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Analysis of Time Use Surveys Using CO-STATIS: A Multiway Data Analysis of Gender Inequalities in Time Use in Colombia

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Abstract: The aim of this article was to study 23 time use activities measured in the two latest Colombian National Time Use Surveys, taken in 2013 (with 119,899 participants over the age of 10) and in 2017 (with a sample of 122,620 participants), to identify similarities and differences between the years of the survey by gender, age group, and socioeconomic level. The study's results were obtained using the CO-STATIS multiway multivariate data analysis technique, which is comprised of two X-STATIS analyses and co-inertia analysis. The results confirm the existence of gender issues related to time use in Colombia, which are associated with gender stereotypes that link women to unpaid work and home care, especially in low socioeconomic levels, where women face limitations in terms of the time available to earn their own income. Additionally, differences were found by socioeconomic level, where Colombians of high socioeconomic status in all age groups are able to devote more time to leisure and recreational activities.

Keywords: time use; gender inequality; multivariate analysis; CO-STATIS; X-STATIS; co-inertia

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1. Introduction

Historically, time use has been studied for a variety of reasons, such as for economic studies aimed at making specific estimates on the contribution of unpaid work to a nation's economy, to calculate the ratio of household work over total time worked, or to establish the association between monetary poverty, income and time distribution, and assignment of men and women. Household work is recognized by those who see the economy as a way of satisfying human needs in a broader context, as well as by researchers who study non-monetary or informal processes [1] (p. 188), and time use is included in the latter.

In social science and public policy studies, time use is analyzed to determine the types of activities people engage in on a regular basis in order to identify ways to satisfy their needs and improve their life quality. Making effective use of time can help achieve a better life balance between work, family, studying, and daily activities. In the public health area, studies are made on how different time use patterns determine the development or worsening of illnesses and their effects on mental health [2–6]. Therefore, the study of time use is an interdisciplinary field with contributions from sociology, psychology, gender and sexuality studies, economics, and other social sciences [7] (p. 20).

The above points to the relevance of discussing the importance of the various approaches and purposes of time use studies, in order to contextualize the problem analyzed in this paper, the multidimensional analysis method used, the results obtained, and its practical implications.

1.1. Time Use Analysis in Gender Studies

Time use is considered one of the key social and economic determinants of gender inequality. As in the case of the study of other gender issues, such as workforce partici-

pation by females, the feminization of poverty, or women's participation in senior level government or private company positions, the study of time use has gained prominence in recent years because it enables understanding existing gender differences and similarities in the context of the care economy and the economic empowerment of women.

The care economy is studied in order to quantify the unpaid work carried out at home in household maintenance activities and the amount of time devoted to caring for the family. Rubiano-Matulevich and Viollaz [8] argue that even though substantial progress toward gender equality has been made in the past decades, the inequalities linked to gender norms, stereotypes, and the unequal distribution of housework and childcare responsibilities persist. This implies the existence of inequalities in the use of time between women and men.

Ferrant [9] also emphasizes the importance of recognizing unpaid care work by measuring and valuing it, because it helps to redistribute unpaid care tasks more equally between men and women by transforming gender stereotypes. This author argues that this is necessary in order to support the achievement of the Sustainable Development Goals in the different countries of the world, because when women have control over their time and are free to weigh the challenges they face at home against those they face in their professional careers, they become empowered and are able to make positive contributions to a nation's economy.

For this reason, it is important for gender studies to assess the different factors that determine the way men and women use their time, differentiating between home care, work, and free time activities, because studies of this type are conducive to the search for gender equality and female empowerment.

1.2. Time Use Studies by Socioeconomic Status

A specific aspect that is often studied is how socioeconomic level also determines and conditions the way people distribute and use their time. Aguiar [10] claims that there are differences in the way people from different socioeconomic levels and lifestyles organize their remunerated and leisure time. Moreover, Neubert [11], in comparing the assignment of work in different occupational categories, socioeconomic levels, and educational attainment levels, found that people with higher education have advantages in terms of time use, not only in connection with the time devoted to work, but also in the organization of their leisure and everyday activities.

Specifically on the use of time by women, Kolpashnikova [12] studied the time devoted to housework in Japan, Canada, and the United States by gender, marital status, age, socioeconomic level (SEL), and the presence of children at home. She found that women with greater purchasing power and higher educational attainment are able to hire assistance to carry out domestic work, enabling them to remain more committed to remunerated work activities.

In terms of studies in the Latin American context, Candia [13] carried out a study disaggregated by socioeconomic variables (gender, age, income, and geographic location of their home) on the use of time by Chilean workers. She found that women have a greater overall workload than men because of unpaid work. This author also found that individuals of higher socioeconomic status devote more time to leisure and free time activities than to unpaid housework.

1.3. Time Use Studies with a Life Cycle Approach

Time use is studied not only with a gender approach, but also in public health studies, with the purpose of analyzing variables of this type that determine differences in the quality of life of people, especially taking into consideration their life cycle stage or age.

For example, in recent literature we can cite the work of Chong et al. [4], Samonova et al. [14], and Blaurock et al. [15] in connection with time use studies with children. These authors support the idea that in this age group, the patterns of time use are associated with a family's resources (i.e., level of education) and the age of the children. On the other hand,

Vernon [16] and Kim et al. [17] are among the authors that assess time use by adolescents and youth. These authors argue that in this life stage, it is important to consider the patterns of time use, including traditional activities (i.e., paid work, homework, television, physical activity, leisure activities, sleeping, etc.) and technological activities (gaming, social networking, Internet).

In the specific case of older adults, some studies that argue why it is important to study time use in this age group are Powers et al. [2], Foong et al. [3], Ko [5], Chai et al. [18], and Steptoe and Fancourt [19].

Specifically, the latter, in reviewing survey data from over 7000 men and women in the United Kingdom in the age range of 50 or older, found similarities and differences in their "worthwhile life ratings" by age, sex, educational attainment, and socioeconomic status. The authors claim that the differences in the life quality of older adults depend on social and economic variables, health conditions and time spent with friends, watching television, being alone, engaging in volunteer activities, and devoting time to exercising or walking.

Due to the above, time use studies are also important for comparisons between age groups, because at different life stages, daily activities are distributed differently, which implies that age can be understood as a determinant of life quality and personal satisfaction.

1.4. Time Use Studies by Means of Modeling Techniques

Time use studies tend to be of a socio-political type and do not always involve modeling techniques to identify multiple associations or patterns that are not obvious from the data at first sight. Studies of this type typically assess the data using descriptive techniques with one or two variables or through econometric estimation methods, where the time use variables are usually analyzed separately or descriptively. However, it is viable to conduct multivariate analysis on data of this type to arrive at results of interest for gender studies. There is no good reason to be limited to simple analyses that are usually solely for confirmation purposes. The possibility of combining the variables opens the door to obtaining results that are sometimes unexpected and beyond the obvious [20] (p. 14).

Due to the above, in order to contextualize the analysis of this study, it is also important to cite some authors who in recent studies analyze official time use data by means of statistical techniques and multivariate analyses to obtain their results.

