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With whom are you doing...?
Applying network analysis to measure intra-household resources allocation, bargaining and interactions

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Version 02

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With whom are you doing...?
Applying network analysis to measure intra-household resource allocation, bargaining and interactions[1]

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Abstract

This paper applies network analysis as an empirical tool for studying intra-household economic relations. Time use surveys, if include *with whom* and *for whom* questions could be used as a roster instrument, a common way for obtaining network or relational data. Based on Portuguese Time Use Survey (PTUS) multimember household data, the research has the following aims: (i) Compute network indicators (e.g. Inclusiveness, Degree and Density) and identify graphs' typologies; (ii) Identify the 'ultimate consumer' and the 'benevolent producer' of public goods in families; (iii) Essay a measure of bargaining power and compare it with the outcomes of the family (e.g. consumption of durable and non-durable goods); (iv) Analyze the association between household income and economic networks typologies. The empirical tests of household models request data, which usually are not easily available. This research is a first essay to illustrates the potential contribution of relational data (obtained through time use surveys) to overcome some of those problems.

Keywords: network analysis, time allocation, economic networks, household models, intra-household relations

1. Introduction

Homo economicus is not an island. This idea is reflected in several economic theories and models explaining individual behavior as school performance (Kang, 2007), job search (Ioannides & Loury, 2004), criminal conduct (Calvo-Armengol, Verdier & Zenou, 2007), teenager behavior (Kooreman, 2007), migrations (Epstein & Gang, 2006), informal insurance (Bloch, Genicot & Ray, 2007), or well-being evaluation (Juster, Courant, & Dow, 1981), just to mention a few examples. These analyses have in common the inclusion of the relationship of each economic agent with others with whom she interacts. [2] Those contacts can be associated with work or friendship, have formal or informal nature, be regular or erratic. Those

[1] ***Acknowledgements***: I would like to thank Robert Pollak for the incentive for essaying this application of networks tools to intra-household economic interactions. I thank also Marta Varanda for comments received about network analysis. The usual disclaimer applies.

[2] Theories like social capital, social cohesion or non-market interactions highlight the importance of market and non-market personal interrelation.

relationships build structures whose characteristics and dynamics are affected by individual behavior and by exogenous factors.[3] They may be called networks.

Network analysis is applied in economics, computer science, physics, neuroscience, communication science, anthropology, cognitive and behavior sciences.

This paper focuses on the **economic networks**, which are the networks[4] of **relations among individuals whose behavior is supposed to impact on the economic sphere in some way** (Zuckerman, 2003)[5]. Network analysis is applied in this paper to study the internal workings of families.[6]

The working of a family can be analyzed through diverse approaches, depending on the specific economic field. Bergstrom (1993) in a literature review of economic theories of family summarizes those approaches. Family can be interpreted as: (i) a micro unit of production by a labor economist or an industrial organization economist; (ii) a pair of agents in a relation of bilateral monopoly, by a bargaining theorist; (iii) a 'little city' by an urban economist; (iv) a 'little club' by a public choice theorist; (v) an organization of benevolently interrelated individuals by a welfare economist.

The economic approach of the intra-household behavior, often considered as a 'black box' in economic theory, received significant contribution from Gary Becker as stressed by Pollak (2003, p.111): Becker "dominated research in the economics of the family, shaping the tools we use, the questions we ask, and the answers we give". The unitary and the collective household models were largely surveyed as well as the empirical studies related with them. There is also a large consensus about the difficulties associated with those empirical tests, independently of the theory and methodological way adopted (e.g. game theory).

Time use literature in general and economics of time use in particular includes multiple aspects of family and intra-family behavior. For review articles about the contribution for household models and accounts see Juster & Stafford (1991), Harvey (1999), Merz & Ehling (1999), Hamermesh & Pfann (2005) and (Ironmonger 2008). For more detailed discussion of the potential and limits of use of time use data for empirical test of household models see Klevemarken (1998) and Apps (2004). Empirical studies include child care, parents labor supply, synchronization[7] of household activity among other issues.

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[3] The present paper uses networks mainly as tools. Several theories were developed in association with networks. One is structuration of Giddens. For him structuration means studying the ways in which social systems are produced and reproduced in social interaction. (Giddens, *Constitution*, p 25-26) and also "the structuring of social relations across time and space, in virtue of the duality of structure" (*Constitution*, p. 376). The discussion of those theories is out of the scope of the present research.

[4] There are different understandings of what networks, social networks or economic networks are. That debate is out of the scope of this paper. See Zuckerman (2003) for the discussion of contributes from economists and sociologists.

[5] Our bold.

[6] Throughout this paper the terms "family" and "household" will be used to refer the same entity.

[7] Jenkins & Osberg (2005) for a study of leisure synchronization based on British Household Panel Data. (BHPD) where is found an inverse relation between social contacts (from with whom question) and working time.

As far as the author knows, in economics the network analysis was not yet been applied to the study of intra-household behavior. However, learning by observing decisions of others can help explain some otherwise puzzling phenomena about human behavior and for example the 'theory of observational learning has much to offer economics and business strategy" (Bikhchandani, Hirshleifer & Welsh, 1998, p.152. So, contact and contact time inside the family is important. Networks inside and outside family are also important for example for searching jobs as argued many decades ago by Bott (1957)[8] and studied more recently by Ionnnides & Loury (2004) and many others.

The present paper argues and tries to illustrate that network analyses are also suitable for study in deeper the intra-household economic relations contributing for shortening the gap between household theory and respective empirical testing.

That study of network analysis as an empirical tool for understanding some aspects related with the economics of intra-household relations, will follow here four research steps:

First, adopting socio economic network tools intra-household interrelations are mapped, typologies are created based on directed and undirected graphs and relational indicators are computed. It is assumed from the economic theory, that density of the family as a network and centrality of each of it members affect the results of the individual and collective decision process.

Second, the household producers and the ultimate consumers are identified for each family, a particular 'little factory', according some economic approaches. The role of each member as producer and co-worker of public goods (for example child care) and consumer are identified. The symmetry of links between household members is analyzed considering the help received and the help given to several household activities in particular market related.

Third, the member's household behavior is studied in association with proxy measures for power and bargaining power (usually measured by the relative wages). Inside the household, the decision about buying durable and non durable goods is assumed to be a reflex of power. The paper discusses the alternative measures.

Finally, the association between income and the networking and other characteristics obtained from the three previous steps is studied.

