Life-Cycle Consumption of Food at Home: Facts from French Purchase Data

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Aging population is a major demographic change documented in Europe, North America and the rest of the developed world. While the Western world has demonstrated this trend for the last century, the newly developing countries are joining the suit worldwide (Kinsella and Phillips 2005). The United Nation projections indicate a rise in the number of individuals age 60 and over from 245 million in 2005 to 406 million in 2050 (Guerin *et al*. 2015; Bloom *et al*. 2011). According to the Global Health Observatory, World Health Organization, the life expectancy for children born in 2015 is 82.4 years in France and 71.4 years globally (World Health Organization, Report 2016).

One of the major foci of public, academic and industry interest in France today is gearing the food industry and public intervention towards a better addressing and suiting the needs of the aging population as an important factor in assisting the elderly in maintaining food security and nutritional quality of diet. To this end, providing empirical life-cycle consumption profiles that would help understand the intricate nature of the evolution of food purchase and consumption in France cannot be underestimated. Moreover, in combination with increasing proportion of the elderly population, this line of research quickly advances to the foreground and becomes essential for managing public health issues and gauging public intervention.

Standard economic theory postulates that demographic changes can be demand shifters, affecting the quantity and composition of food demanded. As straightforward as it sounds, it is, however, not so straightforward to test this theory as the effect of aging is confounded by myriad of other changes, including, among others, changes in household composition (becoming empty nests demanding less food), physical and mental health (demanding specific foods and food attributes), income status (decrease of both absolute income and disposable income for food due to predictable (e.g. retirement) and unpredictable income shocks), opportunity cost of time (more time available for non-work related activities, such as home meal preparation), etc. In this paper, we investigate the effect of aging on food consumption. In particular, we focus on food at home purchases over the course of life cycles of French households.

There is substantial research done in the area of life-cycle consumption, with a particular emphasis on retirement, as the most profound and predictable impact of aging. The theory of the life-cycle permanent income postulates that households smooth their consumption over life cycles to avoid fluctuations induced by predictable shocks (Hall 1978). Despite this prediction, there is considerable empirical evidence to the contrary. In particular, there is ample research that shows that the non-durable consumption, food consumption in particular, decreases upon retirement (see Fernandez-Villaverde and Krueger 2007; Moreau and Stancanelli 2013; Aguila, Attanasio and Meghir 2011; Bernheim, Skinner and Weinberg 2001; Aguiar and Hurst 2013; Fisher *et al.* 2008; Fisher and Marchand 2014; Hurd and Rohwedder 2013, among others). This line of research documents a considerable hump of expenditures on non-durables at the middle age, with a significant drop towards more advanced ages, even after correcting for demographic changes, such as the size of the household (Fernandez-Villaverde and Krueger 2007).

Assumptions based on this evidence, however, have been met with some scepticism, motivated mainly by the appropriateness of measuring the actual food purchase and consumption by food expenditures, which may or may not unambiguously indicate an actual change in consumption (Aguiar and Hurst 2005, 2007; Fernandez-Villaverde and Krueger 2007). In fact, even in the face of diminishing food expenditures, the quantity of foods consumed may remain unchanged or even increase if the changes in price offset or more than offset the changes in quantity.

The latter view is rationalizable if consumers could face different prices for a given good. This, in fact, resonates with the theory of information frictions (Stigler 1961). Stigler (1961) maintains that the same good may be available at different prices due to search and, if the gains of search are sizeable, it will pay to canvass several sellers. In fact, regardless the price distribution, there will be gains to search, and if asking prices are correlated in successive time periods, the savings from search will accrue beyond the search period and materialize in accumulated knowledge. According to predictions of this model, consumers with more time at hand and, therefore, relatively low transaction cost of search, ceteris paribus, would engage more in search and strategic shopping (e.g. more frequent shopping trips, visiting more stores and/or store types per trip, which would result in increased use of store and manufacturer discounts, etc.). Aging, with decreasing demand for time for work- and non-work-related time-intensive activities (e.g. care of young children), provides a perfect background for the application of this theory. Aguiar and Hurst (2007) demonstrate that the propensity to use a discount and the share of total expenditure saved through discounts increase sharply after the age of 49.

The plausibility of the inappropriateness of expenditures for measuring consumption is also rooted in the home production theory (Becker 1965). In the Beckerian home production theory, a household's preferences are represented by a utility function that is defined over the commodity (meals) space, rather than market goods (ingredients or inputs to meals). Hence, households engage in home meal production using inputs of time and market goods to produce meals. Provided the relative availability of the inputs in the household production function changes over the life cycle, it would be expected of rational agents to substitute one input for another accordingly. Aging provides the backdrop against which the change in the relative availability of time and money is translated into the change in household food production. Granted that the market prices for the lesser value-added foods or ingredients to ready-to-consume meals would be lower than those of the ready-to-consume foods, aging consumers, with more time at hand and reduced monetary income, would be expected to engage in home meal production more intensively by purchasing lower-priced ingredients to meals and using time to prepare meals at home. Evidently, both these theories would cast a doubt on the use of expenditures as a measure of actual food consumption.

The first contribution of this paper is to estimate the life-cycle food consumption of households as opposed to the movement of food expenditures. The access to micro data on grocery purchases by the Kantar homescan panel from 2005-2013 enables us to distinguish quantities purchased from expenditure. As a result, we can estimate the home production over the life cycles and address the question of whether there is a decrease in actual consumption of the food basket, as households progress into the advanced age group categories. Our results indicate that, even in the face of steadily declining food expenditures after they reach their peak in 40's, the home production and consumption takes off almost simultaneously. In fact, it increases post 40's well into the advanced age groups, experiencing a sharp increase of more than 50% from the previous age group just around the official retirement age (currently set around 61) in France. This finding indicates that the concerns of declined consumption of (growing) elderly population are, perhaps misplaced. This is a major finding in characterizing actual food consumption and the main contribution of this paper.

Despite the clear advantage of actual purchases over food expenditures for measuring consumption, there is sparse population-level analysis in the area, possibly, due to the lack of access to food purchase national data. For example, Aguiar and Hurst (2007) perform such an analysis, but their analysis has limited geographical (Denver, CO) and time (approximately 1 year) coverage. The limited nature not only makes it hard to generalize the findings over the space and time, but also restricts the use of analytic methods (the data are essentially cross-sectional) and the scope of research questions answered (cohort and other time-variant effects, for example, remain unaccounted for). The second contribution of our paper is to estimate a life-cycle household food production and consumption using detailed food purchase data from a nationally representative panel for nine years.

