Investigating long-term lifestyles changes in France: a statistical and modelling approach

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Abstract

As lifestyles relate to our ways of “doing”, “having”, “using” and “displaying”, our behaviour and all of the related products, objects and infrastructures (Røpke, 2009), they are both a broad and complex object of thought and a key determinant of the sustainability of our societies. Conducted in a qualitative way, the analysis of future lifestyles offers great freedom to imagine dramatic changes of societies and to explore paradigm shifts. These changes could result from the widespread of various existing behaviours considered today as weak signals or from the emergence of social movements of great magnitude. Performing a quantitative analysis is less straightforward and could be conceptually questioned. Yet for the specific problem of sustainable lifestyles a quantitative approach can help ground the scenarios not only on technical solutions but also on elements of lifestyles change. What is missing is a quantitative method to define the possible long term impact of lifestyle change on mobility, housing and consumption patterns. In this paper we introduce a statistical model that we developed especially to address long-term lifestyles changes and their consequences on the consumption of goods and services and on the energy services demand in France. We make use of national mobility housing and consumption surveys to identify significant patterns. We propose a model of their diffusion in the long term according while also taking into account the demographic changes. Our contribution is organised as follows: we first describe the statistical model and the surveys; then an application to future societal trends is proposed in a prospective approach. A set of lifestyles anticipated for France in 2050 that explore various changes are considered. Finally we aim to discuss the contributions and limitations of the proposed quantitative model and how it can fit into futures thinking.

Keywords: lifestyles, consumption, energy consumption, foresight, transition

1. Introduction

Since the Rio Earth Summit in 1992 there has been an increased recognition of the role of societal changes in achieving a sustainable society. A typical quantitative technical and economic analysis will stress factors such as efficiency, carbon content of energy flows and costs or GDP; whereas a societal and lifestyle perspective will put the emphasis on the potential or barriers to a wider diffusion of sustainable practices in a society, and seek a stronger engagement of consumers or citizens to reduce the footprint of our lifestyles while avoid adverse rebound effects. Just as lifestyles relate to our ways of “doing”, “having”, “using” and “displaying”, our behaviour and all of the related products, objects and infrastructures (Røpke, 2009), they are the logical background of our ordinary energy uses and yet remain a broad and complex object of thought. As such understanding they role as a levy towards more sustainable society is essential. Furthermore, when looking forward by 2050 and beyond we are not irreversibly locked in an unchanging set of social patterns or lifestyle: the future decades could either be a movement towards a more energy intensive techno-society or a society with different degrees of sobriety. Conducted in a qualitative way, the analysis of future lifestyles thus offers great freedom to imagine dramatic changes of societies and to explore paradigm shifts. These changes could result from the widespread of

various existing behaviours considered today as marginal or emerge from original social movements of great magnitude.

Yet a scientific and systematic treatment of lifestyle remains an emerging research field that encompasses several disciplines and multiple concepts. Starting from the abundance of the literature on consumption, (Jackson, 2005) challenges the idea that consuming more always increases the welfare against the alternative understanding of consumption as a "social pathology". Beyond a criticism of "utilitarism" this work proposes grounds for a strong rehabilitation of a more complex understanding of the formation of needs than what is embedded in conventional consumers' preferences. The SEI (Kate Scott, 2009) report adopts a more practical and tool box approach and proposes a transversal description of some key themes and methodologies used to investigate either sustainable alternative lifestyles or, with a more restrictive focus, sustainable consumption. The UNEP's survey also provides evidence of differences and similarities in the declared priorities of young adult's across the world. Though the sample might not be fully representative, this report gives multiple qualitative views on the aspirations associated to the notion of sustainable lifestyles (UNEP, 2011). Similarly the SPREAD project offers a comparable exercise centered on Europe (Kuittinen et al., 2012) where participants to several workshops imagined a sustainable lifestyle in Europe in 2050 with the target of 8000 kg as material footprint per year and per person. The challenge of supporting sustainable consumption practices is addressed in (Jaeger-Erben et al., 2015) through a review and typology of several practical examples and, in (Shao et al., 2016) with an attention on the availability of information on products attributes to consumers for a better informed purchase decision. In UK, the sustainable lifestyle approach of DEFRA (Eppel et al., 2013) provides a strong case of a government agency's effort to understand and promote sustainable behaviours and lifestyles. The proposed segmentation in population groups reveals the differences in willingness to engage in more sustainable behaviours and shows for instance that the two extreme groups of "Positive Greens" and "Honestly Disengaged" have similar size. In France (Le Gallic et al., 2014) the iterative and participative process described in (Emelianoff et al., 2012) provides a comprehensive description of five possible future lifestyles defined within the PROMOV project.

This overview of the growing and diverse literature on sustainable lifestyles or sustainable behaviours illustrate that the challenge has been a better understanding of the process of behavior itself, its psychological (values, meaning) or societal (social pressure, collective practices) dimensions, and possible governance schemes. This is done through both conceptual frameworks and practical case studies. Quantitative scenarios of future lifestyle have received less attention mainly because a shared understanding of the boundaries and meanings of lifestyle does not exist. In this paper we propose a numerical model to project alternative social practices (mobility, housing and equipment levels) on the long term in France. It is intended as a dialog tool to bring assumptions formulated as lifestyle change in a form useable for techno-economic analysis and thus bridge the two approaches. A model cannot of course replace the cognitive, human and imaginative value of workshops such as the co-construction workshops cited above. Its interest should be seen as a complementary tool and one that can lightly explore alternative variants. We adopt a macroscopic perspective on social practices and quantify them using existing large scale statistical surveys. Compared to the literature on sustainable lifestyles our focus is put on the impact of changing lifestyles (more sustainable or not) on the demand for energy services. Longer term lifestyle transformation have explicitly been proposed in (Mont et al., 2014) for Europe based on visions drawn from expert groups and a specified sustainability target. Using the information contained in current surveys, our core assumption is that the distribution of practices among the population captures the heterogeneity of practices. The proposed quantitative scenarios are of course exploratory and should not be considered as an attempt to "predict" future lifestyles. Section 2 presents the methodology while section 3 provides some illustrative results on different dimensions.

2. Methodology

2.1. Surveys as a substrate for a quantitative approach of social practices

Our aim is to investigate the consequences of future lifestyles changes on the energy services demand in France, i.e. on the housing demand, on the demand for mobility and on the consumption of goods and services. In order to achieve this goal, we need a quantitative approach of lifestyles. This constitutes a delicate task given that they are related to both qualitative and quantitative dimensions and to both conceptual and practical dimensions. Lifestyles are multifaceted and are marked by our relationships to time, to space, to others, and to ourselves (Héraut, 2013). Nevertheless, they have a visible resultant in the individual and collective practices in a broad sense. It is through these practices that we intend to somewhat "capture" lifestyles traits and apprehend them through data from French national surveys. Most of the surveys are conducted periodically every five to ten years providing a valuable material for foresight.

