions allows to write the utility in terms of inputs:

$$u(m,t) = \Pi_i (a_i b_i^{\gamma_i}) \left(\prod_i m_i^{\frac{\alpha_i \gamma_i}{\sum \alpha_i \gamma_i}} \right)^{\sum \alpha_i \gamma_i} \left(\prod_i t_i^{\frac{\beta_i \gamma_i}{\sum \beta_i \gamma_i}} \right)^{\sum \beta_i \gamma_i} \tag{3}$$

$$= A \; m'^{\sum \alpha \gamma_i} \; t'^{\sum \beta_i \gamma_i} \tag{4}$$

where m' and t' are geometric weighted means of the monetary and time inputs and $A \equiv \Pi_i a_i b_i^{\gamma_i}$. In this framework, the consumer is subject to an income constraint, $\sum m_i = w t_w + V \equiv Y$, and to a time constraint, $\sum_i t_i + t_w = T$, where V is other income and t_w is the time allocated to market work. Utility maximization implies that the shadow price of time, denoted ω, is given by

$$\omega = \frac{\frac{\partial u}{\partial t'} \frac{\partial t'}{\partial (\sum t_i)}}{\frac{\partial u}{\partial m'} \frac{\partial m'}{\partial Y}} = \frac{m' \sum \beta_i \gamma_i \frac{\partial t'}{\partial (\sum t_i)}}{t' \sum \alpha_i \gamma_i \frac{\partial m'}{\partial Y}} \tag{5}$$

The shadow price of time differs from the market wage rate when, for instance, there exists 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 by means of substitutions of monetary and time expenditures in the production of each final goods and by substitution of time or money between activities (see Gardes 2019, section 2.4).

Appendix B: Presentation of Burkina Faso

Burkina Faso, a country situated in West Africa with a population of 16.9 billions of citizens having an average life expectancy of 56 years, contains 46% of young less than 15 years. It is at rank 181th over 187 countries as concerns

[7] Q is assumed to depend on m (rather than x) because the dataset informs only expenditures. This approach yields consistent results when all households face the same prices.

its human development (United Nation Program for Development evaluation in 2014). The per capita GDP is 720 dollars, mainly concentrated in the service sector (52%), industry and agriculture representing only 26 and 22%. Its economic growth is 5% by year since 2000, the unemployment rate is 3%, but 83% of the population is below the poverty line according to the UNPD multidimensional index. 40.1% of the population is under the poverty line defined by the statistical office (INSD, 2015), with a 92% of the poor in rural areas.

The Agricultural Family survey

The RGA Survey (Recensement Général de l'Agriculture, 2008) covers 71 villages in the 45 provinces, with a total of 6941 households surveyed. It contains information on family characteristics (incomes from agriculture or other activities, age of the head and the spouses, number and age of children education level, accessibility to social services, income, financial situation, equipmentâĂę), households' expenditures (over 40 goods and services) and time use over 14 activities: unproductive activity, agriculture in rainy periods, gardening, culture of trees, cattle breeding, fishing, gathering, wood harvesting for selling on a market, wood harvesting for family needs, search for water, market work, other domestic activities, personal activities, other activities. Times are recorded for all adults in the family, while expenditures concern the whole family, including children (the numbers of adults and children are in average 5.36 and 5.72). The hypothesis is thus made that only adults contribute to the domestic productions. Time used for activities such as gardening or cattle breeding are used both for domestic use and to sell product or services on the market. We have no information on this repartition so that we made the hypothesis that 70% of time uses corresponds to consumption by the household and 30% to a production which is sold on the market.

In this paper, the monetary expenditures and the time use have been grouped into three common domestic activities (activity 11 being excluded since it concerns market work): food (time activities 2 to 7, 9 and 10), domestic activities (12), other (13, 14). The full prices are calculated using the two types of expenditure: monetary and time, as explained in Gardes (2019 and 2025, Chapter IV). Expenditures are recorded for one week for food and one quarter for other expenditures, while time uses correspond to one week. All have been transformed into yearly values. As family size can be very large (with an average of 5.35 adults per household), time uses corresponding to all adults in the household may be performed in fact by a small part of these households (say two or three). The descriptive analysis in Table 1 indicates indeed that couple with two adults have a significantly greater ratio of monetary expenditures to time uses than bachelors, which indicate that their time are not the fact of all adults in the family. In order to correct this probable bias, time uses have been multiplied by the ratio of the OECD equivalence scale (one for the first adult, 0.7 for other adults) over the number of adults (which perhaps still overstates the true number of adult corresponding to recorded time uses).

Descriptive analysis for the survey on both monetary expenditures and time uses

The descriptive statistics (see Table B1) suggests that the bulk of the household budget is spent on consumption. An examination of the structure of the household budget shows that on average 74.5% of the monetary budget is devoted to consumption, while 17.6% is allocated to leisure and other activities, and 7.9% for domestic activities. We have the same structure of household spending, taking into account the time budget; however with a lesser amplitude: 71.6% of the total budget is devoted to food, compared with 18.5% to leisure and other and 9.9% to domestic activities. On average, households spend 1 252 291 CFA Franc on food, education, healthcare, transportation, housing, durable goods, leisure, and other items annually. Households have on average eleven members; 5.4% among family heads are female. Household heads are predominantly farmers (86%) most of them being 36 to 60 years old, and few exceeding 61. Only 14% of households attended school.

Table B1: Monetary expenditures and time use in Burkina Faso

Activities	Monetary b.s.	Time b.s.	Full income (%)	Mon. exp.	Full Exp.		Ratio mon. to time value	
		All Households				Singles	2 adults no child	2 adults with child
Food	0745	0.459	0.716	932 723	989 567	16.41	52.26	20.36
Housing	0.079	0.274	0.099	97 755	136 803	2.60	2.32	1.54
Leisure and Other	0.176	0.267	0.185	219 792	255 586	6.14	9.73	2.99
Total	1	1	1	1 252 291	1 381 955	9.58	18.14	7.89

Note: Monetary (%): monetary budget share. *Mon. exp.*: Monetary expenditures in 2008 CFA francs (1000 FCFA (2008) correspond approximatively to 2.65 USD (2015)). Time valued by the opportunity cost of time estimated for each household.

Appendix C: Pseudo-panel in Ivory Coast

Table C1: Pseudo-panel of living standards surveys (2008, 2015) and time use survey (2013)

Year of birth	2008		2015		Whole sample	
	Age	Number	Age	Number	Number	%
Before 1945	≥ 64	384	≥ 71	171	555	4.60
1945-1954	54-63	771	61-70	399	1170	9.70
1955-1964	44-53	1249	51-60	687	1936	16.05
1965-1974	34-43	1922	41-50	1054	2976	24.66
1975-1984	24-33	1868	31-40	1911	3779	31.32
1985-1994	14-23	369	21-30	1281	1650	13.67
Total	6563		5503		12066	100
Year of birth	2008		2015		Whole sample	
	Number	%	Number	%	Number	%
Single or couple without child	1572	23.95	1631	29.64	3203	26.55
Single or couple with child	1576	24.01	1649	29.96	3216	26.65
Other types (extended household)	3424	52.04	2223	40.40	5647	46.80
Total	6563	100	5503	100	12066	100

Note: 12066 observations. 17 cells crossing Age and Demographic Type (excluding one cell containing less than 100 households).

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