The paper is organized as follows: after the Introduction, Section 2 presents briefly the economics of household and socio economic network analysis, two separate fields which combination is the main novelty of this paper. Section 3 describes the main data source and

[8] Bott (1957) a classical and precursor of family networks discuss in her book the 'economic ties' (p.124-126) and the interview instrument which support the book includes many questions similar to time suse surveys.

presents the empirical strategies. Next, in Section 4 empirical results are shown and discussed. At last, main conclusions are exposed, as well as research limits and future avenues of research.

2. Background: Household Models and Socio Economic Networks

Relational data is about the relation between entities: institutions, individuals, countries, etc. Those relations have different nature. For example, material relations represented by exportations of goods between two countries or citations. The present research only analyses the links established among individuals who are members of the same household. The use by economists of the network analysis is usually done in other contexts, for example, international trade, technological diffusion or labor market. The author argues that these measures could be extended and used in intra-household allocation resources (time and money) and interactions between members.

Relational data is distinct from variable analysis which focuses on attribute data. Attribute data, i.e. the characteristics of the agents could be also included in network analysis but the focus of this analysis is on *relation*. Network analysis has already proved useful in diverse study domains: consensus and social influence, sociology of science, markets, diffusion and adoption of innovations, social support, world political and economic system (Wasserman & Faust, 1994).

A brief review of socioeconomic networks[9] framework was recently presented by Vega-Redondo (2007). The process of technological diffusion, the importance of informal social networks in labor markets, are some, among many others aspects studied by economists based on network analysis. Management and Theory of Organizations studies for example the inter-firm partnerships or intra-firm or intra-institution organization. Social movements and recruitment for organization, vote behavior and neighborhood contagion are studied by sociologist and policy scientists. The peer effects and the informal support between households are issues studies by cognitive and social scientists adopting network analysis with different level of complexity.[10]

More details about the main concepts related with network analysis are presented in Appendix 1.

[9] Industrial Organization and Microeconomics studies the network industries or activities (e.g. transportation, communications, and information networks). Networks are referred in different section in Journal of Economic Literature Classification and with different meanings C4 - Econometric and Statistical Methods: Special Topics C45 - Neural Networks and Related Topics D8 - Information, Knowledge, and Uncertainty D85 - Network Formation and Analysis: Theory L1 - Market Structure, Firm Strategy, and Market Performance L14 - Transactional Relationships; Contracts and Reputation; Networks.

[10] Network analysis is also applied in computer science, physics, communication science, anthropology, cognitive sciences, cognitive and behavior sciences and neuroscience.

3. Data and methodology

3.1. Relational data and time use data as roster instrument

Roster instruments and name generator instruments are the most common ways for obtaining network data (Butts 2008). Networks data can also be obtained from other sources like digital or paper archives, sensors or direct observation.

The roster or prompted recall instrument includes *to whom, with whom* or *from whom* questions like: *'To whom do you receive help at home? 'With whom do you go out for leisure activities? 'From whom do you receive advice at school activities?'* Usually after these *whom* questions a list o names is presented for choice.[11] See Appendix 3 for a relational variable description in the case of Portuguese Time Use Survey (PTUS).

Portuguese Time Use Survey (PTUS)

The main data source in the present empirical analysis is composed by the Diary, the Individual Questionnaire and the Household Questionnaire from Portuguese Time Use Survey 1999 (PTUS) carried out by National Office of Statistics (INE – Statistics Portugal) according Eurostat guidelines EUROSTAT (2004). The original Portuguese time use microdata are composed by four micro files.[12]

The PTUS total sample includes 8133 individuals and 4357 households. In the one person households the questionnaire and diary were applied to that person. In the multiple members household only two persons were surveyed: two adults or one adult and one child (between 6-14 years old).Additional information about the PTUS database characteristics are described in Appendix 2 and 3.

3.2. Methodology

The time use data from PTUS can be used only as a quasi-roster instrument but it is not complete because only two members in each family were surveyed.[13] The sub-samples under analysis in the present paper include as possible respondents, 2 persons belonging to the same household. The pairs are: husband and wife, husband/father and children and wife/mother and children.

[11] The name generator, an alternative instrument, is composed by questions which ask the surveyed person to indicate from memory a list of other persons with whom she has some kind of relationship (e.g. friendship, trust).

[12] The Original Microdatafiles are: [1] diário_horizontal_sem_AM_anonimizado (8133 observations); [2]diário_vertical_com_profissão_sem_AM_anonimizado [3] Q_família_sem_AM_anonimizado (4357 observations;);[4] Q_individual sem_AM_anonimizado (8133 observations;

[13] In other countries more than 2 persons in the household respond to the survey.

Usually the network analysis is applied to larger groups with many individuals (nodes or vertex) and lines. This is not the case of the present research. However, for countries where all the household members are surveyed the network size can be enlarged.

Network dynamic, one of the most fruitful field of network analysis, is absent here because all the data are collected for the *same* period. This restriction can be overcome if time use panel data are available.

The household network here studied is a non-complex network if the criteria of Vega-Redondo (2007) are applied. The number and diversity of entities is small, the structure of node interactions as well as the local interaction is simple and the dynamic and exogenous effects are absent.

Some network measures

The inclusiveness is computed as the number of points (nodes, actors) that are included within the various connected parts of the graph, so does not include the isolated nodes.

The density of a graph (d) , is computed as:

(1) $$d = \frac{l}{n(n-1)/2}$$

where l is the number of lines and n the number of vertices. Density is the number of graph's lines as a proportion of the maximum possible number of lines and ranges between one and zero.

The neighborhood of a point is the number of points (individual) adjacent (connected by a line) of it. The degree of connection of a point (or node) is the size of the point' neighborhoods. The Table A1.1 (Appendix 1) shows the sum of the degrees, example in G2 it is 8, because each of the 4 points has 2 adjacent points.

In network analysis, there are characteristics only computed for nodes, networks or a subset of nodes. Other characteristics, as for example degree, can be computed both for nodes or networks. For a summary presentation of the measures used to describe networks and individuals see Monge & Contractor (2003) and Brass (1995).

The cohesiveness[14] of a household or any other sort of network is important because the more each household member are linked, the more she is influenced by group values, e.g. behavior about consumption.. It is likely that within highly cohesive households, individuals

[14] The cohesiveness is a network structure characteristic usually applied to a sub set of nodes.

tend to have very homogeneous beliefs and behaviors (Wasserman & Faust, 1994, p.250). There are different ways to measure the cohesiveness that increase when: the number of ties the member has with to the group, it means the links each individual has with other nodes in the group increase, and the 'exogamous' links outside the group proportionally decrease. Mutuality and frequency of ties among household members also affect positively the cohesion.