Five national surveys were used in order to cover several dimensions of social practices: the population census, the Housing Survey, the National Transport and Travel Survey, the time-use survey and the household budget survey. A short description of their goal, their scope, the existing editions and the size of the samples is provided in Table 1. We used the latest available edition of each of these surveys (except for the population census) to establish a baseline on current practices.

Table 1. Short description of the five used national surveys.

Name	Time use survey	Housing Survey	National Transport and Travel Survey	Household budget survey	Population census
Purpose	To collect accurate information on the use by individuals of their time	To collect comprehensive and accurate data on the housing stock and the conditions of occupation by household	To improve the knowledge of mobility of the households living in France	To study the household expenditure and income at a microeconomic level	To know and follow the evolution of the population of France, in its geographic diversity and its evolution
Editions	1966-1967 1974-1975 1986-1987 1998-1999 2009-2010	1955, 1961, 1963, 1967, 1970, 1973, 1978, 1984, 1988, 1992, 1996, 2002 et 2006, 2013	1966-1967 1973-1974 1981-1982 1993-1994 2007-2008	1979, 1984, 1989, 1995, 2001, 2006, 2011	Since 1801 Every 5 to 9 years from 1801 to 1962 Harmonized data : 1968, 1975, 1982, 1990, 1999, 2006 to 2012
Edition used to establish a reference	2009-2010	2006 *(The latest edition is available since March 2016 and was not used for the first version of this paper)*	2007-2008	2011	2009
Main scope	The survey detail use of time of individuals from the description of two complete days by individual surveyed (use of notebooks)	Nationally, this is the major statistical source to describe the housing stock and the conditions of occupation by households of their primary residence. *Only ordinary*	The survey investigates short and long distance mobility, the use of individual and collective means of transport.	The survey is providing detailed data on all kind of expenditure (including expenditure which are not goods and services; e.g. taxes) and income of individual and household surveyed.	The census provides information on population and housing: gender, age and origin, marital status and place in the household, diploma and place of study, occupation, place

		dwelling is concerned.		*(Only ordinary households)*	of work and mode of transportation, previous residence, housing conditions, location.
Sample of the last edition	≈28 000 notebooks ≈18 000 individuals ≈12 000 households	≈43 000 households ≈43 000 dwelling ≈110 000 individuals	≈45 000 notebooks ≈19 000 individuals ≈19 000 households	≈41 000 individuals ≈16 000 households	All the population is concerned

Each survey includes several variables that provide directly two types of information: information on individual (or household) characteristics and information on their practices. For example, the National Transport and Travel Survey household contains a set of variables describing individual daily mobility (e.g. number of trips, distance, means of transport, aim) and a set of variables describing the individual (e.g. gender, age, situation) and his or her household (e.g. size, composition, age of the household reference person). A key step of our approach is to select a set of variables to build a representation of the people and their lifestyles. The Table 2 reports the types of variables that we used to address the different dimension of lifestyles and the questions addressed by each set of variable.

Table 2. Types of variables used to build a quantitative representation of "people and their lifestyles" and their availability in each survey. *Legend: "+++" means "comprehensive data is available"; "++" means "partial data"; "+" means "a few information"; an empty cell means "no information available".*

	Types of variables	Surveys				
		Time use survey	Housing Survey	National Transport and Travel Survey	Household budget survey	Population census
Who are they?	age, gender, activity status	+++	+++	+++	+++	+++
With whom do they live?	household size and composition, incomes	++	++	++	++	+++
Where do they live?	type of urban space	+++	+++	+++	+++	+++
What do they do?	frequency of different kind of activities and time spent	+++		+	+	
Where do they do it?	location of activities (at home, at work, …), to-face or virtual activity	+++		+++		
What do they have?	ownership of equipment, vehicles, furniture	++	+	+	+++	+
What do they consume?	volumes of each type of goods and services				+++	
How do they inhabit?	building type, dwelling size	+	+++	+	+	++
How do they move?	number of trips, distance and means of transport	+		+++	+	
How do they travel?	location, frequency, duration			++	+++	

By analyzing the surveys, we accede to the information which is contained in the correlation between variables. For example people aged 75 and older make an average of two times fewer trips per weekday than the rest of the population (see Figure 1). This reflects the process of biological and social ageing, i.e. it is more and more common for people beyond 75 years to experience physical discomfort to move/get around on one hand and to see their social networks decrease on the other hand. A different lifestyle characterized by an enhanced social participation or physical capability of this group with time, coupled with the change in population structure could then influence the total trip demand. Another example is given by the correlation between the size of household and the floor space per person in a dwelling (see Figure 2). This correlation reflects the process of space sharing which has a consequence on space needs. To give a concrete application of this process: if several types of rooms could be considered by most of people as a "need" in a dwelling (e.g. kitchen, bathroom, living-room), one of these type of room per household/dwelling is most of time considered as enough.

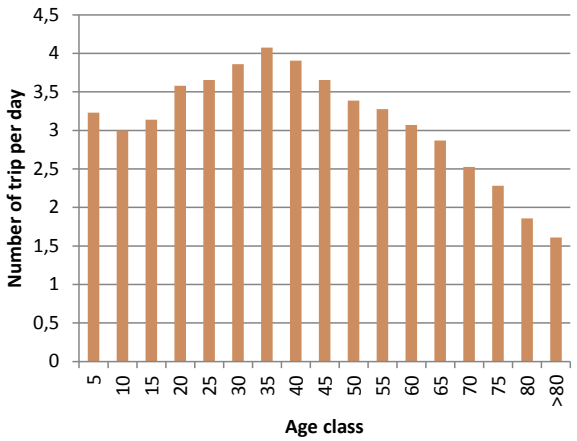


Figure 1. Number of trips per age. Data source: National Transport and Travel Survey 2007-2008.

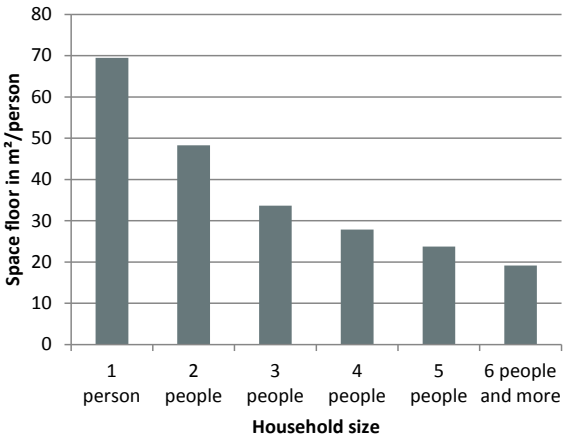


Figure 2. Floor space per person depending on household size. Data source: Housing survey 2006.