In the European context, Rogge and Van Nijverseel [21] quantified and reviewed the quality of life of European Union countries using a multidimensional design. To this end, they used citizen satisfaction data in eight dimensions, based on which they developed a composite index, concluding that the correlations between the variables show a strong relationship between the multidimensional and one-dimensional measurements of subjective life quality.

Fraire [22] also carried out a comparative analysis between European Union countries. This author used the STATIS Dual and Multiple Factor Analysis techniques to compare time use results of surveys made near to 2000 in six European countries: Belgium, Estonia, Finland, Norway, Slovenia, and the United Kingdom. In this study, after presenting descriptive statistics by gender, employment status and marital status by age group, and presence of children in the family, a STATIS Dual analysis was performed to compare the 12 time use activities in each country under each of the considered categories to characterize the population.

Kızılırmak and Köse [23] studied the determinants of the use of free time in Turkey by exploring associations between time used in cultural, social, sports, and other leisure activities compared to socio-demographic variables on gender, age, educational level, household income level, marital status, employment status, health conditions, and time used for childcare. To this end, they examined data from the 2014–2015 TurkStat Time Use Survey and obtained research results by means of a multiple regression model.

Yoon et al. [24] studied time use by Korean citizens over the age of 65 based on surveys taken by the Korean National Statistics Office in 2004 and 2009. The study's results were

obtained using multivariate techniques: correspondence analysis and Biplot analysis, based on which they search for and describe clusters of individuals.

In the Australian context, Richardson et al. [25] conducted a longitudinal cohort study with a group of first-year university students to discover time use associations by gender and age group. The authors found statistically significant differences through hypothesis testing on comparisons between population groups. Bittman [26] also studied time use in Australia, based on data from the Australian Bureau of Statistics.

Several studies of reference in the United States of America [27–30] used modeling techniques to characterize time use in different population groups and also used the records of the American Time Use Survey (ATUS). This international survey is well known for periodically publishing annual information with disaggregation levels that enable using different analytic approaches and facilitate the use of different modeling techniques.

Due to all of the above, in this study, we conducted a multi-dimensional exploration, with no specific response variable to find and analyze underlying patterns and to compare the data from the 2013 and 2017 Colombian National Time Use Surveys (ENUT, by its acronym in Spanish: Encuesta Nacional de Uso del Tiempo) from a gender perspective. The results were obtained from data analysis using the CO-STATIS method [31]. In this technique, the co-inertia analysis [32] is used to relate two compromises obtained from two partial triadic analysis (PTA). The PTA was proposed by Jaffrenou [33] to analyze k-table data, which is also called X-STATIS according to Abdi et al. [34]. Thus, CO-STATIS seeks the relationships between two stable structures.

In this study, we were particularly interested not only in determining whether both survey years are similar, but also in identifying the variables that display gender differences and in determining associations by age group and socioeconomic status. Even though most time use studies focus on how men and women spend their time differently, few conclusions are presented on whether such differences persist in different age groups, or if there are differences by socioeconomic status, a characteristic that, in Colombia, determines the daily routines of the population.

2. Materials and Methods

2.1. Data in Analysis

The data of interest for this study were the responses given by Colombians over the age of 10 in the ENUT DANE surveys taken in 2013 and 2017 [35,36]. In Colombia, these surveys are taken by means of electronic forms filled out by interviewers during face-to-face visits to the households selected to participate in the statistical study. In the first national survey, there were 146,190 participants, for whom the 696 variables were recorded, and the second survey had 146,190 records and 743 variables. Currently, a new survey is in progress, which will enable studying the effects produced by the COVID-19 pandemic on the use of time by Colombians.

Given the level of detail of the ENUT surveys and the substantial amount of information gathered, for this study, it was necessary to process the databases of both years to summarize in 23 fields the different types of time use to be subject to multidimensional analysis, which are displayed in Table 1. The sociodemographic characteristics of the population that were selected for the study were gender, age group, and socioeconomic status. In Colombia, the latter is defined according to a Socioeconomic Stratification system, which is based on the classification of residential properties in accordance with the Colombian Public Utilities Regime (Law 142/1994), according to which higher income households pay more for public utilities and cross-subsidize the bills of lower income households [37].

Table 1. Activities and times in analysis.

Notation	Activities
AGR	Agricultural activities
BAC	Basic activities (eating, sleeping, and taking a shower)
BAR	Going to bars
CUA	Attend cultural events or activities
DHA	Domestic and household activities (preparing food, cleaning the home, etc.)
FHC	Family and home care activities (caring for children and other household members)
FRI	Visit to friends
HAI	Time at the hairdresser
INT	Internet and chats
LJO	Looking for a job and establishing your own business
LMU	Listening to music
MJO	Movements and journeys (for studying, working, or household care)
MUS	Music and art (practice a musical instrument, paint, etc.)
PHO	Speaking on the phone
REA	Reading
REL	Religious acts (to attend or organize religious activities)
RES	Time to rest
SPE	Going to sport events
SPO	Practicing sports
STU	Study time
VOL	Voluntary activities
VTV	Watching videos and TV (media consumption)
WOR	Work time

For this study, the data were processed as follows: for each variable, the total hours and minutes reported by the survey respondents were added, to then find the average use of time in the different population groups by sociodemographic characteristics.

The data were structured as follows. For each of the four age groups, adolescents and youths (between the ages of 10 and 17), young adults (between the ages of 18 and 34), adults (ages from 35 to 59), and older adults (60 or older), a data table was developed (matrix) formed by 23 columns representing the 23 time use activities described above, and by 6 rows that represent the gender combinations (W and M) and socioeconomic status (summarized as 3 levels, where levels 1 and 2 of the DANE classification are designated as L (low socioeconomic status—L SES), levels 3 and 4 as medium level (M SES) and levels 5 and 6 as H (high socioeconomic status—H SES). As mentioned, the elements of each matrix are the time use measurements of each activity by the different sociodemographic levels.

Consequently, for each survey year (2013 and 2017), there is one multidimensional data table, structured as a data cube, because they have the same characteristics (the time use variables) measured over the same objects (combination of gender and socioeconomic status) in the different age groups. Figure 1 summarizes the structure of the information described above for each year of the study. Table 2 summarizes the total records of the study by the demographic variables of interest, with the totals reported by Colombians in the two ENUT surveys.

Below, we present the main methodological references used for this study, which is proposed as a descriptive and exploratory study, and a summary of the conceptual foundations of the modeling techniques used to obtain and present the results.