One of the characteristics of centrality of a node position in the network, which influences the role and the performance of the member, is betweenness. The betweenness measure of a node[15] represents the importance of the household member (node) in bridging[16] the indirect contact or access with the other nodes. Or, by other words, betweenness is the extend to each a household member mediates, or falls between any other two members on the shortest path between them. Together with betweenness other indicators of centrality are degree of the node and closeness.

The betweenness of the node *i* is given by :

(2) $$b^{i} \equiv \sum_{j \neq k} \frac{v^{i}(j,k)}{v(j,k)}$$

where *j* and *k* are different nodes . The total of the shortest paths joining any two nodes is represented by *v(j, k)* , and are equal to *v(k, j).* The v^{i} *(j,k)* represents the number of paths which link *j* and *k* but also go to other node *i* (being *i*, *j* and *k* different).

Reciprocity, one of the indices of mutuality, is only defined for dyads (e.g. a couple, father and mother). A dyad is a pair of nodes (individuals or actors) and all ties between them. A formal definition of dyad is an unordered par of actors (labeled *i* and *j*) and the arcs that exist between the two actors in the par, represented by *Dij*=(*Xij, Xji*), being *i* and *j* different. Later in this paper, the dyadic isomorphism states related with the questions *Does the activity for whom* will be empirically described. Considering a household dyad (H)usband- (W)ife and the activity 'current shopping', 4 dyads are theoretically possible: null dyad D_{hw}=(0,0) (H does not shopping for W and the symmetrical is also true), asymmetric dyad D_{hw}=(1,0) (H do shopping for W who does not it for H), asymmetric dyad D_{hw}=(0,1) and mutual dyad D_{hw}=(1,1). In PTUS Reciprocity is related at least with two survey questions: *For whom did you the activity…* Here we research how strong is the tendency for one household member to help another, if the second member helps the first.

With the original micro files is possible to match the members of the same family and combine their answers related with three aspects (With whom, for whom and who else

[15] The betweenness of the network can also be computed from the betweenness of each of the nodes pertaining to the network.
[16] The bridging effect is one among other roles as star, liaison, gatekeeper and isolate.

participate, all relational variables, see Appendix 3). [17] There are other elements which could complement the network measures of centrality, cohesion and mutuality.

First, the network inside each family/household is identified based on the detailed information obtained from time use survey ‘questions *"with whom" are you doing*. After, the micro data also include information about existence of mutual help in certain activities for example between spouses.[18] For example, there is one question on the survey about "Does your *husband/wife help* with the activity *A*(several activity: preparing meals, caring children, helping children study etc.). In Appendix 3 the summary of the relational data which can be obtained from the PTUS is presented.

4. Results and discussion

Considering our empirical research goals, three type of households are included: couple without children, couple with one or more children (at least one with less than 15 years old) and couple with one or more children (at least one with more than 15 years old), which represent 75,1 % of the total household sample.[19]

From each household are analyzed a minimum of two and a maximum of three: father mother and children. They represent most of the respondents in each household. Only the households with two respondents are considered. Because the intra-household interactions vary between weekdays and weekends, only week days are included.

The original data do *not* include the household size, what is a strong limitation. The size is here computed indirect and approximately using the data of number of children (6-14 years old) combined with the and number of adults (15 and older). Table 1 presents final household sample. The income distribution reflected on data converges with other results obtained for Portugal for the same period. The main source of family income is wages (83%) and 86% of the respondents are wage earners. The lower income families represent more than half of the studied families.

Table 2 shows for individuals the descriptives for age, employment status, education and family income. It also includes the mean descriptives for the variables related with the *With Whom* question (see Appendix 3). Husband and wife are in large majority employers, respectively 94% and 76%. The women have a higher level of education, considering only two categories (basic education and non basic education).

[17]Some time use data consider several or even all member inside of the household. Is the case of Italy, Germany, France, Slovenia, South Africa Australia Monfardini, Cardoso & Fontainha (2008) worked on matched data for father mothers and children for the first previous countries.

[18] Illustrating: Eve declare she receives help from Adam on gardening; Adam declares he receive help from Eve on child care. If persons of the same household/family are matched is possible test the influence of economic, demographic and also networking variables on the decisions and behaviors. Returning to the Eve and Adam example. Is possible to fill a matrix Adam x Eve, signaling the fluxes of help and after using network analysis and measures.

[19] The results for couple with an adult child will not be presented in this paper.

Most of the time is spent alone in particular for husbands.[20] Time with children is double for wife compared with husbands group. Time with others (non household members) is greater for husbands than for wives and for daughter than for sons. Bianchi, Robinson & Milkie (2006, p.103-107) obtained similar results with data from US about time *with other*. Note that this comparisons are done between groups, not between member of the *same* family.

Table 1 Household Sample; Size and Composition

Household Type	Main Source Income %	Income sources %	Income Category[21] Lower (L) =1 Upper (H) =0 Mean (StdDev)
Couple with only one children (6-14 years) [22] N (matched data)=166 (only weekdays)	Wages 82.5 Indep. Work 14.5 Pensions 3.0	Wages 86.1 Indep. Work 21.1 Pensions 6.6 Social Security 15.1 Property 2.4	0.63 (0.48)
Couple without children N (matched data)=937	Wages 22.1 Indep. Work 9.6 Pensions 65.3	Wages 25.8 Indep. Work 20.0 Pensions 75.1 Social Security 3.6 Property 10.7	0.81 (0.39)

Author's computation from PTUS microdata files

Table 2 Members of the Household
Sample Composition and descriptives
Couple with one Child (6-14 years old); Family size 3 persons; weekend

					With Whom Diary minutes ; Weekday				
	N Obs.	Age Mean (StdDev)	Employment Status % in each group	Education[23] Basic or less=1 More than basic=0 Mean (StdDev)	Alone Mean (StdDev)	With Children (hh) Mean (StdDev)	With Family (hh) Mean (StdDev)	With Others Mean (StdDev)	With Total[24] (StdDev)
Husband	71	40.61 (7.96)	Empl. 94.4 Unemp. 2.8 Retired 2.8	.43 (.50)	1121.7 (115.7)	111.7 (123.5)	208.5 (98.2)	96.2 (94.9)	1538.0 (121.16)
Wife	105	37.10 (7.12)	Empl. 76.2 Unempl. 3.8 Retired 15.2 Domest. 2.9 Other 1.9	.36 (.48)	1016.3 (170.1)	236.3 (194.2)	237.6 (142.8)	87.7 (120.2)	1577.9 (159.2)
Child	156	9.98 (2.68)	Student 100.0	.72 (.45)	994.9 (153.4)	0	294.6 (152.5)	174.9 (154.4)	1470.6 (88.2)
Child Son	76	9.95 (2.62)	Student100.00	.76 (.43)	995.9 (156.2)	0	295.4 (156.8)	166.7 (151.1)	1470.0 (92.9)
Child Daughter	80	10.01 (2.75)	Student100.00	.67 (.47)	994.0 (151.6)	0	293.9 (149.2)	182.6 (157.9)	147.0 (84.0)
Total	332								