2.2. Principle of the modelling approach

A survey basically consists of a matrix in which each row represents an individual and each column represents a variable. Some of the variables might describe individual or household attributes (e.g. age, gender), while others describe practices (e.g. number of trip per day per purpose, time spent at home per day). In its generic form a cell of coordinates (i, j) contains the value or the modality of the variable j for individual i. Classification methods then allow for the identification of groups of individual according to the modalities of the variables used as basis for the segmentation. Finally we use the correlations between variables of the surveys as descriptor of social practices. These correlations are thus interpreted as the statistical manifestation of a combination of biological, psychological, cultural, juridical, geographical, demographical or economic processes. They are formalized in correlation matrices whose form is illustrated in Figure 3.

	$z = z_1$	...	$z = z_r$
$\begin{cases} x = x_1 \\ y = y_1 \end{cases}$	$\rho(z = z_1)_{x=x_1 \& y=y_1}$	...	$\rho(z = z_r)_{x=x_1 \& y=y_1}$
...	...	...	...
$\begin{cases} x = x_m \\ y = y_n \end{cases}$	$\rho(z = z_1)_{x=x_m \& y=y_n}$	...	$\rho(z = z_r)_{x=x_m \& y=y_n}$

Figure 3. Form of a correlation matrix. The response variable $\mathbf{z}$ is categorical and has $\mathbf{r}$ modalities. $\mathbf{x}$ and $\mathbf{y}$ are the explanatory variables which have respectively $\mathbf{m}$ and $\mathbf{n}$ modalities.

In this example, one categorical variable – called $\boldsymbol{z}$ and which have $\boldsymbol{k}$ modalities – is analyzed in relation to two explanatory variables – called $\boldsymbol{x}$ and $\boldsymbol{y}$ and which have respectively $\boldsymbol{m}$ and $\boldsymbol{n}$ modalities. Each row represents an unique combination of modalities of $\boldsymbol{x}$ and $\boldsymbol{y}$, in a group and each column represents one modality of the variable $\boldsymbol{z}$. The cells contain a value $\boldsymbol{\rho}$ that is the frequency of a modality for one couple of values $(\boldsymbol{x}, \boldsymbol{y})$. If $\boldsymbol{z}$ is a categorical variable, the cells contain the percentage for each modality; if $\boldsymbol{z}$ is numerical, the cells contain a statistical measure (e.g. mean, percentage of cases between two values). The distribution consistency is checked (Equation (1)) for any couple $(\boldsymbol{i}, \boldsymbol{j}) \in [\![\mathbf{1}, \boldsymbol{m}]\!] \times [\![\mathbf{1}, \boldsymbol{n}]\!]$.

$$\forall (i,j) \in [\![1,m]\!] \times [\![1,n]\!], \sum_{k=1}^{r} \rho(z = z_k)_{\boldsymbol{x=x_i \& y=y_j}} = \mathbf{1} \qquad (1)$$

The statistical approach we propose uses dynamic population and practice matrixes as markers of lifestyles. Its practical starting point is a basic matrix containing a future population pyramid (which is extracted from demographic projections), i.e. only two variables are described: age and gender (an indication of the region could be added). The other variables are added one by one thanks to the correlation matrices. The Figure 4 illustrates the principle of adding a variable to the population matrix. In this case, adding a variable to this matrix increases the number of rows by a factor r (r is the number of modalities of the added variable, z). The population matrix (a) has two variables (x and y). Analyzing the correlations between z (as response variable) and (x,y) (as explanatory variables) provides the correlation matrix (b). These two matrices are combined to create the population matrix (c) which disaggregates each row of (a) in k rows (for the k modalities of z) using the frequencies of the matrix (b). This elementary operation is included in a sequential process starting from the basic population matrix (population pyramid) and leading to a more comprehensive population matrix including several variables describing the future population and its lifestyles.

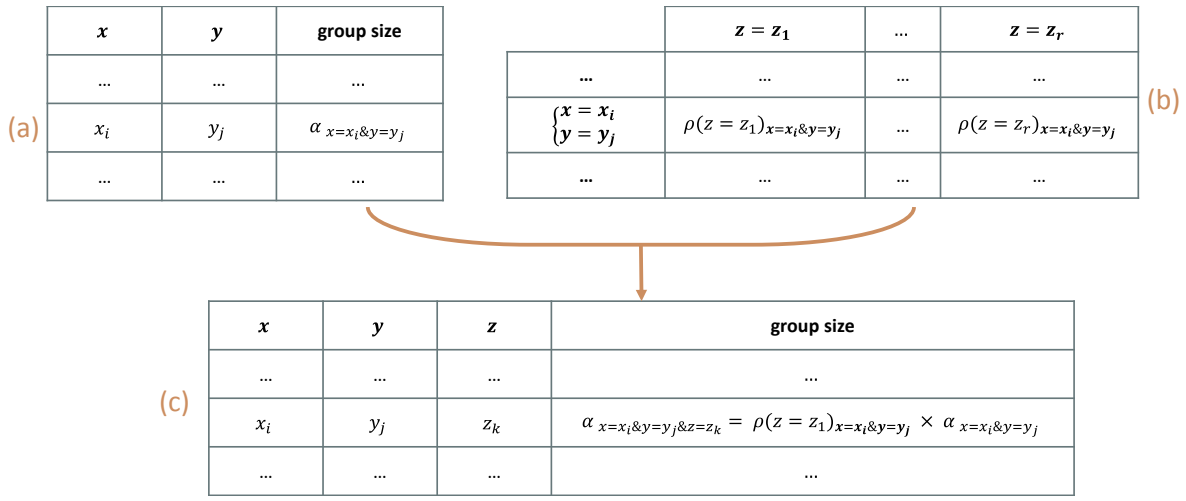
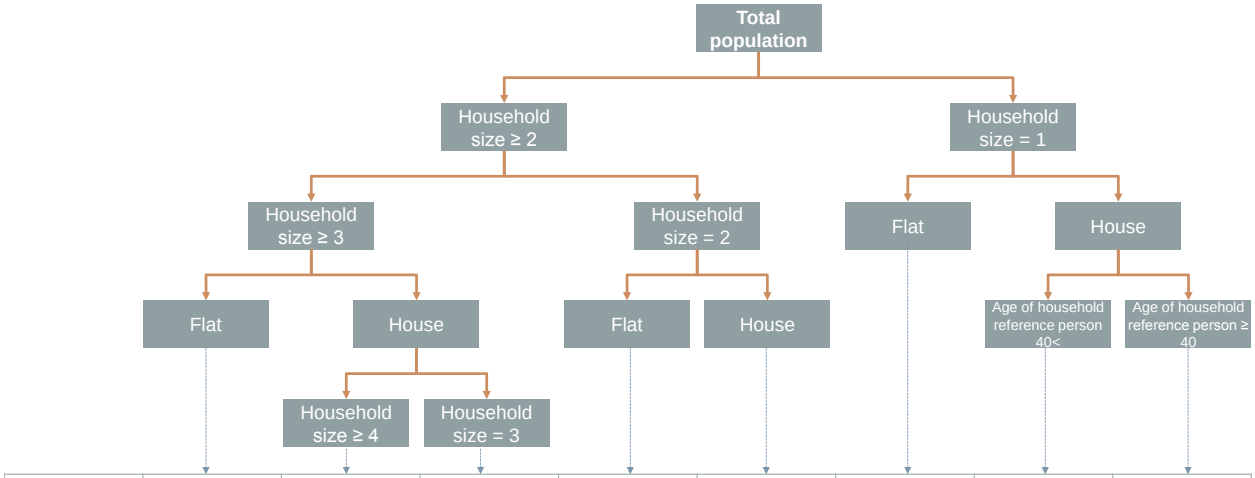