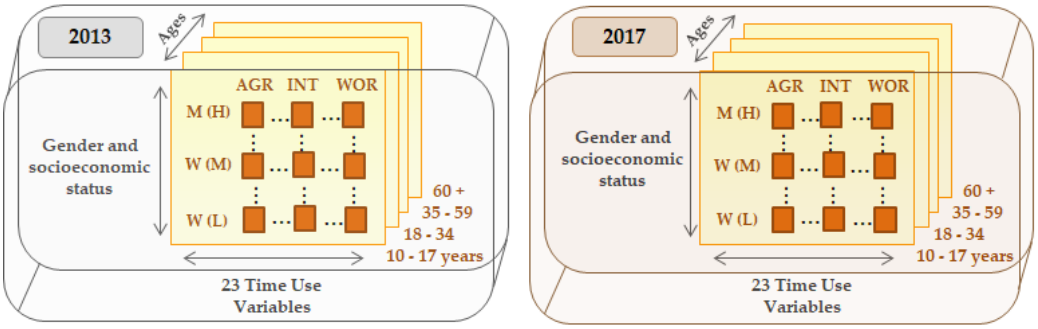


Figure 1. Structure of the data in analysis.

Table 2. Surveyed people by gender, age group and socioeconomic status (SES).

	ENUT Colombia (2013)					ENUT Colombia (2017)				
Women/Men	10–17	18–34	35–59	60+	Total	10–17	18–34	35–59	60+	Total
Low SES	8112	15,005	15,769	5885	44,771	7402	15,186	17,309	7293	47,190
Middle SES	2128	5318	6843	3357	17,646	1649	4597	6487	3741	16,474
High SES	174	516	810	472	1972	115	369	723	507	1714
Total Women	10,414	20,839	23,422	9714	64,389	9166	20,152	24,519	11,541	65,378
Low SES	8153	13,057	13,357	5067	39,634	7644	13,793	14,707	6184	42,328
Middle SES	2150	4666	5324	2317	14,457	1753	4136	5051	2627	13,567
High SES	145	370	565	339	1419	132	351	517	347	1347
Total Men	10,448	18,093	19,246	7723	55,510	9529	18,280	20,275	9158	57,242

2.2. CO-STATIS Analysis

The CO-STATIS method was proposed by Thioulouse [31] as a process to summarize the three-way data analysis when two X-STATIS analyses and one co-inertia analysis are consecutively used, as in this study. This technique has been popular for the study of ecological and environmental information [38,39], and has recently used in the context of socio-economic analysis [40,41]. Figure 2 presents the scheme of the steps to be followed with this method, which is the main technique used in this study.

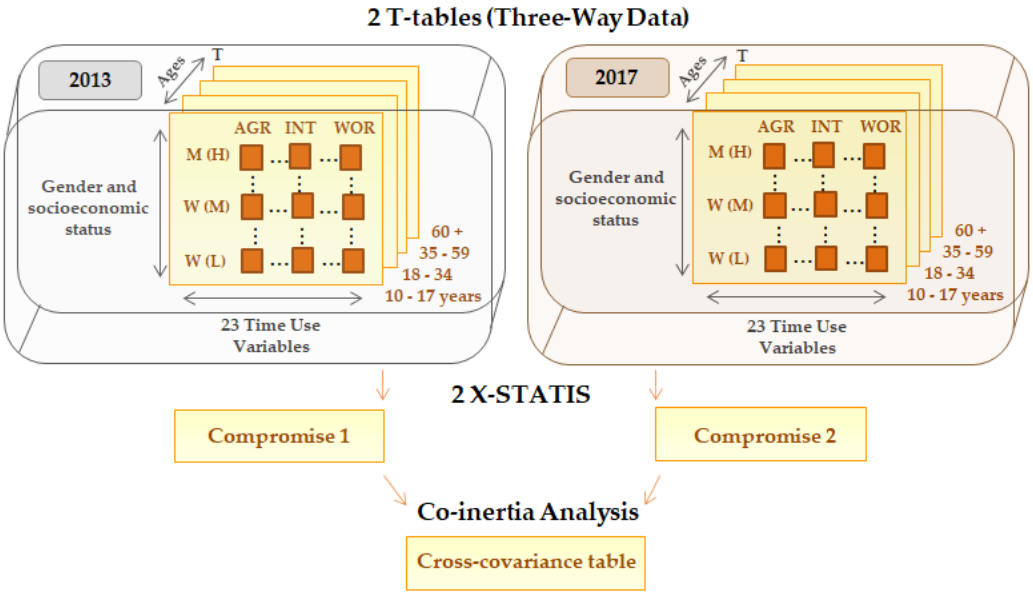


Figure 2. Data analysis scheme for the CO-STATIS technique.

2.3. Step 1: Triadic Partial Analysis or X-STATIS

This technique was first proposed by Jaffrenou in 1978 [33]. It was initially called Triadic Analysis by Thioulouse et al. [42], was later called Partial Triadic Analysis by Kroonenberg [43], and was recently named X-STATIS by Abdi et al. [34]. It has been cited in papers such as [44–49]. This analytical method applies to sets of matrices with three inputs made up by the same individuals (rows) and the same variables (columns), under several conditions or points in time. The intent of X-STATIS is to simultaneously study the sub-matrices of quantitative data in order to detect common patterns. The method is developed in three stages, the first of which is the interstructure analysis, the purpose of which is to study the overall similarities between the tables.

The second stage is the analysis of the compromise, the purpose of which is to summarize the information from the initial matrices to provide an image of the structures that are common to all the tables. Lastly, the intrastructure analysis is performed, which consists in analyzing the reproducibility of the compromise. In this stage, the positions or trajectories are presented for each individual and/or variable included in the original tables, and their relative positions are analyzed in terms of their positions with each other and with the position of the compromise.

To understand how X-STATIS works, Figure 3 below summarizes the scheme of the analysis and provides a description of its general aspects, based on references from [42,50,51]. The chart in Figure 3 shows that the first step is the interstructure analysis, to which end a Z matrix is constructed as a composition of the original data; i.e., starting out with T data matrices (X_T), which are comprised of the same I rows (same individuals) and J columns (same variables), in such a manner that each column vector of the Z matrix matches one of the T matrices in an extended way. Consequently, the Z matrix contains as many columns as matrices for the study and can be viewed as a two-dimensional table.

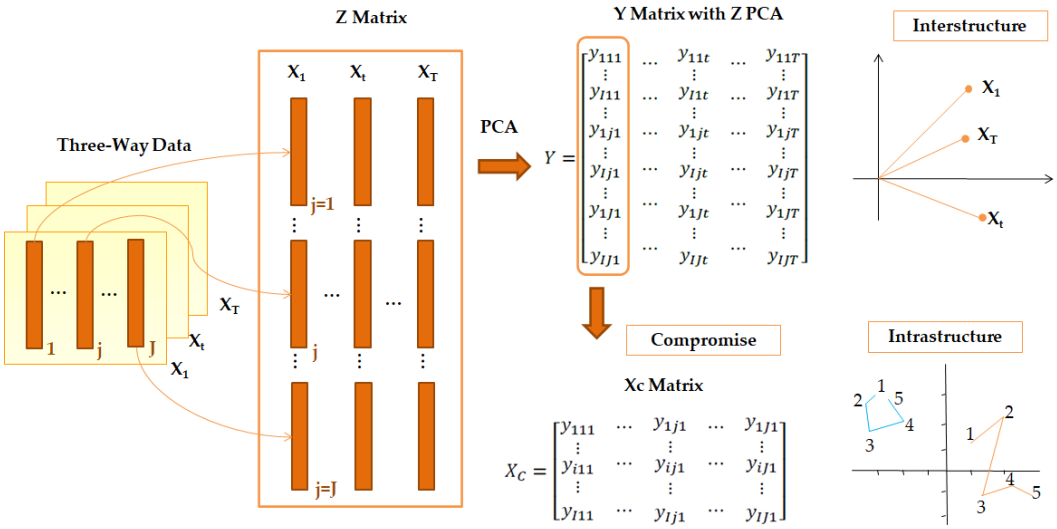


Figure 3. Data analysis scheme for the X-STATIS.

