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Energy consumption and activity patterns: An analysis extended to total time and energy use for French households

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HIGHLIGHTS

- We combine survey data to build a database of expenditures, energy uses and time uses.
- Household activities have contrasted average energy and expenditure intensities.
- Income subgroups exhibit specific activity patterns with specific intensities.
- Household composition and housing type also drive activity patterns and intensities.
- We discuss relevance of these findings for scenario analyses of household energy use.

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ABSTRACT

Household lifestyles, and activity patterns in particular, greatly influence household energy use. In this paper we analyse the disparities in current activity patterns and related energy consumptions and expenditures of households, for a comprehensive set of everyday activities covering 24 h. Thanks to detailed data on energy consumption by end use, we are able to allocate the total of household energy consumptions to the appropriate activities. We comment on average energy and expenditure intensities of time uses of the total population as well as of income, household-composition and housing-type subgroups. Income, an obvious driver of energy and expenditure intensities, is revealed to influence time use as well. Household composition and housing type are also associated with substantial variations in activity patterns and in the energy and expenditure intensities of activities, even within a given income group. Indeed, sometimes the variations associated with income are smaller than the variations associated with other variables. We therefore underline the importance of household disaggregation in household energy analyses, to properly account for such disparities.

1. Introduction

Household consumption is a key driver of energy demand and of greenhouse gas emissions: in addition to direct household energy use, it has a bearing on the energy consumption of economic sectors embodied in consumed goods and services. For this reason, the implications of consumer lifestyle on energy use and emissions have attracted a growing interest in recent years (see e.g. [1–3]). Furthermore, changes in consumption patterns are increasingly regarded as necessary to meet emissions reduction objectives beyond the reach of energy efficiency improvements [4–6].

Beyond the microeconomic standard of utility maximisation under budget constraint, consumption choices do not derive solely from monetary considerations: an extensive literature stresses the importance of emotional, habitual and social aspects, in particular concerning energy use [7–9]. One other fundamental constraint on consumption patterns is time. Time is a budget irrevocably set for all individuals alike. Any increase of the time spent on one activity must be compensated by a decrease of the time allocated to other activities. Indeed, the availability of time could constrain future consumption choices more than the availability of monetary resources. Since Becker introduced the household production approach [10], several studies

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have considered the implications of the substitution of goods for time and of the relative expenditure intensities of different activities [11,12].

For these reasons, as Schipper et al. [13] first pointed out, a fitting way to analyse the impact of lifestyles on energy use is to focus on the interdependencies of time use and energy consumption. Only a few empirical studies besides Schipper et al. [13] adopt this approach, crossing budget and time-use data to compare the energy consumptions associated with different everyday activities. Jalas [14] analyses the energy intensity of time spent on several activities for 2-person Finnish households in 1990, to reveal that the highest intensity is associated with car travel, followed by eating out and clothes washing or ironing. For the author, a comparison of energy intensities is useful to shed light on the possibility of a rebound effect with respect to time, if households externalise some services (e.g. clothes washing) and replace them with activities that are more energy-intensive than the externalised service itself. Brenčič and Young [15] also consider the implications of a rebound effect with respect to time, by studying the impact of time-saving appliances (like microwaves and dishwashers) on time use patterns and energy consumption. They find some evidence of rebound effect with respect to time, as households who own a dishwasher tend to use washing machines and clothes dryers more often than households who do not. Jalas [16] further considers the change in activity patterns and energy intensities of Finnish households between 1990 and 2000, showing that the energy intensities of activities increase over the period, but activity patterns shift in favour of less energy-intensive activities. This decomposition analysis is extended to 2009 by Jalas and Juntunen [17], who show that during the 2000s the energy intensities continued to rise, and activity patterns shifted again towards more energy-intensive activities. Besides, the authors observe significant differences in energy intensities across different household compositions, highlighting the need to take household composition into account (although some of the variation they observe can be attributed to income effects). Similarly, Druckman et al. [18] study the greenhouse-gas emissions associated with everyday activities of British households and the GHG intensities of time spent in these activities. They find that personal care activities (including clothes washing and medical care) have the highest GHG intensity, followed by meals (at home or away from home) and commuting. The large differences in the energy intensity of activities reported by this literature draw attention to the significance of the impact that changes in lifestyles, which imply changes in activity patterns, can have on both direct and indirect (embodied in non-energy expenses) energy consumption.