Figure 4 : Example of adding a variable to the statistical model.

Among the available methods to report the correlation between variables, we used decision trees. Firstly this method allows dealing easily with a mix of numerical and categorical covariates. Secondly the implemented process provides a great flexibility, especially in the selection of variables that are taken into account. Decision trees use numerical categorization to build descriptors or predictors from a data source and are commonly used in data mining. In our case, they are used to group individuals with relatively homogeneous practices or situations with regard to a given variable. The practices or situations of each group are then characterized by standard statistical analyses (e.g. mean, distribution). This method - providing clarity and flexibility - also allows us to control the size of the formed groups to ensure their statistical significance. We use the RPART routines (as “Recursive PARTitioning”) available in R to build the decision trees (Breiman & al., 1984) and (Therneau and Atkinson, 2015).

The Figure 5 is showing an example of classification tree and its associated correlation matrix. In this example, the response variable is the space floor per person. The explanatory variables are the age of the household reference person (5-years classes), the household size (6 classes: 1

person, 2 people, 3 people, 4 people, 5 people, 6 or more), the location of the dwelling (4 classes: rural area, urban area of less than 100 000 inhabitants, urban area of more than 100 000 inhabitants, urban area of Paris) and the building type (2 class: apartment or flat). In this example, we have limited the recursive partitioning to 8 parts. The most explanatory variable is the household size. The sample is split into 2 groups: single-person-household and the others. Each group is then further split in subgroups using the most relevant criteria. Figure 5 also reports the mean and standard deviation of floor space per individual of each group.



Mean	20 m²	28 m²	38 m²	33 m²	55 m²	44 m²	61 m²	93 m²
Standard deviation	8 m²	10 m²	15 m²	13 m²	23 m²	20 m²	22 m²	40 m²

Figure 5. Regression tree related to the space floor per person and its associated matrix. Data source: Housing survey 2006 for France.

2.3. Representing prospective changes in lifestyles indicators

We turn now to the critical question of the dynamics of our lifestyle indicators. Over several decades different social mechanisms can indeed lead to changes over time in the pattern of aggregated practices in a society (here at national level). Firstly we can mention demographic changes and the reconfiguration of the population structure. If it can be argued that there are as many original lifestyles as there are individuals, we can also identify some age based groups with relatively homogenous practices. Changes in the relative sizes of these different groups – all things equal otherwise – would also change the aggregate collection of lifestyles. Population pyramid and revenue distribution are some examples of such structural elements that will evolve in the future and potentially modify the dependent practices. Secondly we can mention some more progressive social changes such as changing in perception of societal priorities (awareness for the environment during the last decades), or new social trends such as remote activity (teleworking, teleshopping, teleconferencing) or the development of a leisure economy. Thirdly some changes are essentially disruptive and can be perceived as radical changes with fast rates of adoption. They can be triggered by unexpected economic crisis reducing brutally the wealth to share in a society, or can originate from a massive spread of new forms of social practices enabled by wider access to new social networking capabilities (car ownership, internet). In our approach they are treated as scenarios. The main principle is to convert narrative assumptions of change into quantitative practice changes in frequency in one or some of the correlation matrices. The Figure 6 depicts this simulation process where some changes are introduced through the replacement of reference matrices by modified matrices.

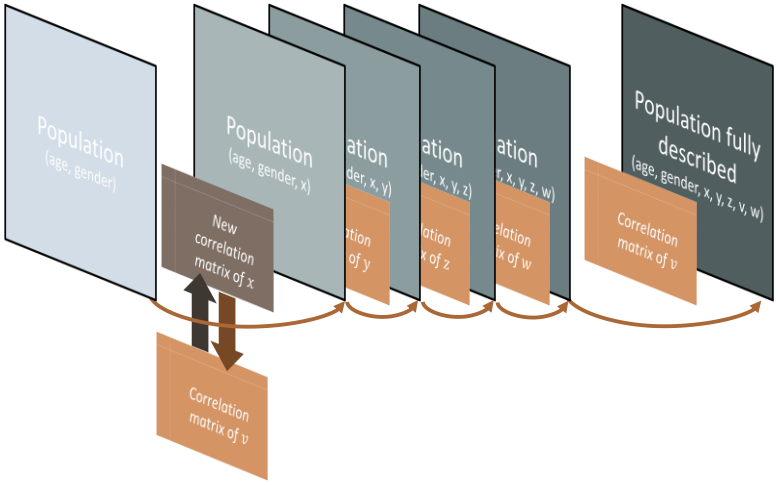


Figure 6. Illustration of the process of changing matrices. In this generic case, the correlation matrix of **x** is changed.

3. Results

Using the methodology presented above we tested the influence of lifestyle changes on housing demand, mobility needs and demand for selected goods in France. Our scope is 2050 and includes people living in Metropolitan France and belonging to a household1, representing about 92% of the whole population living in the French Republic. The housing demand is expressed in terms of number and type of dwellings, and the surface area which are the key determinants of the energy demand both at the household and country level (Maresca & Dujin, 2014). The short distance passenger mobility is assessed through the number of trips made per year, the purposes of these trips, and the corresponding total distance. This structures the social network and the relation to space. The demand for selected goods concerns private cars, household appliances, digital equipment, computer equipment and audiovisual products.