The Z matrix is analyzed by means of a principal component analysis. The first eigenvector is used to construct the compromise matrix as a weighted average of the original tables, using the elements of this first eigenvector as weights. Furthermore, this decomposition of Z allows to represent each matrix as a vector over the first two principal components obtained from the analysis, which enables assessing the relationships between the original matrices.

The next stage of the analysis is to construct the compromise matrix and to analyze the compromise structure. The purpose of this stage is to summarize the information of the initial T matrices (X_T) in a single matrix. This matrix provides an overall summary of all the information contributed by the original matrices, along the t conditions.

The compromise matrix maximizes the mean of the correlations between its variables and the variables of each X_t matrix. It can be said that the compromise provides an image of the structures that are common to all the tables.

Lastly, the final step of the analysis is the intrastructure analysis, which consists in the analysis of the reproducibility of the compromise. It enables representing the positions on the compromise (or trajectories) of each individual and/or variable that comprises the various tables, and their relative positions in relation to the position on the compromise. The compromise positions of the elements are their mean positions. A trajectory is defined as the change in the position of a variable (or individual) over time or in different conditions. Consequently, a trajectory with low variation (wraps around) indicates that this variable (or individual) is stable over time.

If the trajectory is eccentric, it means that this variable (or individual) is not stable over time or across conditions. In the first type, colored in blue in Figure 3, the individuals follow a medium evolution; i.e., the difference in the value for each individual at each point in time and that of an average individual remains regular over time. On the other hand, the eccentric trajectories, also known as large amplitude trajectories, reflect changes in the structure of the individuals over time.

The use of X-STATIS in this study is justified for the effects of determining whether there are similarities between age groups in terms of how Colombians make use of time. This technique also enables observing any differences by sex and socioeconomic level in the trajectories by age groups, in order to make a descriptive comparison between the observations in the two years in which ENUT surveys were made in Colombia.

2.4. Step 2: Co-Inertia Analysis

Co-inertia analysis, proposed by Dolléc and Chessel [52], enables finding common structures between two set of variables; i.e., to simultaneously analyze two data matrices that contain the same individuals (rows) and different or similar variables (columns), to describe their co-structure by maximizing the covariance between the coordinates of the rows of the two tables. This method belongs to the family of techniques that study matrices in pairs, such as canonical analysis and canonical correspondence analysis (CCA), but unlike these, this technique does not maximize the correlations between the coordinates, but instead maximizes the covariance between them.

This method is a generalization of the canonical correlation analysis (CANCOR) and the redundance analysis (RDA), which present more restrictions than co-inertia analysis [53]. In order to describe the main objective of co-inertia analysis, Figure 4 presents a scheme that summarizes the main foundations of the method.

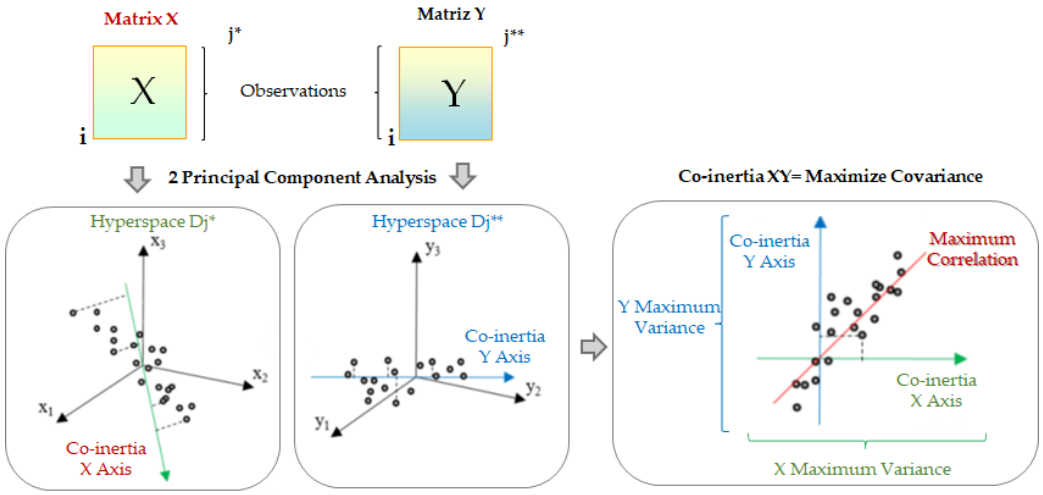


Figure 4. Co-inertia analysis scheme.

For the matrices X and Y, which have the same number of individuals i and the same variables j*, as in this study, or different variables, j* and j**, respectively, the starting point is to analyze the behavior of each data table separately, by means of general principal component analysis. Based on this first analysis, we obtain the cross-sectional matrix of the weights of the individuals or observations in rows D_i and the correspondent metrics D_j* and D_j**.

Co-inertia analysis consists in the eigenvalue analysis of the matrix:

$X^T D_i Y D_j$** $Y^T D_i X D_j$*, where X^T and Y^T are the transpositions of the original matrices. If the columns of the matrix are centered, then the total inertia of each table would be the sum of its variances, i.e., in each case:

InertiaX = trace (XD_j*$X^T D_i$) and InertiaY = trace (YD_j**$Y^T D_i$), and the co-inertia of X and Y is: CoInertiaXY = trace (XD_j*$X^T D_i Y D_j$**$Y^T D_i$), which maximizes the covariance between the row scores of the two matrices. In this regard, Thioulouse [31] indicates that the fact of maximizing covariance assures that the scores do not have small variances, and consequently the result assures a good percentage of explained variance in each space.

The results of this multivariate technique are interpreted as follows: when the two studied structures (matrices X and Y) vary simultaneously, either directly or inversely, the XY co-inertia is high, and when the structures vary independently or do not vary, co-inertia is low or none. The degree of co-structure is measured using the RV coefficient [54], which can take values between 0 and 1, where a higher value indicates greater similarity between the patterns of the two matrices, indicating that matrix Y provides similar information to that provided by matrix X, and vice-versa, in terms of characterizing the studied individuals.