A major pivot in the discussions in the previous literature on consumption of non-durables is the way of measuring the cost of time input in home production or the opportunity cost of time. While the market wage seems to be the norm for estimating the cost of time, mainly due to its near-universal availability in secondary data, it has its drawbacks (see Aguiar and Hurst, 2007, for a detailed discussion of the past efforts). Alternative measures of the opportunity cost of time have been entertained as well. Aguiar and Hurst (2007), for example, construct an estimate of the opportunity cost of time based on gains from price reduction due to additional shopping, measured by the number of shopping trips and time spent shopping.

We argue that the effect of the opportunity cost measured by the gains from price reduction by intensive search and shopping, including the ones proposed by Aguiar and Hurst (2007), on home production is possibly not identifiable. Assuming the two ingredients to the home production function – time and ingredient foods, are substitutable at the margin, it is logical to assume that the more value-added the food ingredients are (e.g. washed, peeled, cut, etc.), the less time input is necessary to produce the final meal. In this regard, extensive shopping and search would result in finding lower prices in *all* market foods across the value-added spectrum – from no value-added or raw ingredient foods (sack of potatoes) to some value-added ingredient foods (sack of frozen washed, peeled and cut French fries) to ready-to-eat foods purchased in marketplace, but which do not require home production (cooked French fries from the deli section). Therefore, granted the price advantage of shopping intensively is proportional regardless the level of the added value, there should not be any substitution between market ingredient foods and time in the home production technology, as the relative prices stay constant. The third contribution of this paper is to propose a measure of the cost of time based on the savings from substituting away from more value-added to less value added ingredient foods. We measure this as the ratio of the quantity of ingredient foods and the quantity of all foods purchased by a household. The ingredient foods are identified as foods listed as ingredients in the national nutrition database INCA 2 (Individual and Nutritional Food Consumption Survey, French Agency for Food, Environmental and Occupational Health and Safety (ANSES)). We show that the price for ingredient foods is indeed lower than that of non-ingredient or value-added foods, indicating a positive value to be had from the substitution from ready-to-eat foods to ingredient foods. This differential value serves as the basis of our measure of the cost of time.

The past literature on consumer expenditure, both on durables and non-durables, typically abstracts from time and cohort effects (Fernandez-Villaverde and Krueger 2007). We contribute to the knowledgebase by exploiting the panel nature of this database to fully exploring the time and cohort effects, as well as the effect of aging, on food at home consumption. Our results indicate that while the home food production increases both with or without cohort effects as households age, failing to account for the cohort effects would underestimate the actual increase in home production at every age. Of particular concern would be understated increase after the retirement – while the estimation without the cohort effects indicates an essentially flat home food production after the retirement period (age 60-64) compared to the pre-retirement period (age 55-59), the inclusion of these effects results 6.29% and 12.53% increase in age groups 65-69 and 70-75, respectively.

The life-cycle movements of food expenditures and home production in France received considerable attention. While some did address the intra-household allocation of time to work and non-work related activities (Bourguingnon and Chiuri 2005; Chiappori, Fortin and Lacroix 2002; Rapport, Sofer and Solaz 2011) and others documented the life-cycle evolution of food expenditures, to our knowledge, no previous effort of empirical analysis of the life-cycle evolution of actual food production and consumption in France exists.

Life-Cycle Expenditures, Prices and Shopping Strategies

In this section, we map out food expenditures, prices paid and shopping strategies on different stages of life. In other words, to motivate the further discussion on home meal production, we explore whether prices do vary across life cycles, other things held equal. For the same token, we motivate whether our proposed measures of the opportunity cost does vary as households age. The variation in market prices and the opportunity cost of time is essential to invoke and test the home production theory in this context.

The previous research in life-cycle consumption profiles displays hump-shaped path almost universally (Fernandez-Villaverde and Krueger, 2007; Aguiar and Hurst, 2007; Aguila, Attanasio and Meghir, 2011). We demonstrate a similar hump in France in Figure 1.

However, when adjusting for the household size[1] and other demographics, the hump all but disappears, unlike the findings in Fernandez-Villaverde and Krueger (2007), for example, who find that this adjustment mitigates the hump in the non-durable expenditures in the United States, but does not make it disappear altogether. This could, perhaps, be explained by the fact that Fernandez-Villaverde and Krueger (2007) and other studies of life-cycle consumption of nondurables use data from consumer expenditures for *all* food consumption, whereas we use food at home expenditures only in this study. There is the difference attributable to the different geographical location too, of course. Nevertheless, the smoothness of food expenditures over life cycles does not imply smooth life cycle consumption, addressed below.

The life cycle behavior of prices and shopping strategies brings even more detail to the life cycle consumption (Figure 2).

Although the prices paid decline steadily after 25-29 until early to mid-50's they level off afterwards the last age group – 70-75-year olds. Overall, there does not seem to be any evidence that, as time becomes a more abundant resource in the advanced-age groups, the households pay lower prices because of intensive shopping and/or home production.

To reflect the ability to reduce the cost of goods, we considered a number of possible shopping strategies. For example, the increase of number of shopping trips in a given time period could reflect, all else being equal, an increased ability of the shoppers to notice and take advantage of the store promotions, such as store prices cuts and other deals. As Figure 2 shows, the elderly consumers do in fact make increasingly more grocery shopping trips and shop longer. In fact, the consumers in 70-75-year-old group make almost 40% more trips and spend more than twice as long (increase of 106%) in shopping than 25-29-year olds.

Yet another strategic shopping behavior is shopping around: visiting a number of stores as opposed to just one, or a number of store types (convenience, small grocery or supermarket stores, for example) as opposed to just one type, in search of lower prices. Our results indicate (not shown here) that although visiting more stores per shopping day does increase steadily, scrambling store types in search for lower prices does not constitute one of the shopping strategies the consumers tap into as they age.

As mentioned above, households could potentially drive the cost of consumption down by engaging in home production. In other words, they could strategize by purchasing more ingredient foods as opposed to more value-added, or even ready to eat, foods. This hypothesis rests on the supposition that the ingredient foods are indeed more economically priced than value-added foods, of course.