3.1. Scenarios description

We highlight here four types of characteristic factors to concretely illustrate the proposed statistical model. The first one is the evolution in the household composition resulting from different cohabitation practices and more generally from changes in the relationship to others and to oneself. The second one is the changes in the location of the dwelling resulting from the societal appeal to metropolitan, urban or rural lifestyles. The different options include rural areas, urban areas of less than 100 000 inhabitants, urban areas of more than 100 000 inhabitants, and the urban area of Paris. The third one deals with the structural determinants of time use: sharing between work, leisure, sociability and other activities. The fourth one addresses the relationship to the space and sharing between real and virtual activities and also the part of each activity which is carried out at home or outside. These key dimensions are combined in three lifestyle scenarios exhibiting contrasting hypotheses of change (Table 3). They are inspired from a set of five lifestyles anticipated for France in 2050 and defined by (Emelianoff et al., 2012):

- The first scenario is a *business as usual* scenario. The household size continues to decrease as a result of the ageing population. The preference for houses continues to feed the urban sprawl. The main structure of time use is similar to the current one, *i.e.* especially work or study structure the organization of the week for most people.
- The second scenario called “individual and virtual society” consider a more individualistic and performance oriented society. The will of performance and personal development drives most people to live alone, without constraints of others. To access to the most sought leisure and services, they live in large cities in small apartments. More and more activities are carried out virtually: work, social relations, shopping… Individuals pay great attention to their home where they spend a lot of time.

[1] *i.e.* excluding for example people living in caserns or in retirement home.

- The third scenario called “social link society” is radically different. Social ties are placed in the heart of the society and its organization. It results in widespread forms of group housing. The relationship to time also changes and productive work gradually loses its structural role towards social tasks and civic activities.

Beside the three scenarios, the current situation is depicted as a reference. Demographic changes in volume and structure for the three scenarios is based on the central projection of the National Institute of Statistics and Economic Studies for 2050 (“Insee projection”). In this scenario the population size is increasing by 16% relatively to 2010 one and reaches 70.3 billion in our scope. In addition, the population ageing changes the age structure of the population between the current situation and the three scenarios.

Table 3 : Summary of the hypotheses distinguishing the three scenarios

	Business as usual	**Individual and virtual society**	**Social link society**
Demography	INSEE projection Central hypotheses	INSEE projection Central hypotheses	INSEE projection Central hypotheses
Household composition, relation to others	Current practices	More individual society Individual households are the norm.	More collective society Extended households and families are the norm
Location of the dwelling	Current practices	Very strong attraction for metropolitan area to the detriment of rural areas in particular	Attraction for urban area and densification
Time use	Current practices	Current practices	3 work days instead of 5, but 2 days devoted to social tasks and civic activities More emphasis on sociability activities
Location of activities, relationship to space	Current practices	Most of the time at home The share of virtual activities increases	Current practices

3.2. Housing demand

The household is the driver for the housing demand in our modelling approach. Its composition (size, number of adults and children, age and situation of its members) will influence its aspiration in terms of location, type of dwelling and surface area. The current links between these variables are considered through their current correlations. The size and composition of the housing stock resulting from the simulation of the three scenarios varies significantly (see **Figure 7**). Firstly, the cohabitation practices have a great influence on the number of dwellings needed. The dynamics of the size of household is given in (Table 4).

Table 4: Dynamics of size of households for the three scenarios. B = business as usual; I = individual and virtual society; S = social link society.

	2010			**Dynamic: average annual rate**			**2030**			**2050**		
Scenario	*B*	*I*	*S*	*B*	*I*	*S*	*B*	*I*	*S*	*B*	*I*	*S*
1 person	14%			0,00%	2,7%	-0,4%	14%	27%	13%	14%	40%	12%
2	28%			0,00%	0,3%	-0,7%	28%	30%	25%	28%	31%	21%

3	19%	0,00%	-0,6%	-0,1%	19%	17%	19%	19%	15%	18%
4	22%	0,00%	-2,5%	-0,8%	22%	15%	19%	22%	8%	16%
5	11%	0,00%	-2,5%	0,2%	11%	8%	12%	11%	4%	12%
6 and more	6%	0,00%	-2,7%	3,2%	6%	4%	14%	6%	2%	21%

The preference for living alone in the "individual and virtual society" thus results in a need for about 42% more dwellings than in the "business as usual" scenario where the demographic effect conducted to an increase of 18% compared to the current situation. The will for more collective housing practices in the "social link society" involves that the size of the housing stock remains stable. However, changes in its composition would result in needs for housing construction or conversion. In this scenario, the main demand would concern the large apartments in urban area would be whereas the "individual and virtual society" scenario would strongly increase the demand for small apartments in big cities.

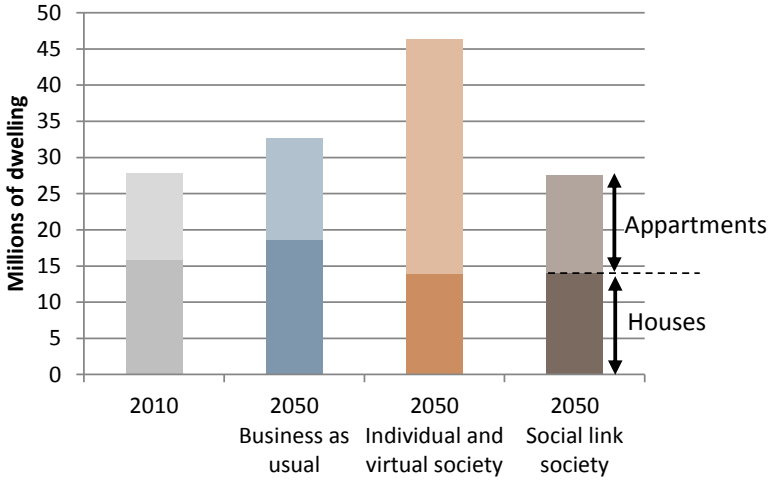


Figure 7 : Size and composition of the housing stock for the current situation and the three scenarios. The lowest (and dark) part of the bars is for houses, the upper (and clear) part is for apartments.

In terms of surface, two effects influence the results (see **Figure 8**). On one hand, the share of space is accentuated in the "social link society" scenario contributing to a decrease of 8% of the mean surface area per person. Conversely, in the "individual and virtual society" scenario, the share of space is reduced contributing to the increase of 27% of the mean surface area per person. On the other hand, the preference for urban or metropolitan area in these two scenarios contributes to reduce the demand for surface area per person. This simulation thus reflects the highest pressure on space and on the housing market in dense areas. A small increase of the surface area per person is also visible in the business as usual scenario resulting from the single demographic effect (population ageing).