[20] The time spent in work is usually classified by respondents as time alone.
[21] The category lower income (L) includes households with less than 898 euros per month the category upper (H) includes equal or more than 898. The original data has 9 net monthly income categories, the bottom interval is 'less than 299 euros' and the upper is 'more than 4.987 euros'. The original values were in the old Portuguese currency *Escudos.*
[22] No adult or babies are member of the household
[23] Original data include seven categories of education. Here, the dichotomous variables includes in the Lower level group (L) Primary Education or fist stage of basic education or lower. It proxies the UNESCO ISCED level 1 and 0 and corresponds to a stay at school about 4 or less years at school. The values converge with the Portuguese national data.
[24] The total minutes per day alone or with someone (children, family or other) can sum more than 1440 minutes per day, because the alternatives *with whom* are not mutually exclusive.

Author's computation from PTUS microdata files

Network Indicators (Inclusiveness, Degree and Density) and Network Typologies

For the three-persons families 332 individual observations are available, two for each family. The pairs for each family may belong to one of the three categories: Husband-Wife (20 individual observations), Husband–Children (122 individual observations) and Wife-Children (190 individuals). The adjacency matrices, in the second line of Table 3 represent, considering all the activities and all the 144 episodes during one diary-day the existence (or not) of contacts or interrelations between the family members as declared by the respondents. Zero represents the absence of contact and one, the existence of contact.[25]

The information about those links is obtained from the question '*with whom* [are you doing'] activity A_i. Each individual has four alternative answers: alone, with children, with family member not children and with others.

In order to build the adjacency matrix and the results presented in Table 3, built using matched data for the same family (in other words for each family there is a pair of observations) different methodologies were adopted:

For the sub-sample of husband and wife pairs (H-W), combining the information surveyed from both the matrix is directly filled up. The W (and H) gives information about the existence of time spent together between Wife (Husband)-Children and between Wife (Husband) –Husband (Wife). This observation is obtained from the alternatives *with children* and with other *family* member not children.[26]For the contact of wife and husband there is information from both sides. The contact is assumed only with both spouses of the same family refer it.

For sub-samples of parents and children (means Father-Children and Mother children), the matrix is indirectly filled up. For the children surveyed, from the alternatives *with family* (includes contact with mother *and* father) the links with each of the parents is obtained by the following way. The total time spent with parents is compared with the time declared by the other respondent of the same family (father or mother). If the time declared by the child is more than the time declared by the surveyed parent, it is deduced that there is also contact with the *Other* parent (not surveyed). For the parents the information is obtained from the answer about *with children* and *with family* (it means with the spouse in this 3 family member).

[25] Note that the *time* spent *together with someone* can also be computed from PTUS. The period of reference is the 24 hours (144 episodes) of the survey day. This information about the contact duration allows, using network analysis to weight the link between the family members. In this paper only non weighted links are considered. Future author's research will include weighted network links.

[26] The family size and composition (3 members, couple and children) allows these computations.

Two types of network are predominant in these families: network (net1) where all members spent time together and a network (net2) where only links between mother and father and mother and children exist. This result is obtained from information given by fathers *or* by mother. The answers received from both (remember that in each family only one adult –father or mother- is surveyed- differ a bit: 28% fall in the category according information from fathers, and 33% according mothers. Families which only have dyads (two persons connecting and the third isolated) represent a thin percentage of total (4%). The family income level seems not affect the type of network created inside the family.

Few more than half of families (53%) shown the maximum density index, (d=1) and an incomplete inclusiveness exists in 4% of the families. The networks measures here calculate are used later in the paper as variables for the study of the three last topics referred in Introduction.

Public goods production inside the household

Producers and ultimate consumers; Common Preferences

The study of the family with multiple consumption decision-makers can be approached by different ways.[27] For our research goal the following are particularly relevant: (i) assumption of a proportional rule which means that the income is equally divided by household members and ignoring public goods[28]; (ii) comparing the aggregate consumption of the household with the individual consumption of each member in order to test the unitary model of family decision-making. The available data are in general not adequate for that test and other alternative measures have been developed: the effects of redistribution inside the family on global family consumption; the imputation of the consumption to each member according the nature of the goods (for example toys for children, dresses for women, etc.); different consumptions of leisure for family members.

The difficulties of identification of the ultimate consumer, at least when only public goods are considered (household production) , is partially illuminated using PTUS data which includes a question about *to whom* . Common preferences inside each family can be approached by the question *If you have more time…* (see Appendix 3) considering the matched answers inside each family.

[27] For a survey of those approaches see for example Bergstrom (1995).

[28] Public goods are jointly consumed household commodities as light or garden. The public good contribute for the utility of each member of the household. The agreement, the joint decision between parents about "how to educate their children" can be considered a public good (Bergstrom, 1995, p.12-13)

Table 3 – Family Networks and Network Measures[29]
Three – Person Household (Couple with children between 6 and 14 years old);
Matched data for same household; week day
Total and Low Income Families

Graph	H W C			H W C			H W C			H W C			H W C			H W C			H W C			H W C		
Adjacency matrix	*	1	1	*	1	0	*	1	1	*	0	1	*	1	0	*	0	0	*	0	1	*	0	0
	1	*	1	1	*	1	1	*	0	0	*	1	1	*	0	0	*	1	0	*	0	0	*	0
	1	1	*	0	1	*	1	0	*	1	1	*	0	0	*	0	1	*	1	0	*	0	0	*