[1] We use unit of consumption by OECD equivalence scale $Unite_{Consomm} = 0.3 + 0.7 \times Adults + 0.5 \times Child$, there children are the members 15 and younger.

Figure 3 below demonstrates that the price for ingredient foods is indeed lower than the price of all foods (including ingredient foods).

Vindicating this supposition is the increase in purchasing ingredient foods and time spent in home meal production, as depicted in Figure 2.

The proportion of ingredient foods in all purchased foods does steadily increase as households age, starting mid to late 60's. For the households in retirement and post retirement age groups – the 65-69- and 70-75-year olds, the proportion of ingredient foods in the shopping baskets exceeds that of the immediately preceding age group by a factor greater than 2 and 4, respectively. Similarly, the households in the 70-75-year-old group spend more than double the time (increase of 168%) in home meal production. The complete results of the regressions used to compile the graphs in Figures 1 and 2 appear in Table 1.

Conceptual Framework

The conceptual framework of this paper builds upon the Beckerian home production theory and search (Stigler, 1961). We start out with a simple cost minimization setup. In each period in period $t, t = 1, \dots, T$, household $j, j = 1, \dots, J$, purchases q_{ijt} units of market good $i, i = 1, \dots, N$, at price p_{ijt}. As discussed above, household may use a shopping strategy s, to get a lower price, as a reward measured by the opportunity cost of time spent in search for lower prices. Such strategies could potentially include increasing time spent in search and shopping, researching and using promotions and coupons, searching lower prices by visiting more stores at each shopping trip, visiting more economically priced outlets, purchasing larger quantities when at sale and stocking, purchasing less value added alternatives, purchasing generic brands, etc. To reflect the dependence of price on a shopping strategy, we express it as a function of elements of shopping strategy s, with a positive but decreasing savings from using strategy s. We also assume the price depends on a vector of variables representing shopping needs, S (Aguiar and Hurst 2007), represented by the number of distinct food groups and products purchased. Finally, households spend time for preparing home meals, cleaning, washing, etc., represented by h.

In every period, in order to maintain consumption level c, households make consumption decision by minimizing the expenditures on food

$$\min_{Q,s,h} p(s, N\,)Q + \mu(s + h) \qquad (1)$$

subject to the home technology possibilities of converting market goods to meals:

$$f(h, Q) = c$$

where Q and P are indices of quantity of goods purchased and price paid, respectively, and μ represents the opportunity cost of time. Regular concavity conditions of the price in terms of shopping strategy s and the production function $f(h, Q)$ are implied.

The optimality conditions yield

$$\frac{\partial p}{\partial Q} Q + P = \frac{\partial f}{\partial Q} \lambda \qquad (2)$$

$$-\frac{\partial p}{\partial s} Q = \mu \qquad (3)$$

$$\frac{\partial f}{\partial h} \lambda = \mu \qquad (4)$$

For calculation purposes, we adopt a fairly general functional form for the production function – constant elasticity of substitution form below:

$$c = f(h, Q) = \left(\varphi_h h^{\rho} + \varphi_Q Q^{\rho}\right)^{\frac{\gamma}{\rho}} \qquad (5)$$

The marginal rate of technical substitution associated with this functional form is

$$\frac{\frac{\partial f}{\partial h}}{\frac{\partial f}{\partial Q}} = \frac{\varphi_h}{\varphi_Q}\left(\frac{h}{Q}\right)^{\rho-1} \qquad (6)$$

Substituting the numerator and denominator from the optimality conditions (2) – (4) and taking the logarithm of both sides renders

$$\ln\left(\frac{\varphi_h}{\varphi_Q}\left(\frac{h}{Q}\right)^{\rho-1}\right) = \ln\left(\frac{-\frac{\partial p}{\partial s}Q}{\frac{\partial p}{\partial Q}Q + P}\right)$$

or

$$\ln\left(\frac{h}{Q}\right) = -\frac{1}{\rho-1}\ln\left(\frac{\varphi_h}{\varphi_Q}\right) + \frac{1}{\rho-1}\ln\left(\frac{-\frac{\partial p}{\partial s}Q}{\frac{\partial p}{\partial Q}Q + P}\right) \qquad (7)$$

For the ease of computation, we assume the price in (1) has a log-linear functional form for the ease of representation and calculation. Each household j, in each period t, pays prices

$$lnp_{jt} = \alpha_0 + \alpha_s lns_{jt} + \sum_{k=1}^{K}\alpha_k S_k + \alpha_Q lnQ_{jt} + \varepsilon_{jt} \qquad (8)$$

Combining (7) and (8) yields

$$ln\left(\frac{h}{Q}\right) = \beta_0 + \sigma ln\left(\frac{s}{Q}\right) \qquad (9)$$

where $\beta_0 = \sigma ln\left(\left.{-(1+\alpha_Q)\varphi_h}\middle/{\alpha_s\varphi_Q}\right.\right)$ and $\sigma = {}^{1}\!/_{(1-\rho)}$. Incidentally, σ is the elasticity of substitution between time and market goods in CES functions.

We use the estimates from (9) to recover the necessary parameters to calculate consumption level c from (5). Unfortunately, without making extra assumptions φ_h, φ_Q and γ cannot be identified. For the identification purposes we restrict φ_Q and γ to be equal to unity.

Price and Quantity

In every period, households purchase a large variety of food products in different forms, shapes and quantities. To meaningfully measure the fluctuations in food prices for different households, food baskets purchased and across time, we resort to constructing an index that would not only allow comparisons over time, but also cross-sectionally. The latter will reflect the price differential in each period as a measure of the opportunity cost of time. To capture this effect, we construct a variation of Paache index – a ratio of actual food expenditure and the cost of the same basket at the average price cross-sectionally. To express the relative standing of each household, we normalize the price index of the rest of the sample to 1, following Aguiar and Hurst (2007). To reflect the former, or the time effect, we inflate all nominal values using the consumer price index for food, for the corresponding year (National Institute of Statistics and Economic Studies (INSEE).