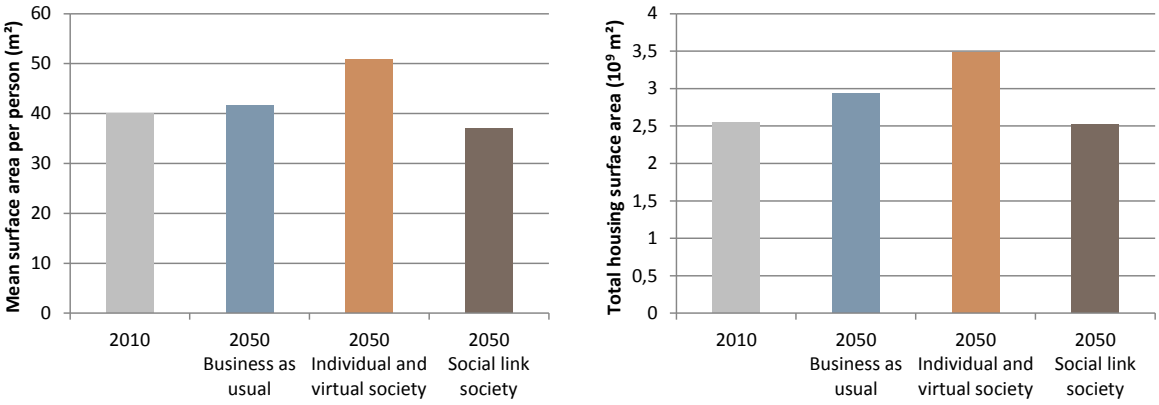


Figure 8 : Mean surface area per person and total housing area for the current situation and the three scenarios.

The use of these three scenarios demonstrates the influence of lifestyles changes on the housing demand. These aggregated results may be useful for understanding their influence on the construction sector, on the urban dynamic or on the energy demand - which depends on the total surface area to be heated. More detailed results are available, for example an assessment of the housing demand per size of dwelling. But especially, depending on the goals in which the model is used, it would be interesting to explore more comprehensive scenarios, taking into account other type of lifestyle changes.

3.3. Demand for specific goods

We now consider the impact of our consumption of goods and services for cars, household appliances, digital equipment, computer equipment and audiovisual products. Whereas many other factors could be introduced for clarity we focus here on couple of them:

- The composition of households which reflects the effect of sharing goods at the household level – note that some other hypotheses could be defined to simulate the effects of sharing at a district, apartment building or community level.
- The location of the dwelling which is a key determinant of the need for car to move around. The changes in age structure of the population could be mentioned as a third impact visible when the current situation and the business as usual scenario are compared.

The lifestyle assumption has a significant effect on the size of the car stock (see Figure 9). The increase of 24% of the car stock in business as usual scenario compared to the current situation show that the effect of changes in age structure of the population is not negligible (compared to the increase of 16% of the population size). Comparatively the “social link society” scenario combines the effects of car sharing at the household level and of a more urban society resulting in an increase of only 4% compared to 2010. The dynamics of location is given in (Table 5). Finally in the “individual and virtual society” scenario, the downsizing effect of location of household is largely compensated by the reduction of car sharing at household level due to the substantial increase of the number of households and a more individualistic approach.

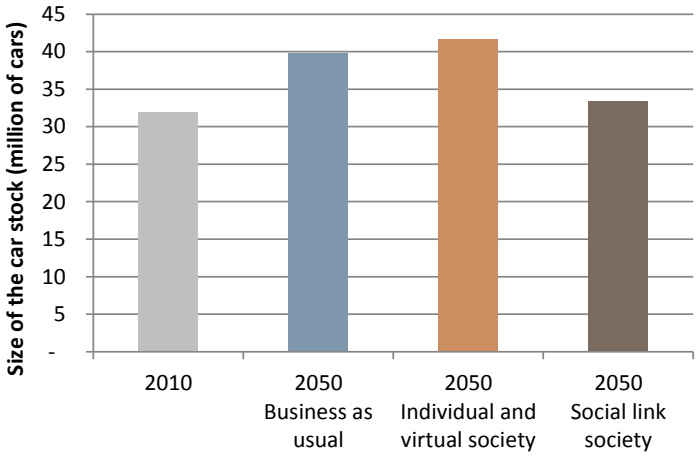


Figure 9 : Size of the car stocks for current situation and the three scenarios.

Table 5: Dynamics of location of the households for the three scenarios. B = business as usual; I = individual and virtual society; S = social link society. Expressed in percentage of households in each area.

	2010			**Dynamic: average annual rate**			**2030**			**2050**		
Scenario	*B*	*I*	*S*	*B*	*I*	*S*	*B*	*I*	*S*	*B*	*I*	*S*
Rural area	23%			0%	-2,3%	-0,3%	23%	16%	22%	23%	9%	20%

Urban area of less than 100 000 inhabitants	30%	0%	-0,9%	-0,5%	30%	26%	28%	30%	21%	25%
Urban area of more than 100 000 inhabitants	30%	0%	1,0%	0,7%	30%	38%	35%	30%	45%	39%
Urban area of Paris	16%	0%	1,1%	0,0%	16%	21%	16%	16%	25%	16%

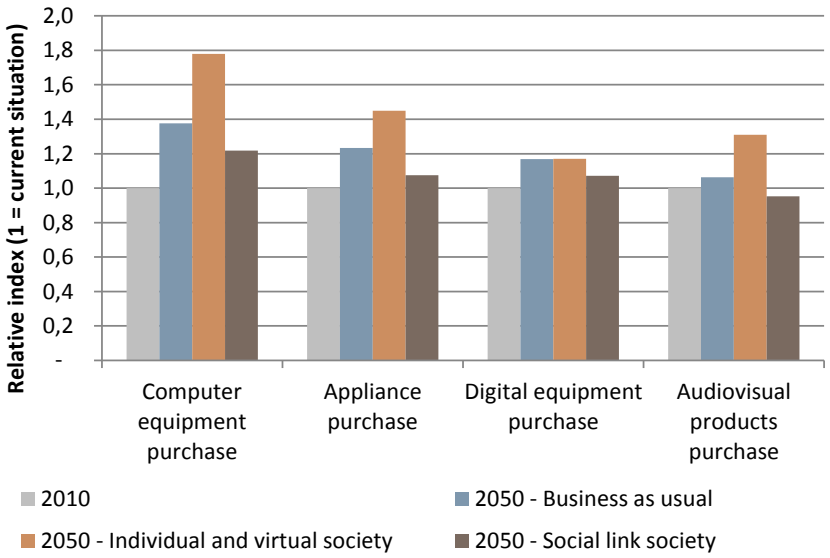


Figure 10 : Consumption of four types of durable goods in the current situation and the three scenarios (using relative quantitative index)