Network	net1	net2	net3	net4	net5	net6	net7	net8
Triads		Triad1	Triad2	Triad3				
Dyads					dyad1	dyad2	dyad3	isolated
Frequency Of each type[(a)] % ALL HH	53,6	30,1	10,2	1,8	2,4	1,8	0,0	0,0
Answers from couple	*40,0*	*20,0*	*0,0*	*0,0*	*40,0*	*0,0*	*0,0*	*0,0*
Answers from Father-children	*55,7*	*27,9*	*14,8*	*0,0*	*0,0*	*1,6*	*0,0*	*0,0*
Answers from Mother-children	*53,7*	*32,6*	*8,4*	*3,2*	*0,0*	*2,1*	*0,0*	*0,0*
Frequency Of each type[(a)] % Only Lower Income Families	52,9	30,8	9,6	1,0	3,8	1,9	0,0	0,0
Number of Connected Members	3	3	3	2	2	2	2	0
Inclusiveness	1.0	1.0	1.0	1.0	0.66	0.66	0.66	0
Sum of degrees	6	4	4	4	2	2	2	0
N.of lines	3	2	2	2	1	1	1	0
Density	1	0.66	0.66	0.66	0.33	0.33	0.33	0

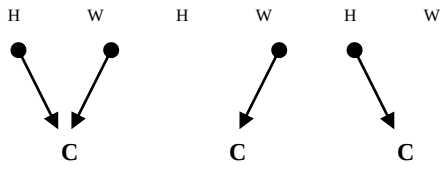
Author's computation from PTUS microdata files using relational information (with whom variables) considering 144 time episodes a day. Value zero (no link) means that during diary day there was no contact in any of the 144 episodes.
Legend: H=Husband (Father); W=Wife (Mother); C= Children.
[(a)] The results for each type of network were obtained from different survey pairs of respondents, as explained above. The answers from the different pairs of respondents converge in general among them. Note that, the difference in the answers from pair couple, correspond to 10 families (10 couples; 20 individual).

Children as sociometric stars

A sociometric star is the recipient of numerous and frequent choices from others.[30] This concept of star is useful to understand for example *from whom* the child in the family receives support for school related activities (study at home, doing school homework, etc.). The star has a local centrality. Figure 1, based on PTUS, shows three types of stars and the respective association with the network previously computed (Table 3). It shows the distribution of families according the answers to the questions:

Do you help your children with school homework usually? Does your spouse help your children with school homework usually? Do other persons (non household members) help your children with school homework, usually? [31]

Table 4 Children as a sociometric star
Children receives support from [*p1, p2, p3…pn*] related with school homework
Three – Person Household (Couple with children between 6 and 14 years old);
Matched data for same household; week day



Frequency [(a)] of each type % All households	70%	25%	4%
Frequency [(a)] of each type % Lower Income Households	69%	28%	3%
Households with Network Net1	78%	16%	5%
Households with network Net2	66%	17%	0%

Author's computation from PTUS microdata files using relational information (*who supports children school homework*). Legend: H=Husband (Father); W=Wife (Mother); C= Children. [(a)] The sum is less than 100% because other arrangements exist (e.g. with mother, father and others)

The more frequent situation is: both parents support the school work at home (70%) and in one quarter of the families only one parent gives that support, more frequently the mother (25%) than the father (4%). Families with lower income exhibit identical patter of the total of families.

[30] In the socionetwork literature, the star usually held a position of great popularity or leadership considering the network which the star belong.
[31] There is also a fourth about the help from employer, not empirically relevant.

When compared with the type of household network (*net1* and *net2*) the results are as expected. In households showing the maximum density, by other words, which belong to net1 (d=1) the support to children school work is more frequently shared between both parents (78%) than in the case of households belonging to net2 (d=0.66) where the frequency is 66%.

The results above also suggest coherence between the information available from the diary (*with whom* during one diary-day) and from the individual questionnaire (what is the *usual participation* in one activity; dichotomic answer).

Non common preferences

Testing the hypothesis of common preferences inside the family is challenging. The strategy adopted in this paper assumes that the answer to the question *'On which main activity would you choose to spend more time if you could?'* [32]reflects the behavior of each individual when the time budget constrain is relaxed.

Table 5 – **Main Preferences of Husbands and Wives**
'On which main activity would you choose to spend more time if you could?'
Three – Person Household (Couple with children between 6 and 14 years old)

Main preferences After time budget restriction changes	Husband - Father		Wife - Mother	
	%	Pref. rank [a)]	%	Pref. rank [a)]
Doing nothing, relaxing	21	1	17	1
Meeting with Family	21	1	17	1
Meeting with Friends	10	3	6	3
Household Work and Family Care	10	3	17	1
Shows and Leisure Travel	7	4	15	2
Volunteer Work or Religious	0	-	6	3
Active sport	17	2	5	4
Other activities 7 activities	14	-	17	-
Total	100		100	

Author's computation from PTUS microdata files. [a)] Each respondent chooses only one from list of 14 alternative activities. The preferred rank was computed from the frequencies of each activity.

The comparison of the main preferred activities of fathers and mothers (husbands and wives)[33] (Table 5) shows that there are two common leisure activities at the top of preferences of both (*doing nothing* and *meeting with family*) but *household work and volunteer work* are different. Some of the activities chosen do not imply necessarily any kind of market consumption.

Comparing the preferences of each member of the *same* couple is not possible for this sample of three person households because the lack of enough observation.[34] Analyzing as alternative, the sample of two member household composed by couples[35] the percentage of coincidence for the main activity if time budget is relaxed, is small. At the top of the declared

[32] The surveyed person chooses only one alternative from a list of 14 (see Table A3.1 in Appendix A3).

preferred activities for both members of the *same* couple are *Doing Nothing* (12%) and *Meeting with family* (11%).

For the households with adult children[36], the difference of preferences between children and parents for the *same* family is large. In particular the preference for *Meeting with Friends* is higher than mother or father preference for the same activity.[37]

Household producers and ultimate consumer – Intra-household Reciprocity

From the set of activities for which information about producer and ultimate consumer is available (Table A3.1 in Appendix 3) the activities *buying sporadic and buying current consumption goods* were selected because they are economic activity, directly related with market and consumption. In addition, goods and services which sopping is sporadic, not current, related at least partially with durable goods[38] and so, they can approach household wealth formation.