To create the price index for household j, at time t, we start by obtaining average prices for product i, weighted by quantities purchased at different levels of price as

$$\overline{p}_{it} = \sum_{j \in J} p_{ijt} \frac{q_{ijt}}{\overline{q}_{it}} \quad , \forall t \in T \qquad (10)$$

where $\overline{q}_{it}$ is the total annual sum of the quantities purchased of product i across all households in a calendar year. The price index is then defined to be the ratio of the expenditure a household would have paid if the prices were set at the average level in (10) and the expenditure actually paid:

$$\tilde{p}_{jt} = \frac{\sum_{i \in I, t \in T} p_{ijt} q_{ijt}}{\sum_{i \in I, t \in T} \overline{p}_{it} q_{ijt}} \qquad (11)$$

or

$$\tilde{p}_{jt} = \frac{X_j^t}{Q_j^t} \qquad (12)$$

where X_j^t is the actual expenditure by household j, in time t, and Q_j^t is the "normalized" expenditure or, if expressed as the ratio of the actual expenditure, X_j^t, and the price index, $\tilde{p}_{jt}$, the homogenized or "normalized" quantity, by household j, in time t:

$$Q_j^t = \sum_{i \in I, t \in T} \overline{p}_{it} q_{ijt} \qquad (13)$$

Finally, to normalize prices, the price index is centered around 1 by dividing the annual price index for each household in (12) by the mean index across all other households:

$$p_{jt} = \frac{\tilde{p}_{jt}}{\frac{1}{J-1} \sum_j \tilde{p}_{-jt}} \qquad (14)$$

This index basically reflects the gap between the price a household pays and the typical price (average) paid by the rest of the sample, in each period.

Data

The purchase data are obtained from Kantar homescan panel. The Kantar panel is selected to be nationally representative and provides detailed information concerning the products purchased and prices paid. It also provides information concerning the retail outlet name and type and transaction date. A detailed description of products is available as well, ranging from general food groups to refined identification number provided by the company (like UPCs). In our sample, households purchased, on average, 1.76 distinct products (*Product*) from 1.29 food groups (*FG*).

An array of typical demographic variables describes the participating households, including the area of a household's residence, households income, household size, number of children, etc., and individuals (panelists), including the age, gender, education and socioeconomic status of the panellist, etc. On average, 89% of our panellists are women, with approximately 80% in active work force. Couple (married) households constitute 72% of the sample, with 0.88 children and average household size of 2.67 persons. The summary statistics appear in Table A1 in the Appendix.

We restricted our sample to keep only the households no younger than 25 or older than 75. The upper limit is imposed to ensure that the preferences rather than possible health issues are the main driver of food choices. The resulting sample is an unbalanced panel of 38,027 households, spanning from 2005 to 2013, with of 130,468 household/year observations[2].

Kantar homescan dataset provides information that allows us calculate certain shopping strategies – frequency of shopping trips, number and type of stores visited at each trip, number of individual products and broader product groups purchased each trip, etc. However, it does not provide information on the length of a shopping trip or any information on the frequency or length of the home production process. To this end, we augment Kantar purchase data by time use data from the Time Use and Decision-making within Couples Survey (Enquête Emploi du Temps et Décisions dans les Couples) in France or EDT. EDT surveys a nationally representative sample of households' use of time. At the end of the survey, the households provide a diary about their time use in 10-minute intervals for 144 activities. Activities 311 (Kitchen: preparation and cooking, peeling), 312 (Washing and storage dishes, cleaning the table), 313 (Setting the table, serving the meal) and 314 (Canning, preserving, etc.)[3] were combined to create the home production variable: h. For the shopping time, unfortunately, the questionnaire was not designed to ask specifically for grocery shopping time in either waives – the activities related to shopping cover all shopping. Nonetheless, we opt to use the time in shopping assuming the time in grocery shopping is a monotonic transformation of all shopping, rendering the departure from the true or grocery shopping time a mere attenuation bias. As a result, activities 322 (Storage shopping, loading and unloading the car) and 351 (Purchases of consumer goods, shopping) were combined to create shopping time variable: s.[4]

The EDT survey provides a rich set of sociodemographic variables. We created cells using 10 age groups based on the age group of the household head and 6 family composition/ sex combinations – single female head without children, a single male head without children, a single female head with children, a single male head with children, a couple without children, a couple with children, altogether 60 cells. As with Kantar, the age restriction from 25 to 75 was applied. In the case of couples, the time of each of the couple in a household was treated as a perfect substitute of the other and, therefore, was added to create h and s for the entire household. The mean values for h and s were calculated for each of the 60 cells. We then imputed the cell means of h and s to similar cells in home purchase data.

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[2] Although the Kantar purchase data are available from 1998, we did not include the earlier years due to a number of considerations, including but not limited to, the differences of purchase scanning, product and product group coding system, change in household identification numbers, drastically smaller sample size compared to the later years, etc.
[3] This activity is available in the 1998-99 waive only.
[4] We experimented with alternative definitions of s and h to ensure robustness. For example, h1 measures time for just pure cooking and preparing (311 and 314 only), h2 measures time for preparing and related activities (311, 312 and 314). Similarly, we considered an alternative for s the time just for pure shopping: 351. The results with alternative measures were essentially identical. In this paper we report the results for s and h only.

The time use survey is administered every 10 years in France. We use the two available waives of EDT: 1998-99 and 2009-10, with 6,857 and 16,136 households, respectively. For the years represented by our purchase data: 2005-13, for the years that the EDT was not conducted we intrapolated and extrapolated the EDT data from the available years. In our sample, on average, households spend 42 minutes per day for shopping and almost 2,5 hours per day in home productions.

Price and Quantity Indices

In each period, households make choice of a variety of distinct products (e.g. a 250 gram glass jar of fresh mozzarella cheese balls), identified by a unique identification code, from over 300 broader product groups (food group of mozzarella cheeses). The summary statistics in Table A1 indicate that in the combined sample, the price index in (14) is, indeed, centered around one, with 2990 "units" of food purchased in (13), on average, annually.

Shopping Strategy

All else equal, households will seek to accrue benefits from shopping (Stigler 1961). Standard economic theory suggests that they will do so until these benefits are in par with the opportunity cost of time. The optimality condition in (3) suggests just that. To capture shopping strategies that could reflect household behavior in this kind of optimization, we use a series of shopping strategies that could potentially result in lower prices. One such variable we created reflects the frequency shopping trips, proposed by Aguiar and Hurst (2007). As households shop frequently, they are more likely to find store and manufacturer promotional prices. The average number of trips per month – *Trips*, captures this strategy. Our data suggest that households make on average 6.82 shopping trips per month.