The RV is called the vector correlation coefficient and is a multivariant extension of the Pearson correlation coefficient, with the key difference that it measures the existing correlation between data tables rather than between variables. For the effects of analysis, in addition to interpreting the RV coefficient, graphic representations of the results can be made, showing the individuals as dots and the variables of each matrix as vectors. The co-structure between both set of variables can be inspected graphically representing both sets of individuals onto the same graph using an arrow to connect the same pair of individuals. The shorter these arrows, the greater the co-structure between the matrices. It is also possible to plot the inertia axes over the co-inertia axes to inspect in which extent each co-inertia axis will approach a direction of maximum inertia.

3. Results

First, we present the results obtained from application of X-STATIS in each year in order to find underlying data patterns for the characteristics of gender, age group, and socioeconomic status of Colombians in each year of the ENUT survey. Afterwards, we present the results obtained from the comparative analysis of the two years of the study by means of co-inertia analysis of the compromises of the series of tables from each year. The graphic representations and tables presented below were obtained using the R statistical package and the ade4 function.

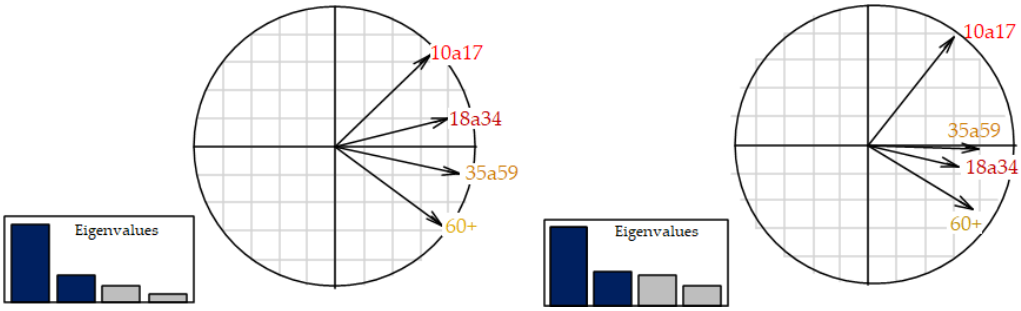
3.1. Results Using X-STATIS

3.1.1. Interstructure Analysis

The first step of the X-STATIS is the interstructure analysis to compare the overall structures of the matrices that summarize the age groups, in order to observe which age groups are similar to each other. The information provided by the vector correlation matrices (RV) shown in Table 3 and the representations in Figure 5 indicate that in both years the greatest vector correlations are perceived in the older adult groups, whereas the lowest correlations are found between the latter and minors. Moreover, in ENUT 2017, all vector correlations were lower than those found in 2013.

Table 3. Vector correlation matrices.

	ENUT 2013					ENUT 2017			
	10–17	18–34	35–59	60 or older		10–17	18–34	35–59	60 or older
10–17	1.00	0.48	0.45	0.22	10–17	1.00	0.24	0.35	0.18
18–34	0.48	1.00	0.57	0.43	18–34	0.24	1.00	0.28	0.33
35–59	0.45	0.57	1.00	0.67	35–59	0.35	0.28	1.00	0.48
60 or older	0.22	0.43	0.67	1.00	60 or older	0.18	0.33	0.48	1.00



(**a**) ENUT 2013 (**b**) ENUT 2017

Figure 5. Interstructure graphics.

Figure 5 shows that in both years the interstructure is almost similar showing that the largest angle is formed between the vector that represents pre-teens and over-60 group. Therefore, these are the less similar groups. From this pattern it can be interpreted that there is a much clearer common pattern between adults and older adults in the most recent ENUT survey than in the first, in terms of how Colombians use their time according to their socioeconomic status (SES). In 2013, the order of the vectors is more evident, starting with the youngest group (at the top of the graph), to the over-65 age group (at the bottom).

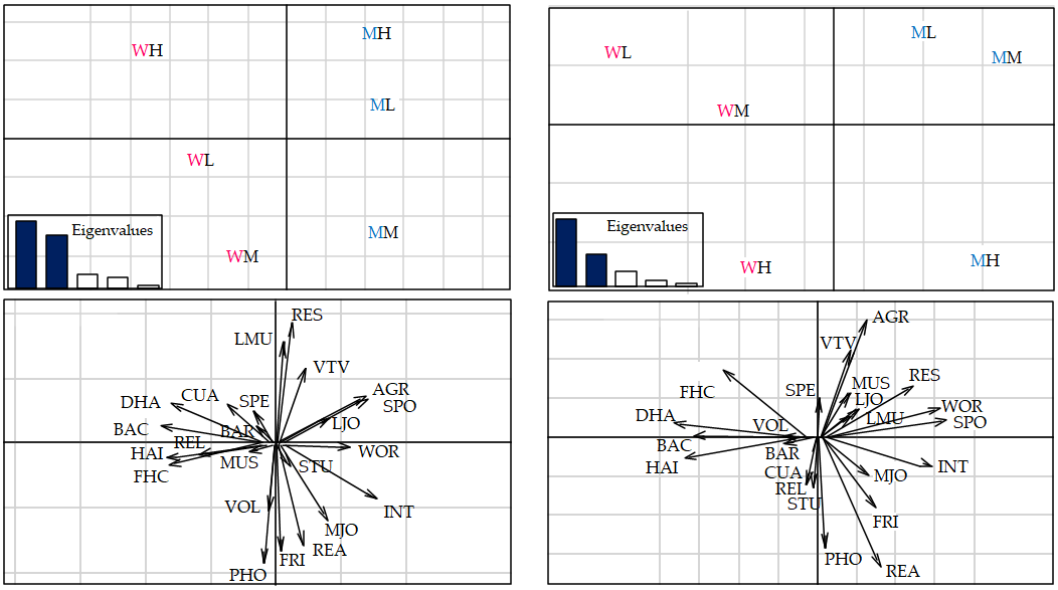
Before interpreting the graphic results of the compromise table, it should be noted that based on the eigenvalues obtained, which are shown in Table 4, in the 2013 ENUT, the first two axes account for 45.6% of the variability of the information, whereas in the second survey this percentage decreases to 35.9%.

Table 4. Compromise eigenvalues (accumulated inertia).

	Dim1	Dim2	Dim3	Dim4	Dim5
ENUT 2013	25.19	20.42	4.84	4.22	1.32
ENUT 2017	24.27	11.67	5.72	2.21	0.83

3.1.2. Compromise Analysis

Figure 6 displays the covariance structure of the time variables for the first 2 dimensions of the axes of the principal components of the compromise, and also presents the positions of the gender–SES (socioeconomic status) combinations in that compromise. By observing the first two axes of the compromise, we can interpret three characteristics that the two years have in common: the behavior of the gender–SES combinations, the associations between the variables and the interpretation that can be given in combination to the positions of gender by socioeconomic status in the compromise space.



(**a**) ENUT 2013 (**b**) ENUT 2017

Figure 6. Graphs of the compromise variables and the sex–SES (socioeconomic status) combinations.

The first interesting pattern we can observe in Figure 6 is the sharp difference between gender and socioeconomic status. In both years, the first axis of the compromise makes it possible to differentiate by gender (women on the left of the graph and men on the right), while the second axis reflects the ordering by socioeconomic level.