Table 6 – Current and Sporadic Consumption
Who and *To whom* [a)]
Three – Person Household (Couple with children between 6 and 14 years old)

Household member	Current Consumption (shopping)			Sporadic Consumption (shopping)		
	Always %	Never %	To whom (others) %	Always %	Never %	To whom (others) %
Husbands	31.0	15.5	91.7	38.0	5.6	89.6
Wives	71.4	1.0	98.1	32.4	14.3	96.7
Households with Lower Income						
Husbands	33.3	20.0	86.1	33.3	6.7	88.1
Wives	72.7	0.0	98.5	25.8	19.7	96.2
Households with Max. density net1[b)]						
Husbands	31.6	18.4	96.8	39.5	5.3	94.4
Wives	65.5	1.8	100	36.4	12.7	100

Author's computation from PTUS microdata files. [a)] The alternatives are: only to the respondent; to the respondent and to others ('others' in the above table). [b)] Individual who belongs a household which has net1 as network type (see Table 3). The figures must be interpreted carefully because of the sample size.

[33] The questionnaire for children (6-14 years old) did not include the question under analysis.
[34] For this type of families, only 20 observations (10 households) correspond to couples. The remaining answers are pair of parent (mother or father)-children.
[35] Sample characteristics is presented in Table 1.
[36] Idem.
[37] Results (available from author upon request) not presented in this paper.

The difference between both couple members is greater for sporadic consumption than for current consumption. In the lower income households and for sporadic consumptions that difference increases. The households with the maxim density (net1, see Table 3) seem to present slightly shared activity of shopping, in particular sporadic shopping.

Table 7 – Intra-household Reciprocity
Two-Persons Families , Matched Couples
Activity: Sporadic Consumption; Two – Person Household

Type of Dyad N=937 households (1874 individuals); Matched data		
Current Consumption (Shopping)	Total Families N=937 Frequency %	Low income families N=762 Frequency %
mutual dyad D_{hw}=(1,1)	90.5	91.8
asymmetric dyad D_{hw}=(1,0)	2.3	1.5
asymmetric dyad D_{hw}=(0,1)	3.1	2.8
null dyad D_{hw}=(0,0)	3.9	3.6
Sporadic Consumption (Shopping)		
mutual dyad D_{hw}=(1,1)	89.9	92.6
asymmetric dyad D_{hw}=(1,0)	1.9	1.6
asymmetric dyad D_{hw}=(0,1)	3.1	2.2
null dyad D_{hw}=(0,0)	4.6	3.3

Author's computation from PTUS matched data.
The percentages shown correspond to valid percentages.

The majority of shopping activity is done not to the exclusive benefit of the person who shops. Considering all sample, about more than 90% do shopping for others. Considering only the low income families the values have a slight decrease compared with all families, in particular for husbands and current consumption (86.1% against 91.7%). In the households where the network has unitary density (net 1 able 3) , the shopping is done for all the members, which suggest that for more cohesive families the economic activities are also more shared among members. It is likely that the same happens with other decisions of consumption and investment taken inside that type of families.

Current and sporadic shopping has a large reciprocity, about 90% of the persons in the couple do the activity for her/him self and for others. Low income families, the large majority of the families under analysis, reveal identical patterns.

5. Conclusions

The main goal of the paper is apply a methodology based on social network analysis to calculate indicators inside the household, in order to obtain measures which could be applied in empirical studies household behavior.

The results obtained show that network analysis can be applied to intra-household research. The density of the family network seems to affect purchasing behavior of household members and investment in human capital through support of children activities related with

school. Inside more connected families, the support given to children is higher and the decisions about consumption which includes durable goods is more shared between the couple.

The results converge with previous studies about the non homogeneity of preferences inside the family. The preferences by gender and age are different.

The results concerning income influence suggest a null or weak influence in the family cohesion (measure by density index) and in the children school activity support. However the share between each couple member of the activity of *sporadic shopping* seems to be influenced by income, showing husbands in lower income families more weight in the activity when compared with all sample.

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Appendix 1
Network Concepts and Indicators

Graphs and related concepts

A **directed graph** (or **diagraph**) *G* is a pair (*V,E*), where *V* is a finite set and *E* is a binary relation on *V*. The set *V* is called the **vertex set** of *G*, and its elements are called **vertices.** A vertex can represent an individual, a group of individual, a country etc. The research represents each **vertex** as a family member. The vertices are also named **nodes** or **actors**. The last two names are more frequent in Social Sciences and the former in Mathematics, Computational Science and Artificial Intelligence. The set *E* is called the **edge set** of *G*, and its elements are called **edges** (Cormen *et al.* 2005 : 1080). Vertices are also named **points**, **nodes** or **actors**.

In the Figure A1.1a may represent a household and each six circle the household six members. Each vertex is represented by circles and edges are represented by arrows. It is hypothetically based on a question of a time use survey (TUS) about *To whom are you doing Activity i* (e.g. the respondent does shopping to herself and to children), is a pictorial representation of a directed graph on the vertex set {1,2,3,4,5,6}. The edges can represent material fluxes (e.g. doing a *inter-vivos* money transfer, as in the intergenerational transfer models) or immaterial fluxes (e.g. communication of information about the labor market, as in the job search models). S**elf-loops** edges from a vertex to itself-are possible (e.g. shopping for herself, case of actor 2).

Figure A1.1a
Directed Graph – Household with six members
(example: to whom are you shopping)

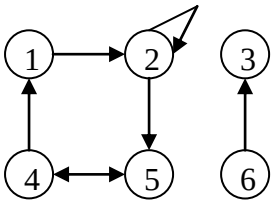
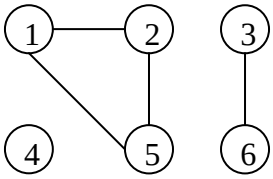


Figure A1.1b
Undirected graph- – Household with six members
(example: with whom are you having meal)



In an **indirected graph** $G=(V,E)$, the edge set E consists of unordered pairs of vertices, rather than ordered pairs. That is, an edge is a set $\{u,v\}$, where $u, v \in V$ *and* $u \neq v$. By convention, the notation (u, v) is used for an edge, rather than the set notation $\{u, v\}$, and (u, v) and (v, u) are considered to be the same edge. In an undirected graph, self-loops do not exist, and so every edge (or line) consists of exactly two distinct vertices.

Figure A1.1b is a pictorial representation of an undirected graph on the vertex set {1,2,3,4,5,6}.(Cormen *et al.* 2005 : 1080), vertices are represented by circles and edges are

represented by lines rather than by arrow as in the directed graphs. It is hypothetically based on a question of a time use survey (TUS) about *With whom are you doing Activity i* (e.g. actor 2 is having meal with other two family members, actors 1 and 5).

Although certain terms have slightly different meanings in the two contexts (directed and undirected graphs) many definitions graphs are the same.