Shopping strategies to find the best price are not confined to the shopping frequency only. Strategizing the shopping basket is another. *Ing* measures the proportion of a shopping basket that are ingredient foods. The ingredient foods are identified by using recipes from INCA 2 (Individual and Nutritional Food Consumption Survey 2006-2007, French Agency for Food, Environmental and Occupational Health and Safety (ANSES)).. Any product that appears in the list of "ingredients" in the recipes in this database was defined as an ingredient for our purposes. It should be noted here that the status of "ingredient" has nothing to do with being processed or fresh. On average, a third of foods purchased per shopping trip were ingredient foods.

Yet another shopping strategy is based on taking advantage of the fact that certain store types are more economically prices than other. For example, supermarkets and other largescale stores typically offer lower prices on the same items as smaller retailers. In other words, consumers shop around or they visit several different stores or store types. Our data indicate that households visit 1.2 stores on average, but mixing store types was almost never done in our sample (this statistic is not reported here).

The complete list of variables, along with the description and summary statistics are reported in Table A1 in the Appendix.

Results

Prices and Life-Cycle Opportunity Cost of Time

The estimation of (8) provides the elasticity of price paid with respect to shopping strategies. Eventually, these parameters will be used for estimating the household production or consumption specified in (5).

As mentioned above, there are a number of alternative measures used to estimate the cost of time entertained in the literature: the wage rate, income, frequency of shopping, the length of shopping, etc. (e.g. Prochaska and Shrimper 1973; Aguiar and Hurst 2007) The wages as a measure for the cost of time faces many obstacles, a few of which are: wages may not the only income for a household, wages are problematic to measure cost of time for households with multiple earners, wages are not adjustable at the margin, etc. Similar criticism appears to apply also to income. The criticisms of shopping frequency and shopping time are many too – time per trip may not be constant, or the accumulated knowledge of the shopping venues may contribute to shorter shopping times, etc.

Our proposed measure of the cost of time is the ratio of ingredient foods quantity index (constructed as in (4), but only for ingredient foods) and the total food quantity index in (13). We claim that the savings from buying ingredients as opposed to ready-to-eat foods serves as a better measure of the cost of time in the context of this research. The estimates of the elasticity of price with respect to shopping intensity are reported in Table 3.

The pooled OLS estimate of the ingredient in (8) is -0.0061 (column I of Table 3). This means doubling the proportion of ingredients would lower the price index by 0.61 percent, all else held equal. Despite the significance (p-value = 0.0000) this seems a relatively small effect. In perspective, considering that the estimate of Q is 0.0032 (p-value = 0.0000), or doubling the amount purchased increases the prices paid by 0.3 percent, the composition of the shopping basket does look rather influential.

As with the other measures of the opportunity cost of time, this measure too has shortcomings. The most obvious shortcoming is the overlap between ingredients and the degree processed, as "ready-to-eat" typically assumes some form of thermal or other processing. In other words, while some foods cannot be consumed as is (they have to be combined with other foods to be consumed, for example, wheat flour), others could be consumed both as is and as an ingredient in another dish. For example, an apple is in our list of ingredients (an ingredient in an apple pie, for example), but it could also be consumed just by itself (an apple).

Considering this measurement concern, the OLS estimates are likely to be biased. To address these concerns, we turn to instrumental variable estimations. We use several alternative instruments. The first instrument we consider is the proportion of shopping trips on Saturdays in all trips. The premise here is that the time allocated to both home production and shopping is systematically different for households on weekends than on weekdays. For example, households may prefer to not engage in shopping or housework and opt for eating out on days when they do not work. In fact, there is extensive literature that demonstrates that weekend is a significant factor in restaurant visits (Binkley 2008; Nayga and Capps 1992). Assuming food away from home is a substitute to food at home, it makes sense that the day of the week is a good predictor for home production and shopping time.

We chose to use only one of the weekend day – Saturday, as, in France, even though the grocery stores are typically closed on Sundays by law, some stores may opt to open on Sundays. For example, the small proprietorships are not subject to this legislation. Even the larger-scale stores could opt to open on Sundays by paying a free (Code de Commerce). The concern that there could exist some systematic differences between the stores that are open and the ones that are not, might give rise to systematically differential price, we felt it safer to consider Saturdays only. This instrument has the appealing quality that it is unlikely to be associated with the error term in (8) as there is no reason to believe that the prices are systematically different on Saturdays. The estimates from this regression appear in column II of Table 3. The first stage regression estimate (not shown here) is negative and significant ((p-value = 0.0000) and the first stage F-statistic of 39.82 indicating strong and relevant instrument. The parameter estimate for ingredient from this estimation is -0.1252, meaning doubling ingredients will lower the price by 11.15 percent.

An alternative instrument we use is the number of children in the household. On the one hand, an argument could be made that households with children have the higher opportunity cost of buying ready-to-eat and can advantage from the economies of scale from home production. On the other hand, households with children have tighter time constraints and, therefore, higher opportunity cost of time. In the first stage of our IV estimation with the number of children as the instrument indicates that former effect dominates – the parameter estimate is 0.0214 (std = 0.0000). The F-statistic is fairly high, supporting the strength of the instrument. The second stage estimate indicates that doubling ingredient would lower the price by an impressive 50.67% – a much larger effect than the previous ones considered so far.

For comparison, we estimated the price elasticity with alternative measures of the opportunity cost of time – the number of trips and shopping time. The estimate for the shopping trips is very close to the ingredient estimate and has similar sign and significance. The estimate for the shopping time is also negative significant, but of a much smaller magnitude by a factor of more than 2. As mentioned above, considering that this variable does not measure grocery trips directly, we have more confidence on the previous two measure rather than shopping time.

In summary, our estimates of the elasticity of price with respect to shopping strategy is between approximately 1 and 50 percent, a fairly wide range.

To recover the opportunity cost of time from the estimated elasticities, we use the corresponding optimality condition (3) from the cost minimization and taking advantage of the log linear functional form of the price estimation in (8) we get

$$\mu = -\frac{\partial p}{\partial s} Q = -\frac{\partial lnp}{\partial lns} \frac{p}{s} Q = -\alpha_s \frac{X}{s} \qquad (15)$$

where α_s is the elasticity of price with respect to shopping strategy, estimated in (8), X is the actual expenditure on food and s is the shopping strategy. Since α_s does not vary across households, we then express the opportunity cost of time as the ratio of the expenditures on the shopping strategy.