The sharp differences by gender displayed by both compromises are basically explained by the variables WOR, INT, and SPO (time devoted to work, the Internet, and sports). It can be seen how the vectors that represent these variables characterize the right end of axis 1, and consequently it is the men (especially in 2013, and with greater intensity in the low SES) who spend more time in these activities compared to women (located on the left size of the axis).

An analogous interpretation, but in the opposite direction, is that women (especially in low and medium socioeconomic levels) devote much more time than men to DHA, BAC, HAI, and FHC (domestic and household activities, basic activities, hairdressing, and family and home care), because the vectors that display such activities are on the negative portion of axis 1, which displays the points that represent women.

Regarding the differences in time use by socioeconomic status, the graph shows that higher socioeconomic levels spend more time in leisure activities than lower levels. See how in 2013, resting or listening to music (vectors RES and LMU located in the direction of the second axis) characterize men and women from higher levels, whereas in 2017, they display more time in the direction of activities such as reading, speaking on the phone and visiting friends (vectors REA, PHO, and FRI).

According to the above, regarding the structure of variance and covariance of the variables in the compromise space, we can summarize by saying that in both years, we can see four sets of variables that are differentiated from each other. The first involves household activities, home care, going to the hairdresser, and, to a lesser extent, basic activities, and which characterize the women who are located towards the left of the representations of Figure 6 (the vectors DHA, FHC, HAI, and BAC). On the opposite side of this group of variables are paid work, practicing sports, and agricultural activities, which are associated with men (the vectors WOR, SPO, and AGR).

On the second axis, which sets the differences in terms of socioeconomic status, two other groups of variables stand out, which are: reading, speaking on the phone, and visiting friends, and to a lesser extent commuting time and studying (vectors REA, PHO, FRI, RES, and STU), all of which are on the opposite side of watching television or attending sports

events (vectors VTV and EVE). This latter group of variables displays differences between the years: in 2013, the vectors that represent just resting and listening to music (RES and LMU) are also directly correlated with the variables VTV and SPE (small angle between the vectors).

3.1.3. Intrastructure Analysis

Intrastructure analysis enables projecting all the variables from each studied matrix over the compromise, i.e., to analyze each age group matrix to assess the degree of similarity or difference between the covariance structures of the various age groups, between the groups and compared to the compromise of time use activities. This is represented in Figure 7, which specifically presents the results of the latest ENUT. The graphics from 2013 are not included because, in terms of interpretation, the conclusions that can be obtained from that year are, in general, similar to those described below.

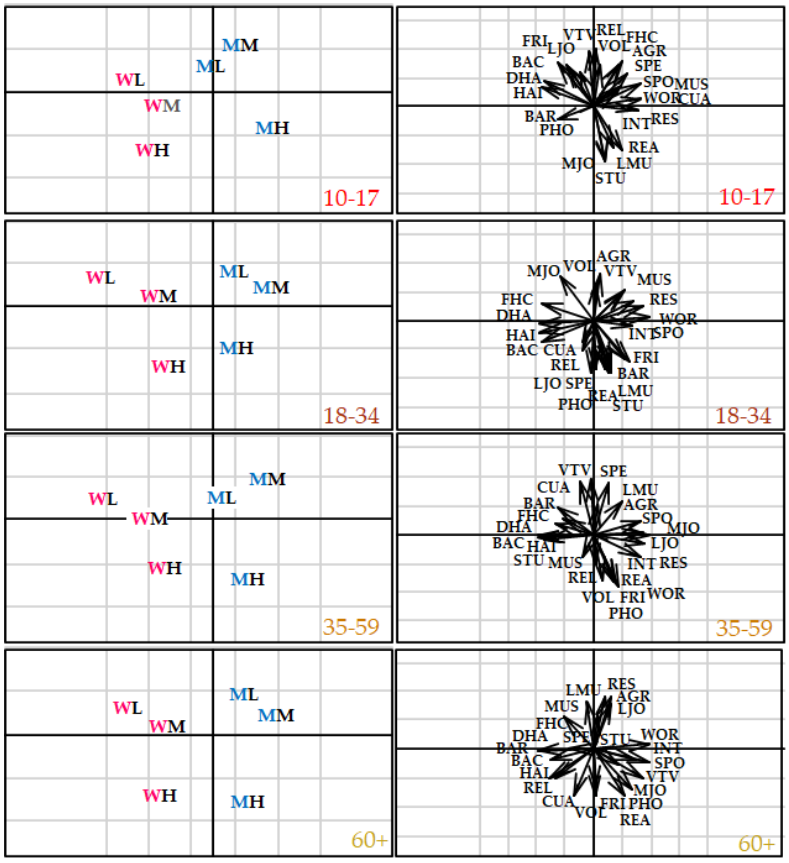


Figure 7. Compromise projections of gender–SES and age group in the year 2017.

In Figure 7, in the representations on the left side, for all age groups, the distance between men and women is large, and they are ordered by socioeconomic status; i.e., the differences in time use between Colombian men and women are found throughout every age group. Specifically for men, the distances between low and medium socioeconomic levels are always smaller compared to the higher socioeconomic level. The greatest difference between age groups is in the structure of variance and covariance of the vectors, because different variables form subgroups of greater association depend on the specific age group.

According to Figure 7, among preteens and teens, the subgroup of variables related to studying, listening to music, reading, and commuting times (STU, LMU, REA, and MJO) is differentiated from the other variables and they are associated to a greater extent with women and men from higher socioeconomic levels. In contrast, in the older adult group, the variables with the closest associations with each other (with less correlation compared to other vectors) are looking for a job or creating an own business, activities related to

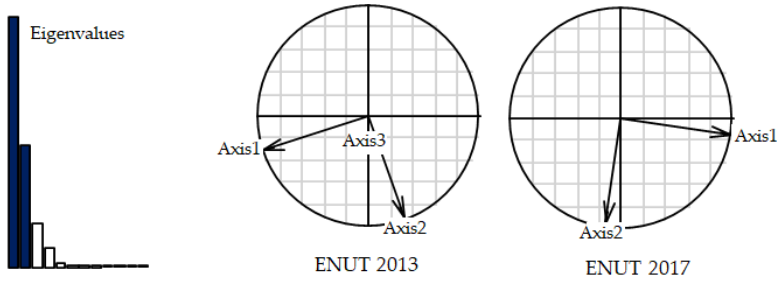
agriculture, listening to music, and resting (vectors LJO, AGR, LMU, and RES). Such activities are more characteristic among older men from medium and low socioeconomic levels, who are therefore the ones who devote most time to these activities in this age group.

In the case of age groups of the economically active population, a clear difference is observed in terms of the activities carried out by men from high socioeconomic levels. Young adult men spend more time being with friends, going to bars, studying, and listening of music (FRI, BAR, STU, and LMU), whereas men in the 35 to 59 age group spend more time working, reading, speaking on the phone, and with friends (variables WOR, REA, PHO, and FRI). Regarding women in all age groups, it can be observed that the vectors that represent the variables of household and home care activities (FHC and DHA) are always located on the left of the graph. This means that in Colombia, independently from their age, women report that they devote a great amount of time to unpaid activities related to household chores and caring for the family.