Besides the studies cited above, which focus on the implications of lifestyles and energy intensities of activities for household energy use, it is worth noting that time use information has other important applications in energy research. For example, the energy intensity of activities, as regards electricity, is relevant for load profiling and demand management [19,20].

The purpose of our work is twofold: to quantify the variability of direct energy intensity and non-energy expenditure intensity of daily activities and to investigate to what extent activity patterns and the energy- and non-energy intensities of activities are sensitive to household characteristics. For the latter purpose we explore 3 axes of household differentiation: income, household composition and housing type. Our analyses rest on the combination of a number of datasets to construct a comprehensive, consistent vision of time use and associated energy consumptions and non-energy expenses. This allows us reaching further than previous studies in two respects. The first is that our results extend to all activities, covering all 24 h of an “average” day, whereas the studies previously cited exclude some activities for the inability to properly allocate expenditure and energy or emissions data. The second is that detailed data on energy consumption by end use (taking into consideration the heterogeneity of energy prices, household equipment and behaviour) allows us to cover the totality of household direct energy consumption, attributing it to the appropriate activities.

In Section 2 of this paper we present our methodology. In Section 3 we comment on the resulting activity patterns, energy intensities and non-energy expenditure intensities of time uses for the average household and for household subgroups defined by income, demographic composition and type of dwelling. In Section 4 we discuss our results and conclude.

2. Methodology

Because of the unavailability of any recent survey simultaneously reporting time-use and expenditure data, our study primarily builds on the statistical treatment and analysis of two data sets: the French 2009–2010 time-use survey (*Emploi du temps*, EDT) [21] and the French 2011 household expenditure survey (*Budget De Famille*, BDF) [22], both carried out by the French statistics agency INSEE.

The time-use EDT survey consists of 27,903 time diaries of individuals above 11. Each time diary reports activities at 10-min intervals for a 24-h period, as well as their locations. Time diaries were collected in 6 survey waves covering one full year, to warrant seasonal representativity. The household expenditure BDF survey provides data about income sources and expenditures of 15,797 households. Expenditure diaries cover a period of one week for daily expenses, but extend to the full year leading up to the survey period for non-daily expenses like energy. Similarly to EDT, they are the result of 6 survey waves spanning over one year and are therefore representative of the whole year. INSEE provides weights to scale up the observations of both EDT and BDF at the level of the entire French population. Our analyses systematically concern such scaled-up data.

To cross EDT and BDF data we could theoretically estimate either time uses of BDF households based on EDT, or expenditures of EDT individuals based on BDF. We settle on the former option because BDF does not provide the fully individualised expenses that would be required to assign consumption budgets to EDT individuals,[1] whereas it describes the composition of each household, giving detailed information about household members. We can therefore estimate the time uses of all individuals of each household in BDF and sum them up to obtain household time uses.

The objective of our study then calls for an allocation of expenditures, and especially energy expenditures, to time uses, and a conversion of energy expenditures into physical units. We also decide to treat transport similarly to energy, i.e. as ancillary to (out-of-home) activities, which requires disaggregation of transport time, expenses and direct energy consumptions by purpose. To perform these further data treatment steps we exploit 4 additional surveys on residential energy consumption and travel behaviour via clustering, i.e. assuming that the average conditions (expense and time breakdowns, energy prices) observed on specific household subgroups of the 4 additional surveys apply to all members of corresponding subgroups of our core BDF survey.

We summarise the steps of our database building in Fig. 1. The following subsections successively detail each step.

2.1. Choice of time-use categories and time-use estimation

The first step of our data treatment consists in estimating activity patterns for individuals of the BDF survey. There are 140 time-use categories in the EDT survey. We initially group these categories in 15 everyday activities (Table 1), although we will eventually distribute two of these time uses, namely the transport-time categories, to away-from-home activities. Our classification is a compromise between the detail of daily undertakings and both the ease of allocation of expenditure to the activities and the quality of the statistical estimation of time uses. It is similar to that of previous studies [17,18,11]. We split some activities in two based on whether they take place at home or

[1] Because of this understandable limitation of BDF, our analysis systematically operates on household data, which we convert into individual data using the comprehensive BDF data on each of its households’ composition.