The **degree** of a vertex in an undirected graph is the number of edges incident on it. For example, vertex 2 on Figure A1.1b has degree 2. A vertex whose degree is 0, such as vertex 4 in Figure A1.1b, is named **isolated**. In a directed graph, the **out-degree** of a vertex is the number of edges leaving it, and the **in-degree** of a vertex is the number of edges entering it. The degree of a vertex in a directed graph is its in-degree plus its out-degree. Vertex 2 in Figure A1.1a has in-degree 2, out-degree 3, and degree 5(Cormen *et al.* 2005 : 1081). For example actor 2 does shopping for herself and also for actor 5 and 4 . Actor 1 only does shopping to agent 2.

A **path** or **length** *k* from a vertex *u* to a vertex *u'* in a graph $G = (V, E)$ is a sequence $<v0, v1, v2, ...,vk>$ of vertices such that $u=v0$, $u'=vk$, and $(vi-1, vi)$ belong to E for $i = 1,2,\ldots k$. The **length** of the path is the number of edges in the path. The path is **simple** if all vertices in the path are distinct. Is the case of <1, 2, 5, 4 > in Figure A1.1a**.** The path <2,5,4,5> is not simple. **(**Cormen *et al.* 2005 : 1081)

An undirected graph is **connected** if every pair of vertices is connected by a path. The **connected components** of a graph are the equivalent classes of vertices under the "reachable from" relation. The graph in the Figure A1.1b has three connected components: {1,2,5}, {3,6}, and {4}. Every vertex in {1,2,3} is reachable from every other vertex in {1,2,5}. An undirected graph is connected if it is exactly one connected component, that is, every vertex is reachable from every other vertex **(**Cormen *et al.* 2005 : 1082). Using the question from TUS *With whom***,** the actor 4 is alone, the actors 3 and 6 are together but separate from 1, 2 and 3 actors.

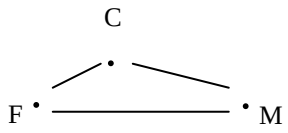
A directed graph is **strongly connected** if every two vertices are reachable from each other. The **strongly connected components** of a directed graph are the equivalence classes of vertices under the "are mutually reachable" relation. A directed graph is strongly connected if it has only strongly connected component. The graph in the Figure A1.1a has three strongly connected components: {1, 2, 4, 5}, {3}, and {6}. All pairs of vertices in {1, 2, 4, 5} are mutually reachable. The vertices {3, 6} do not form a strongly connected component, since vertex 6 cannot be reached from vertex 3**(**Cormen *et al.* 2005 : 1082). Considering the example of an household and the *to whom* question, the four members 1,2,3,5 are a strongly connected considering shopping activity.

Representation of relational data: Adjacency Matrices and Graphs

Relational information can be represented by graphs as well as by the associated adjacency matrices. The Figures A1.2a and A1.2b exemplify both formats. The Figure A1.2a ' the adjacency matrix is symmetrical and all nodes (for example family members, *p* are Father, Mother and Child) are linked. The *t* can represent the time episode between 19:30 and 19:40 and the activity *Ai* can be having meal. To be with someone is obviously an undirected relation.

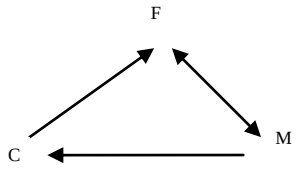
The Figure A1. 2b represents a directed relation, for example *Activity i* can be 'doing shopping'. The surveyed person in a household can be doing shopping for herself (matrix does not show main diagonal) or for other members of the same household (for example children or spouse). Both formats represent the relations during a diary-day: Mother does shopping for Father and Children, Father does shopping for Mother and Children does it for Father.

Figure A1.2a
Undirected relation
respondent is doing Activity i at time t whith person p
Graph and matrix format



	F	M	C
Father	-	1	1
Mother	1	-	1
Child	1	1	-

Figure A1.2b
Directed relation
respondent is doing Activity i at time t to person p
Graph and matrix format



	C	F	M
Child	-	1	0
Father	0	-	1
Mother	1	1	-

Network Measures and Indicators

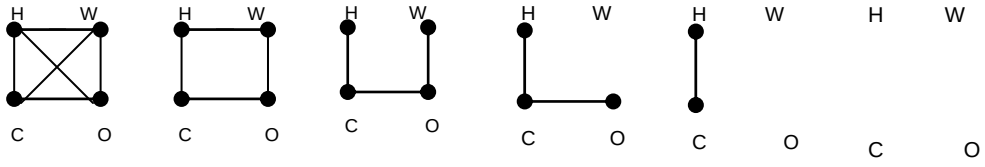
Multiple relational or network measures and indicators can be computed using relational data. Those measures can be associated with one specific actor (node, vertex) or with the network as a whole.

Examples of measures related with one actor (ego-measures), usually associated with the role she/he performs in the network are: in-degree, out-degree, betweenness, centrality, prestige, star, liaison, bridge, gatekeeper, isolate. Examples of measures which describe the

network structure are: size, inclusiveness, component, connectivity/ reachability, connectedness, density, centralization, symmetry and transitivity. Some of these measures are used in the present research and the computation and meaning is explained in the text.

The graphs and measures in Table A1.1 illustrate hypothetical results using relational data included in some time use surveys (TUS). It assumes that the alternatives answers for the TUS' *With Whom* question are: *alone, with children, with spouse* or *with others*. So, the undirected graphs exemplified show four vertices (nodes or actors), husband, wife, children and other. The maximum number of lines (edges) are six, because each individual, represented by a dot, may connect with all except itself. [39] The empirical results for Portugal, organized in a similar way of this Table A1.1, are presented in section 4 of this paper.

Table A1.1 – '*With whom'* Time Use Survey (TUS) questions
Illustrative graphs and network indicators

Undirected graph examples[40]						
Graph number	G1	G2	G3	G4	G5	G6
N. of connected points	4	4	4	3	2	0
Inclusive ness	1.0	1.0	1.0	0.7	0.5	0
Sum of degrees	12	8	6	4	2	0
N. of lines (*l*)	6	4	3	2	1	0
Density	1.0	0.7	0.5	0.3	0.1	0

Legend: H=Husband; W=Wife; C=Child; O=Others.
Note: This Table adapts, considering a family as a network, the general and theoretical network graphs presented by Figure 4.4. in Scott (2000: 71).

[39] For simplification, the category 'Others', is assumed as a sole entity and represented as a node.
[40] The presented graphs are only an illustration of the possible connections, does not represent all possibilities.