Figure 4 depicts the opportunity cost of time in (15), which is proportional to the real expenditure and shopping strategy variable ratio. In Figure 4 we also depict the income as an alternative measure of the opportunity cost of time.

As can be seen from the plot, our preferred measure of the opportunity cost of time rises sharply and peaks in late 40's. Remarkably, despite the different rate of rise, all series reach the peak at the same life stage (in 40's) and the decline after early 50's in one series is almost a parallel fashion. A notable exception is perhaps the shopping time, which peaks a decade earlier in late 30's, but reaches a local maximum in late 40's as well, although never statistically significant at any age. The proportion of ingredients, income and shopping time peak in late 40's and the number of trips peaks in early 40's. In the case of the shopping trips, Aguiar and Hurst (2007) observe a similar peak a decade earlier, eventually dropping to a -25%, as opposed to our -19%, in the last age group.

Remarkably, our measure of the opportunity cost of time closely mimics that of measured with the income – peaking in late 40's and the near parallel drop afterwards. This reminiscence of the opportunity cost of time measured by ingredients of the trajectory of life-cycle movement of income could be attributable to a larger role the monetary income plays in the cost of time as opposed to time used in other, non-market activities. It could also be attributable to a relatively stable share of the non-market activities in the opportunity cost of time. As it appears in Figure 4, this share increases drastically after the late 20's, reaching its peak in 40's, declines slightly afterwards and stays constant throughout the rest of the life cycles.

In summary, regardless of the measure of the cost of time, the decline at a near-identical rate after 50's is apparent. This sets the groundwork for exploiting this change of the opportunity cost of time in home meal production and consumption.

Life-Cycle Home Production and Consumption

To be able to directly calculate home production in (5), we need to combine the estimated elasticity of price with respect to shopping strategies in (8) with the estimation results of home production time from (9).

We estimated (9) using random effects estimation method. To ensure the robustness of our findings we performed the same estimations by fixed effects and pooled OLS methods as well (not reported here). The results were remarkably robust to the choice of the estimation method. The estimation results indicate that the elasticity of substitution between time and goods, σ, varies from 0.7158 to 0.7161 (all significant at 1% level), estimated from (9) using all alternative definitions of h discussed in the data section.

With the estimated σ statistic and the assumptions concerning the production function parameters mentioned in the Data section: setting $\varphi_Q = 1$ and $\gamma = 1$, we are equipped to estimate the home production in (5) divided by expenditures, to normalize and enable comparisons across households of different size:

$$\frac{C}{X} = \frac{(\varphi h^{\rho} + Q^{\rho})^{\frac{1}{\rho}}}{\sum_{i \in I, t \in m} p_{ijt} q_{ijt}} \qquad (16)$$

The parameter estimates from the regressions of the normalized consumption $\left(\frac{C}{X}\right)$, the opportunity cost of time, household income and food expenditures are depicted Figure 5 below and reported in Table 4.

The results indicate that the fitted consumption increases post 20's sharply, levels off late 30's to late 40's, even declining slightly in late 40's, and takes off afterwards, with a particularly sharp increase in late 50's and early 60's. What is striking about this pattern is that the slowing down in home production occurs precisely when the opportunity the other series – the opportunity cost of time, food expenditures and income, are at their peak. When the opportunity cost of time and household income start declining at late 40's, the home production immediately takes off, despite the evidence that the food expenditures appear to be dipping as well. This pattern chimes well with our prediction discussed in the Introduction. In summary, in concordance with the evidence that households engage in strategic shopping and more intensive home production, the substitution of time with market goods would seem to be sufficient to produce and maintain at least the same level of consumption throughout the life cycles.

Concluding Remarks

Over the next few decades, the share of the elderly population in France and worldwide will increase steadily. There is concern that upon retirement aging people cannot maintain the pre-retirement level of consumption, giving rise to nutrition and health deprivation, even food insecurity. Compounded by the increasing proportion of the aging population, this can quickly become a public health threat. The objective of this research is to reflect quantitative, qualitative and structural changes in food basket as households age. In this paper, we demonstrate that food expenditure and income decline as households advance to older age groups. So does the opportunity cost of time. Through strategic shopping and managing the composition of food basket, and more time commitment to home meal production, the actual consumption, in fact, steadily increases throughout life cycles.

A cautionary note is in place though – our results pertain to home consumption only. Unfortunately we do not possess the empirical means, the data, most notably, to address this issue for the entire food consumption. Nevertheless, as is well documented previously, the population steadily substitutes away from food away from home with aging, which renders our findings appropriate and valid for gauging policies aimed at mitigating the income shock at retirement and other nutrition and food policies aimed at the elderly population. (a bit more on future research and with system more detailed of food)

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Table 1. Price. Expenditure and Time over the Life Cycle: Log Deviation from 25-29-Year Olds

	Dependent variables					
	Price	Ingredients	Grocery Shopping Trip	Shopping Time	Home Production Time	Food at Home Expenditure
Regressors	I	II	III	IV	V	VI
Age 30-34	-0.0023	-0.0077	0.0775	0.0377	0.1529	0.1441
	(0.0009)	(0.0050)	(0.0092)	(0.1182)	(0.1077)	(0.0103)
Age 35-39	-0.0072	-0.0230	0.1350	0.1610	0.2208	0.2270
	(0.0013)	(0.0074)	(0.0135)	(0.1333)	(0.1211)	(0.0150)
Age 40-44	-0.0084	-0.0351	0.1788	0.3132	0.1636	0.2802
	(0.0016)	(0.0097)	(0.0176)	(0.1638)	(0.1491)	(0.0196)
Age 45-49	-0.0080	-0.0339	0.2296	0.3477	0.1045	0.2746
	(0.0021)	(0.0122)	(0.0220)	(0.2002)	(0.1807)	(0.0246)
Age 50-54	-0.0086	-0.0164	0.2555	0.5702	0.2615	0.2253
	(0.0026)	(0.0148)	(0.0265)	(0.2370)	(0.2130)	(0.0296)
Age 55-59	-0.0058	0.0028	0.3047	0.7235	0.5847	0.2014
	(0.0031)	(0.0173)	(0.0311)	(0.2769)	(0.2487)	(0.0349)
Age 60-64	-0.0028	0.0195	0.3588	1.1332	1.0580	0.1958
	(0.0037)	(0.0198)	(0.0357)	(0.3144)	(0.2813)	(0.0400)
Age 65-69	0.0018	0.0496	0.3868	1.0628	1.3634	0.1804
	(0.0043)	(0.0223)	(0.0407)	(0.3654)	(0.3234)	(0.0451)
Age 70-75	0.0095	0.0824	0.3960	1.0639	1.6793	0.1701
	(0.0049)	(0.0248)	(0.0456)	(0.3840)	(0.3425)	(0.0505)
N	130,468	130,468	130,468	27,852	27,852	130,468
Households	38,027	38,027	38,027	27,852	27,852	38,027