3.2. Results of the Co-Inertia Analysis

Below we present the results of the simultaneous comparative analysis of the compromises from the X-STATIS analyses of the two ENUT Colombia surveys, to inspect objectively the obtained patterns. Co-inertia analysis was performed to describe patterns that are not visible at first sight by means of indirect comparisons made in explaining the partial triadic analyses between years (the results displayed previously in Tables 3 and 4 and Figures 6 and 7).

Figure 8 presents a table that summarizes the explained variability of each co-inertia axis and their eigenvalues, along with the correlations between them and the axes of the principal component analysis of the individual compromises for each ENUT survey. In this figure, we can see that the first two co-inertia axes summarize 81.2% of the variability of information, and for this reason, in the eigenvalue graph, only two axes are highlighted as necessary to explain the data's behavior. This is also confirmed by observing that the high correlations (greater than 0.91 in absolute value) between the PCAs of each compromise table and the co-inertia axes arise in the first two dimensions (these are highlighted as important in brown).



Coinertia Axis			Correlations between Axis			
Co-inertia Axis	Projected inertia	Eigenvalues	Co-inertia ENUT 2013		Co-inertia ENUT 2017	
			Axis1	Axis2	Axis1	Axis2
Axis1	54.41%	31.02	-0.94	-0.31	0.98	-0.15
Axis2	26.78%	15.27	0.31	-0.91	-0.14	-0.93
Axis3	9.86%	5.62	-0.01	-0.14		
Axis4	4.76%	2.72				

Figure 8. Co-inertia axes and correlations with axes of the principal component analysis.

The RV coefficient obtained from the co-inertia analysis was 0.7334, which indicates that the two structures of the compromises of ENUT 2013 and 2017 vary simultaneously with high co-inertia. This, in terms of interpretation, implies that the times reported in both surveys are consistent with each other; however, some behaviors in specific variables and groups of sociodemographic characteristics are worth mentioning based on the interpretation of Figure 9, which presents the projection of the first two co-inertia axes, both of the

new sets of standardized coordinates of the sex, socioeconomic status, and age groups, and of the canonical weights of the variables of each compromise table.

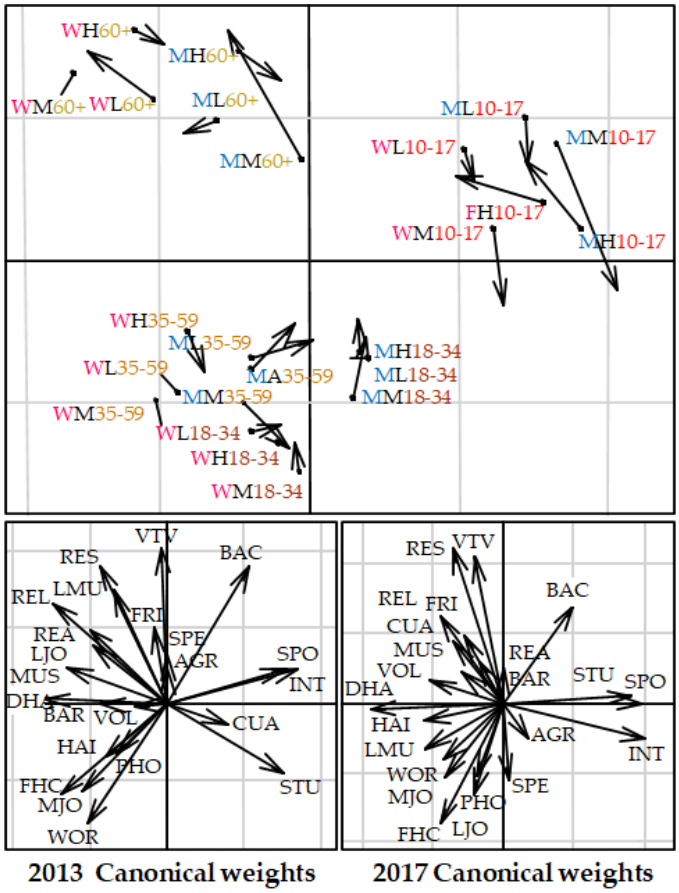


Figure 9. Co-structure graphs of the co-inertia between ENUT 2017 and 2013.

The co-structure graph on the top of Figure 9 projects the new standardized coordinates of the sociodemographic characteristics on the Co-inertia axes of the two datasets. Each pair of points are linked by an arrow. The origin of each arrow indicates the position according to the ordering of the first compromise matrix (from the ENUT 2013 survey), and the arrow indicates the position according to the ordering of the second matrix (of ENUT 2017).

It can be observed that most combinations of gender, SES, and age display short arrows, which means that the times reported in both ENUT surveys were similar and consistent. The exceptions are for the older adult groups, independently from gender, in the medium socioeconomic level (MM60+ and WM60+), and for teens of medium and high status (MH10-17, WH10-17, MM10-17, and WM10-17), whose vectors are longer.

Regarding this finding, specifically for older adults of medium SES, it can be said that the direction of the vectors indicates a shift in the reported times from watching videos and television and simply resting (vectors VTV and RES in ENUT 2013), toward studying (direction of the STU vector in ENUT 2017). This behavior is because in the first ENUT survey this group did not report time related to studying, but in the second survey, both men and women over the age of 60 reported that they spent on average over two hours studying, and they reported a slight decrease in the time they use to watch TV or simply rest.

On the other hand, the graphs in Figure 9 show the weights of the variables from the co-inertia analysis. Here we can see differences in the size of the vectors and changes in their direction, that is, changes in the structure of co-variation in each year. For example, the vectors that represent religious activities and reading (REL and REA), which are located

in quadrant I of the representations in both years, are longer in ENUT 2013, which reflects a greater variability in the information of that year compared to 2017.

In contrast, the vector that can be seen to change direction between 2013 and 2017 is CUA, which represents the cultural events or activities. This change in CUA position implies that it covariates positively or negatively with different variables in the two years compared, and characterizes different age groups. In the first ENUT Colombia survey, attending cultural events was observed as a feature of young adults, whereas in the latest ENUT, it is included in the group of variables that characterize older adults.

A quadrant change was also observed in LJO (looking for a job and establishing an own business), which in 2017 is located in the third quadrant. It directly covariates with FHC, MJO, WOR, and PHO (family and home care activities, time spent in movements and journeys, work time, and speaking on the phone). Nevertheless, in 2013, LJO was located in the second quadrant directly related to REL, MUS, and REA (time to attend or organize religious activities, time spending in practice a musical instrument, paint, etc., and time to read).

4. Discussion

Below we discuss the implications of the results obtained in this study from an interpretive standpoint, with the aim of contrasting the main findings with observations from studies by other authors, and to emphasize their potential for the formulation of public and socioeconomic policies.