Appendix 2
Technical Description of Portuguese Time Use Survey (PTUS)

Table A2.1 Technical Description of the Portuguese Time Use Survey (PTUS)

		Notes
Statistic Entity	Statistics Portugal (INE – Instituto Nacional de Estatística)	
Sampling unit	Individual Household (7 types)	(a)
Instrument	3 instruments (and 4 data files) Diary Individual questionnaire Household questionnaire	(b)
Response rate	87.7% household net response rate	
Number of diary days	1 day (equally distributed by all week)	
Survey period	October, November, December 1999	
Multi-member household survey	Yes Min: 1 member; Max: 2 members	(c)
Age range	6-14 (children questionnaire) 15 and over (adult questionnaire)	
Type of diary	Fixed time slot completed on the day the activities were performed	
Mode of data collection	Self-administered diary	
Time interval in the diary	10 minutes (144 time events/slots)	
Number of activities coded	177 activities (also grouped code)	
Diary Day	Seven days equally distributed	
Data on secondary activities	Yes	
Data on where the activity was carried out	Yes	
Data on who else was present	Yes	(d)
Data for whom the activity was carried out	Yes	(d)
Data on help received from whom	Yes	(d)
Data on help given to whom	Yes	(d)
Data about perception of time	Yes	(e)
N. valid cases in the original files	Individual (NI= 8.133) Household (NHH=5.202)	(f)

Source: Author organization from INE, Statistics Portugal (1999) IOT Methodological Description and 4 datafiles. The Portuguese data are not included in Multinational Time Use Surveys-MTUS database. For similar tables about Technical Description of the Time Use Surveys included in MTUS data base , see Readme .txt file for each country. The

Notes:

(a) There are two different surveys according the age of the respondent.

(b) See Table A2.2.

(c) This characteristics is essential for our network analysis.

(d) See also Appendix 3.

(e) The questions about Perception of time (feeling stressed, etc.) are similar to Canadian General Social Survey 1998 - Cycle 12 Time use (Fontainha 2006).

(f) All the present computations use non-weighted data. Resulting from matching process and control for household size, the sub samples studied are relatively small. The estimates and precision level were computed by Statistics Portugal using a software (SAS-CALJACK) made available to Statistics of Portugal PTUS team by Pierre Lavallée (Statistics of Canada).

Table A2.2 Portuguese Time Use Survey (PTUS) Instruments content

Instruments[(a)]	Main Content
Diary For each time allocation interval of 10 minutes of of each individual, are details are obtained on:	Main Activity; Secondary Activity Activity Place (where) Means of transport Presence (no presence) of other individuals
Individual Questionnaire	Main Job; Secondary Job Occupation [(b)] Time Allocation (intervals and frequency) Leisure/ Recreation Household work (chores etc.) Family care activities Support given to other families Volunteer Work
Household Questionnaire	Family Composition (type; *does not* include household size) Characteristics of residents (age, gender, relation with household representative, level of education) Family support given to other families Characterization of the use of some equipment (TV, personal computer) [(c)] Net monthly Income [sources and amount (intervals)]

Author organization from PTUS documents and files.
[(a)] See Table A2.1 for general Technical Description and Appendix 3 for the main variables discussed in the paper. [(b)] Used as wage proxy in our research. [(c)] One of the main sponsors of the PTUS was a media group (TV channel, newspapers, magazines, etc.). Some topics are related to the participation of that sponsor of the PTUS.

Appendix 3
Relational data and Behavior Decisional data

Table A3.1. Relational and behavior data from Portuguese Time Use Survey (PTUS)

Questions and Associated Variables	Activity	Relation or Behavior
Who was with you? (*"with whom" are you doing the Activity a)* A_{ij}	All the 177 activities	Who/Whom Alone With: Children With Family With Other
"For whom" are you doing the Activity a…	6 activities: Preparing meals; Cleaning; Laundry; Gardening; Administrative tasks; Regular Shopping; Sporadic Shopping	Respondent(self) Spouse Other family Others
Who else participates Child care (frequency, time use, participation of others)	5 activities: childcare, support school child activity, support gym and swimming, paying with children and theatre and cinema, going to doctor	Spouse Other family Employer Others
Who else participates Several activities (frequency, time use, participation of others)	7 activities including shopping current and sporadic (goods and services)	Spouse Other family Employer Others
On which main activity would you choose to spend more time if you could?	14 alternative activities: 1-work; 2- study; 3-household work and family care; 4-gardening and pets; 5-Voluntaree work and religious activities; 6- interaction – meeting with family; 7- interaction - meeting with friends; 8-shows and leisure travels; 9-active sports practice; 10- Hobbies and games; 11- media leisure (includes TV); 12-reading; 13-doing nothing, just resting; 14- Other.	Preferences

Appendix 4
Attribute and relational variables

symbol	***content***
Attribute Variables ***Household***	
fam2	= 1 if a two-member family and a couple (husband and wife); 0 otherwise
fam_3Ch	= 1 if family is a three-member and a couple (husband and wife) with one child between 6 and 14 years old; 0 otherwise
fam_3Ad	= 1 if family is a three-member and a couple (husband and wife) with one adult child with 15 or more years old; 0 otherwise
inc_m	categorical variable main income source (1-wages; 2=independent work; 3=pensions; 4 welfare benefits; 5= capital and assets profits/income)
inc_wg	= 1 if wages are the main source of family income
inc	= net monthly income (categorical, ordered,9 levels)
inc_L	= 1 if family income is lower than 898 euros per month; 0 otherwise
Attribute Variables ***Individual***[41]	
age	age (in years)
`ini_ind`	educational level (categorical, ordered , 7 levels)
edu_bas	= 1 if educational level is Basic or lower (corresponds 4 or less years) ; 0 otherwise
emp_st	employment status (categorical, 8 status)
empl	= 1 if employment status is Employed; 0 otherwise
dome	= 1 if employment status is Domestic; 0 otherwise
stud	= 1 if employment status is Student; 0 otherwise
pens	= 1 if employment status is Pensions; 0 otherwise
wager	=1 if the employer is receives wage
occu	Occupation, main job (categorical, 10 categories)
occ_b	= 1 if employer has a blue-collar occupation , main job ; 0 otherwise
Relational Variables	
Individual *Whith whom variables*	
alone	time spent alone (in minutes per day)
wchil	time spent with children (in minutes per day)
wfam	time spent with family member not child (in minutes per day)
wo	time spent with other (in minutes per day)
wat	time spent alone and with someone (in minutes per day)

[41] All the variables are computed for each of the sets: husband, wife and children. The symbol prefix is *hu*, *wi* and *ch*.