Notes: All regressions include time, area and cohort dummies as regressors. All dependent variables and continuous control variables are in natural logarithms. The regressions in Columns I – III and VI use the Kantar purchase data. The regressions in Columns IV and V use EDT data. The reference group is the 25-29 year olds. The controls for the regressions in Columns I are the natural logarithms of the number of food groups purchased, the number of stores visited at each trip, the number of products and quantities purchased. The controls for the regression in Columns II are the sex of the household head, number of children and the marital status of the head of the household. The controls for time regressions in IV and V include the sex of the household head and life cycle status of the household. All nominal values (price and expenditure) are converted to real values using consumer price indices (CPI) for the month of July of the corresponding year. The CPI are obtained from the National Institute of Statistics and Economic Studies (INSEE) https://www.bdm.insee.fr/bdm2/index?request_locale=en. The reference year for the CPI conversion is 2015.

Table 2. The Elasticity of Price with Respect to Shopping Intensity: the Opportunity Cost of Time

Measure of Intensity	Proportion of ingredients, in natural logarithms	Proportion of ingredients, in natural logarithms	Proportion of ingredients, in natural logarithms	Average number of shopping trips per month, in natural logarithms	10-minutes intervals of time spent shopping, in natural logarithms
	I	II	III	IV	V
Elasticity: α_s	-0.0061 (0.0014)	-0.1252 (0.0318)	-0.5067 (0.0339)	-0.0045 (0.0017)	-0.0028 (0.0010)
Regression Method	OLS	IV	IV	OLS	OLS
Instrument	None	Saturday	Child	None	None
First Stage F(Prob >F)	-	39.82 (0.0000)	254.32 (0.0000)	-	-

Notes. Robust standard errors clustered at the household level are included in the parentheses. All regressions include controls: the natural logarithms of the number of food groups purchased, the number of stores visited at each trip, the number of products and quantities purchased.

Table 3. Consumption, expenditure and the opportunity cost of time over the life cycle: Log deviation from 25-29-year olds

Age Group	Consomption	Opportunity Cost of Time	Food Expenditure	Income
Age 30-34	0,0369	0,1385	0,1441	0,0637
	(0,0053)	(0,0109)	(0,0103)	(0,0093)
Age 35-39	0,1046	0,2271	0,2270	0,0772
	(0,0068)	(0,0159)	(0,0150)	(0,0133)
Age 40-44	0,1224	0,2912	0,2802	0,0873
	(0,0081)	(0,0209)	(0,0196)	(0,0174)
Age 45-49	0,0914	0,2916	0,2746	0,0940
	(0,0093)	(0,0264)	(0,0246)	(0,0220)
Age 50-54	0,1553	0,2391	0,2253	0,0882
	(0,0107)	(0,0318)	(0,0296)	(0,0268)
Age 55-59	0,1893	0,2048	0,2014	0,0475
	(0,0120)	(0,0376)	(0,0349)	(0,0317)
Age 60-64	0,3073	0,1888	0,1958	0,0100
	(0,0132)	(0,0431)	(0,0400)	(0,0365)
Age 65-69	0,3267	0,1508	0,1804	-0,0210
	(0,0144)	(0,0487)	(0,0451)	(0,0416)
Age 70-75	0,3458	0,1116	0,1701	-0,0524
	(0,0156)	(0,0545)	(0,0505)	(0,0469)

Notes: The data for this figure are the coefficients from regressions of the consumption, opportunity cost of time, income and food expenditures on age, time, area and cohort dummies. The income is a categorical variable reported in Kantar. To make it continuous, we replace the category indicator with the midpoint of the category. All the dependent variables are in natural logarithmic transformation. The reference group is the 25-29 year olds. The omitted age group is 25-29.