The other durable goods analyzed are also well anchored in our current society. While disruptive technological innovations could make them obsolete they have deeply integrated our practices and activities (leisure, productive work and domestic work). Figure 10 shows that for these goods and independently of the scenario, a significant reduction below today's levels is not at reach without targeting our practices. Here, the household composition and the associated sharing at household level are the main explanatory effect. The simulated scenarios do not outline a path towards a straightforward material sobriety but without efforts to better understand lifestyle related drivers (and their differences depending on the types of goods) we can miss 10% to 20% of reduction relatively to a "Business as usual" case. These differentiated outcomes illustrate the usefulness of a model to quantitatively challenge how far our initial narratives go. More complex scenarios, including changes in relationship to space (e.g. extent of the area where is organized the everyday life) or property (an increase of the sharing practices at community or building level and not only at household level) for instance could then be envisioned as extension to the present scenario set.

3.4. Needs for short distance mobility

Trips are not performed for themselves but to reach a desired location where an activity of interest is performed. In this section, we now discuss the social practices in terms of short distance mobility (and associated purposes) and as lifestyle markers for our scenarios. This relates to the dimension "ways of doing". Besides the household composition and the location of the dwelling the additional explanatory force highlighted here is the use of time (see also Table 3).

The "social link society" scenario tests such a structural change inspired by one of the five scenarios described by (Emelianoff et al, 2012).In this society, time spent on productive work decreases by 40% for workers, representing three days a week. This has two consequences: the number of unemployed is reduced and most people spend two days in social tasks and civic activities. It also involves a reduction of the number of commuting for work, which are replaced by travels for the new practiced activities.

Furthermore information and communications technologies change our relationship to space, leading to new arbitrages between real and virtual activities (work, leisure, learning, shopping). In "individual and virtual society" this share is largely moved towards more virtual activities. The withdrawal leads most people to prefer spending more time at home. The equivalent of 40% of full-time workers work from home, pupils and students spend 40% percent at school, two-thirds of purchases are made online, an increasing part of the sociability and leisure activities are carried out from home…

The simulated impacts of these assumptions at a macroscopic level are illustrated in (Figure 11 and Figure 12). A first result is that compared to the 16% increase of population, the evolution of the number of travels (+3%) and of the total distance (+2%) are low, highlighting the effect of population ageing on the reduction of the intensity of practice in a "Business as usual" case. Here again altering this lower intensity of practice with further assumptions on good health and "socially reconnected aging" could be a potentially disruptive change. While this topic is beyond the scope of this paper, (Moisescu, 2014) and (Lumme-Sandt, 2011) illustrate this better ageing potentially disruptive evolution of old age lifestyle. The second main effect is that the virtualization of the society results in a drastic reduction of the short distance mobility (-41% by number of travels). In this scenario, our hypothesis does not consider any rebound effect linked to a resource given that the virtualization is the result of a will to stay at home. Here a parallel with the private car stock indicates that while owning a car remains a strong individualistic aspiration, the higher virtualization decouples this aspiration and a regular use. In this "private car for exceptional trips" world, the material and energy footprint of transportation could be less correlated. Thirdly and conversely, the release of time for workers in the "social link society" scenario causes some kind of rebound effect resulting in a higher number of travels per year (+7% compared to the current situation). However, these activities are closer to home, limiting the influence of this increasing on distance travelled. In addition the distance travelled is slightly reduced due to the more urban society.

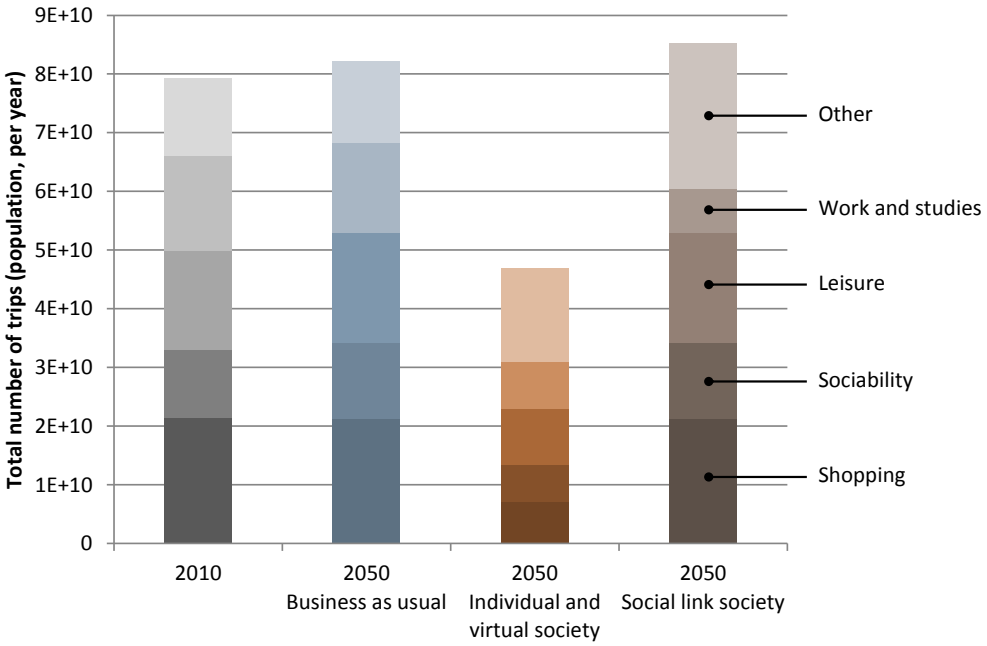


Figure 11: Total number of travels of the population per year in the current situation and the three scenarios.