4.1. Findings with the X-STATIS Analysis

Regarding the compromise results obtained from the X-STATIS analysis, we can say that in Colombia there is gender inequality in terms of time use, with greater dedication by women to unpaid activities related to household maintenance and care, especially in low socioeconomic levels, which limits the time they devote to income generation activities. This is concluded based on Figures 6 and 7, through the joint interpretation of the positions of the dots of females of low SES (represented as WL, to the left of the graphs for both years) and the positions of the household and family care activities (DHA and FHC), which are located in the same direction.

Internationally, we can cite at least five authors whose findings are in line with these results regarding the time use gender gap that stereotypes women in care and unpaid work activities [55–60]. Other studies in Latin America arrive at the same conclusion, such as those by Jara-Díaz and Candia [61], which studies the socioeconomic information of different population segments in the latest Chilean time use survey and conclude that there are substantial gender differences in terms of workload, where women take on most of the unpaid work and enjoy less leisure time, whereas men devote more time to paid work.

Consequently, in the region, it is necessary to continue implementing public policies that promote the positioning of women in different social spheres and in the labor market, promoting their efforts to obtain decent and egalitarian remunerated work opportunities. This is necessary in order to promote women's economic empowerment and for highlighting the idea that the inequalities in time use between men and women reflects deep social inequality [62] (p. 50).

From the interpretation of the compromise structures of the X-STATIS analysis presented, conclusions can also be reached in terms of the dependence of free time on the economic capacity of the population, because unequal time use conditions were found between people from low socioeconomic levels compared to high levels, and economic wellbeing depends not only on the consumption of goods and services, but also on the consumption of free time [63] (p. 29). In this study's results, both the positions that represent the gender–SES combinations, and the associations found between the variables indicate a greater predisposition of the population with higher income to engage in more leisure and free time activities.

This result is also consistent with what was observed a decade ago by Aguiar [10] (p. 106) in studying time use in Brazil, where time use is stratified as a function of paid work, care of the home and family, leisure, and commuting, which characterize highly differentiated lifestyles in a hybrid or unequally developed society. Consequently, this result, although it implies inequality in terms of socioeconomic status, could also be interpreted as an opportunity in terms of possible communications-focused public policies, given that free time should not only be defined in terms of the consumption of cultural goods or activities that must be paid for (such as going to a movie theater, attending sport events, or investing in private parties).

There are numerous free time activities that can be done at no cost and that also offer rest; consequently, communications campaigns targeted at the population of low socioeconomic status promoting activities of this type could help low-income Colombians make better use of their free time without affecting their income. The existing relationship between time use and socioeconomic status of the population has also been recently studied by Vagni [64], who holds that time use is both a cause of social inequality and a consequence of social inequality. However, how social class stratifies time use patterns is seldom studied.

Another important finding that was obtained through the X-STATIS analysis is regarding behaviors of the age groups. It can be said that time use studies should not only focus on establishing differences by gender, but also by stage of life, because as indicated in the interstructure and intrastructure analyses, the time use activities mostly depend on the age group. Cowan was one of the first theorists to point this out, noting that life transitions such as finding a first job, marriage, and retirement are moments that necessarily involve a reorganization in the way people use their time [65] (p. 18).

4.2. Findings with the Co-Inertia Analysis

It can be concluded that the time use reported in the two ENUT studies in Colombia is highly consistent; however, application of this methodology enabled perceiving differences in the reported times that were not evident through indirect and descriptive comparisons between the two X-STATIS evaluations. One of the most relevant of these findings is related to the free time activities of older adults, and specifically regarding the time devoted to resting, watching television, studying, reading, and attending religious or cultural events.

This finding is important in terms of the demographic transition that Colombia is currently experiencing, because as the country's population tends to become older, perceiving by means of modeling techniques the changes in behavior related to the times reported by older adults in the country, implies considering the importance of designing and implementing policies for the wellbeing of this population. This is given that their needs, social interaction experiences, and individual free time activities may be dynamic with the passing of time.

The activities that may be worthwhile for adult life may be focused on maintaining harmonious family relationships, fulfilling personal hobbies or rooting for a favorite football team, being in touch with nature, religious faith or spiritual activities, making money, intellectual achievements, feeling satisfaction at work, or engaging in stimulating travel or other experiences [19].

In general, regarding time use by Colombians by age group, we can say that the findings of this study are consistent with other conclusions in the Latin American context. Benvin, Rivera, and Tromben [66] point out that the life cycle of individuals is another important element for the analysis of time use. For example, men and women in the 25 to 45 age group work more time and it is in this age group that the greatest gaps are found between men and women.

4.3. General Conclusions

From all of the above, the main conclusion of this study is consistent with the idea that time use is highly stereotyped according to expectations on gender, age, and status [12,67]. These three demographic characteristics display a substantial number of associations that

explain time use. Specifically, based on the graphics, tables, and results presented in this paper, we can conclude that the ordering of these factors to condition the way people use their time is consistent with what these authors propose.

Time use studies, and especially those based on a multidimensional perspective, should be considered a useful tool to design public policy actions and strategies that not only help mitigate the inequality between men and women, but that also facilitate planning of the population's needs depending on their life cycle stage and purchasing power.

It is in this specific aspect that we can summarize the practical implications of this study's results, because the design of social public policy strategies and actions aimed at mitigating the gender issues reflected in time use patterns should also consider possible differences by age group and socioeconomic level. Furthermore, in the specific context of Colombia, strategies of this type should focus on mitigating other conditions not reviewed in this study, such as belonging to ethnic groups and to vulnerable populations that are victims of the armed conflict.

From a methodological standpoint, it is fair to say that in the field of social sciences and politics, time use variables are often analyzed separately and in a descriptive manner; however, examining them by means of multivariate techniques such as CO-STATIS, X-STATIS, and/or co-inertia enables finding several relationships that are not evident at first sight. In this sense, it should be noted that this study, unlike other time use studies carried out in Colombia [62–68], contributes to the assessment of existing interrelationships between the numerous factors that determine time use by the population.

Consequently, it is recommended to use multivariate techniques in future time use studies and in general in the context of sociodemographic studies because these techniques can make significant contributions for the design of population intervention actions that help improve the life quality of people (in different dimensions) and promote gender equality. This recommendation is particularly applicable to time use research in Latin American countries, where at the regional level there is a need to periodically move forward in measuring time use to recognize women's contribution to the economy in both the productive and reproductive dimensions [69].

Lastly, it is relevant to point out that the main limitation of this study is that even though it compares the data of the two latest time use surveys in Colombia for the years of the study (2013 vs. 2017), the findings obtained do not reflect the current situation of time use in the country and these studies do not yet reflect changes in patterns that may have been produced in the routines of Colombians due to the COVID-19 pandemic. We will have to wait for new surveys that cover the pandemic and post-pandemic periods, which implies that more academic research is now needed to assess the organization of time use and the mental health effects on family and social life during the health emergency [70,71]. Studies of this type are necessary specifically because women report that they work more in lock-down than in ordinary conditions with no health emergency. The boundaries between work and leisure become lost when there are no defined start and end times.

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