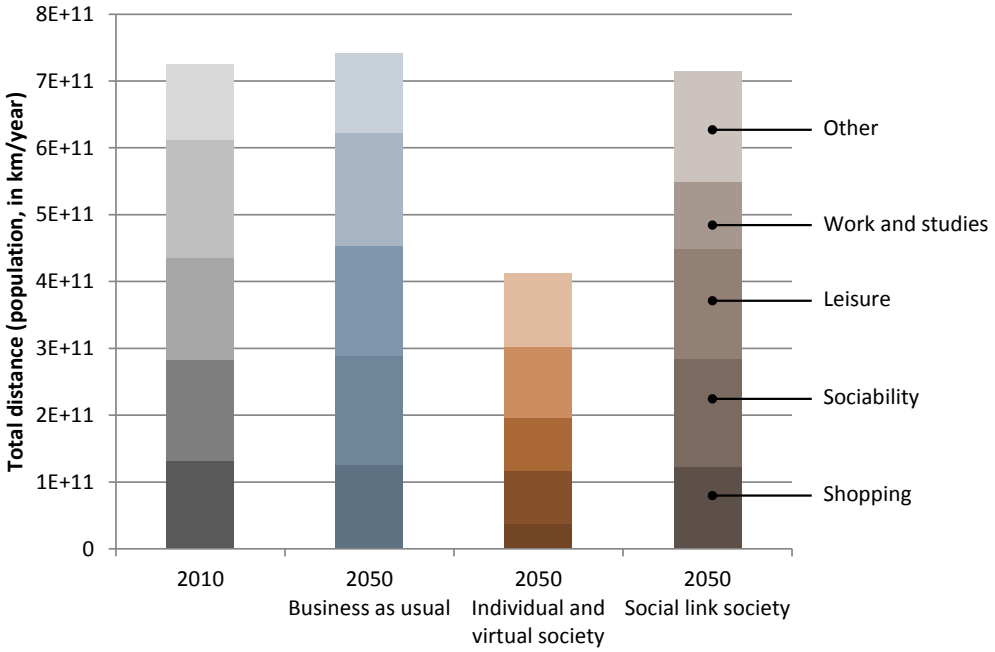


Figure 12: Total distance travelled per year by the population in the current situation and the three scenarios.

4. Conclusive discussion

Lifestyles are a central yet complex dimension of the assessment of the different open options for our societies both in terms of desirability and sustainability. This work proposed a numerical model to project alternative social practices (mobility, housing and equipment levels) and to quantify some of their implications on the long term in France. The modelling approach is based on the use of official surveys as basic material and it aims at defining a consistent explanatory environment to question the broad idea of lifestyle change. It should again be stressed that its underlying paradigm is one of an exploratory tool and not a prediction.

From this rationale a statistical model was described and results for a set of contrasted future lifestyle scenarios were discussed. The simulations took into account the diversity of population, and demonstrated that the correlation between characteristics and practices can bring a renewed understanding to the macroscopic implications of alternative lifestyles change narratives. Such changes are not initially intended and formulated as either sustainable or unsustainable.

Nevertheless the rate of adoption of radical lifestyles or the rate of reconfiguration of our social practices (and meta-structures such as cities and institutions) might remain slow. The evaluation process and the large number of potential proposals might also appear counter-productive in terms of normative policy choices. On these two aspects a robust insight could be that despite the inherent difficulties ignoring the effect of lifestyle is also a first order approximation that can lead to half-blind estimates of perceived “needs”: on one hand regarding the rationale of the Business as usual cases that are used as reference for mitigation, and on the other in the existence of opportunities for less costly mitigation options.

References

Breiman, L., Friedman, J., Olshen R., Stone, C., 1984. Classification and regression trees, Wadsworth & Brooks.

Emelianoff, C., Mor, E., Dobre, M., Cordellier, M., Barbier, C., Blanc, N., Sander, A., Castelain Meunier, C., Joliton, D., Leroy, N., Pourouchottamin P., Radanne, P., 2012. Modes de vie et empreinte carbone. Les Cahiers du CLIP, n°21, 132 pp.

Eppel, S., Sharp, V., Davies, L., 2013. A review of Defra's approach to building an evidence base for influencing sustainable behaviour. Resour. Conserv. Recycl., SI: Resourceful Behaviours 79, pp. 30 – 42.

Hérault, B., 2013, Tendances et mutations sociales en France à l'horizon 2025 - Rapports aux autres, au temps et à l'espace, support de formation, 33 pp.

Insee. Enquête « Budget de famille » 2011.

Insee. Enquête « Emploi du temps et décisions dans les couples » 2009-2010.

Insee. Enquête « Enquête nationale transports et déplacements » 2007-2008.

Insee. Enquête logement 2006.

Insee. Recensement de la population 2009.

Jackson, T., 2005. Live Better by Consuming Less?: Is There a "Double Dividend" in Sustainable Consumption? J. Ind. Ecol. 9, pp. 19 – 36.

Jaeger-Erben, M., Rückert-John, J., Schäfer, M., 2015. Sustainable consumption through social innovation: a typology of innovations for sustainable consumption practices. J. Clean. Prod. 108, Part A, pp. 784 – 798.

Kate Scott, 2009. Literature Review on Sustainable Lifestyles and Recommendations for Further Research.

Kuittinen, O., Mokka, R., Neuvonen, A., Orjasniemi, M., Ritola, M., Wikholm, M., 2012. iFuture - The Diversity of Sustainable Lifestyles. Rapport D7.3 People's forum workshop summaries. SPREAD project - Sustainable Lifestyles, 60 pp.

Le Gallic, T., Assoumou, E., Maïzi, N., Strosser, P., 2015. Les exercices de prospective énergétique à l'épreuve des mutations des modes de vie. VertigO - la revue électronique en sciences de l'environnement.

Lumme-Sandt, K., 2011. Images of ageing in a 50+ magazine. J. Aging Stud. 25, 45–51.

Maresca, B., Dujin, A., 2014. La transition énergétique à l'épreuve du mode de vie. Flux N° 96, pp. 10 – 23.

Moisescu, P.C., 2014. The Social Integration of Elders Through Free-time Activities. Procedia - Soc. Behav. Sci., 5th World Conference on Educational Sciences 116, pp. 4159–4163.

Mont, O., Neuvonen, A., Lähteenoja, S., 2014. Sustainable lifestyles 2050: stakeholder visions, emerging practices and future research. J. Clean. Prod., Special Volume: Sustainable Production, Consumption and Livelihoods: Global and Regional Research Perspectives 63, pp. 24 – 32.

Røpke, I., 2009. The role of consumption in global warming - an ecological economic perspective. Anthology on Global warming, Routledge, p.11.

Shao, J., Taisch, M., Mier, M.O., 2016. Influencing factors to facilitate sustainable consumption: from the experts' viewpoints. in Journal of Cleaner Production, accepted.

Therneau, M., Atkinson, E., 2015. An introduction to recursive partitioning using the RPART routines. Mayo Foundation. 52 pp.

UNEP, 2011. Visions for change: Recommendations for Effective Policies on Sustainable Lifestyles Based on the Global Survey on Sustainable Lifestyles (GSSL).