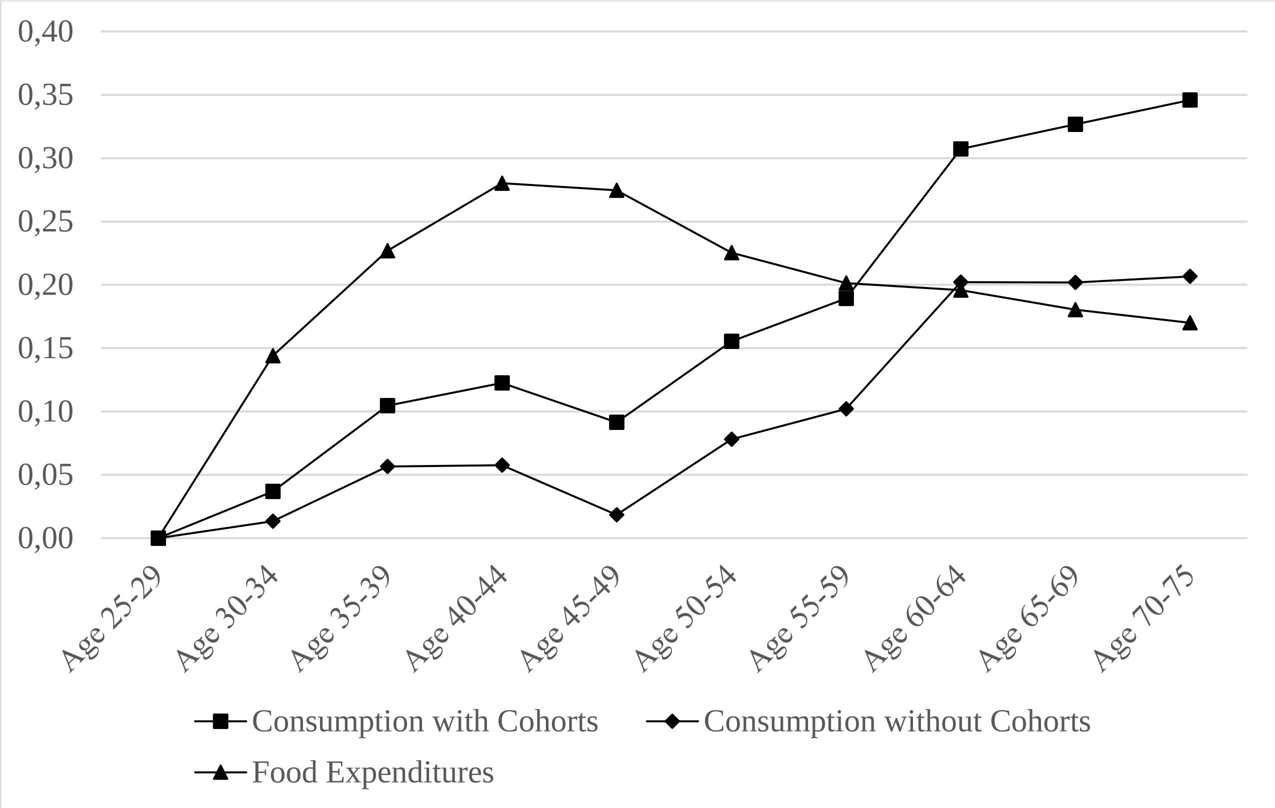

Figure 1. Food at home expenditure and consumption over life-cycle: Log deviation from 25-29-year olds

Notes: The data for this figure are the coefficients from the regression of log annual expenditures and consumption on age groups. All values are expressed as log differences from the reference age group. The reference group is the 25-29 year olds. The nominal values are converted to real using consumer price indices (CPI's) for the month of July of the corresponding year, obtained from the National Institute of Statistics and Economic Studies (INSEE) https://www.bdm.insee.fr/bdm2/index?request_locale=en. The reference year for the CPI conversion is 2015.

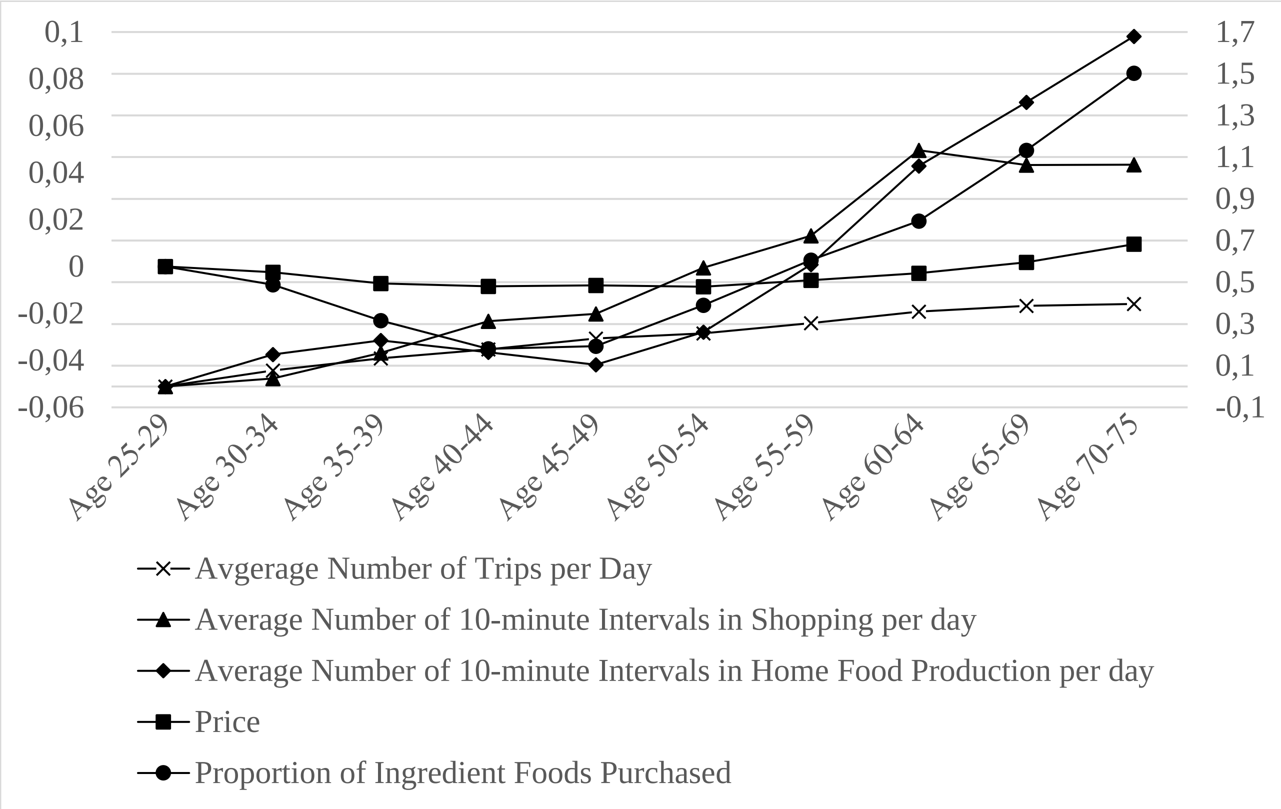

Figure 2. Food prices and shopping strategies over life-cycle: Log deviation from 25-29-year olds

Notes: The data for this figure are the coefficients from pooled OLS regressions of log prices, ingredient proportion, time spent in shopping, time spent in home production and the number of trips on age dummies. The reference group is the 25-29 year olds. The controls for the regressions of price and the number of shopping trips include the number of food groups purchased, the number of stores visited at each trip, the number of products and quantities purchased. The controls for the regression of the proportion of ingredient foods purchased includes the sex of the household head, number of children and the life cycle status of the household. The controls for time regressions include the sex of the household head and life cycle status of the household. The price values are converted to real using consumer price indices (CPI) for the month of July of the corresponding year. The CPI are obtained from the National Institute of Statistics and Economic Studies (INSEE) https://www.bdm.insee.fr/bdm2/index?request_locale=en. The reference year for the CPI conversion is 2015.

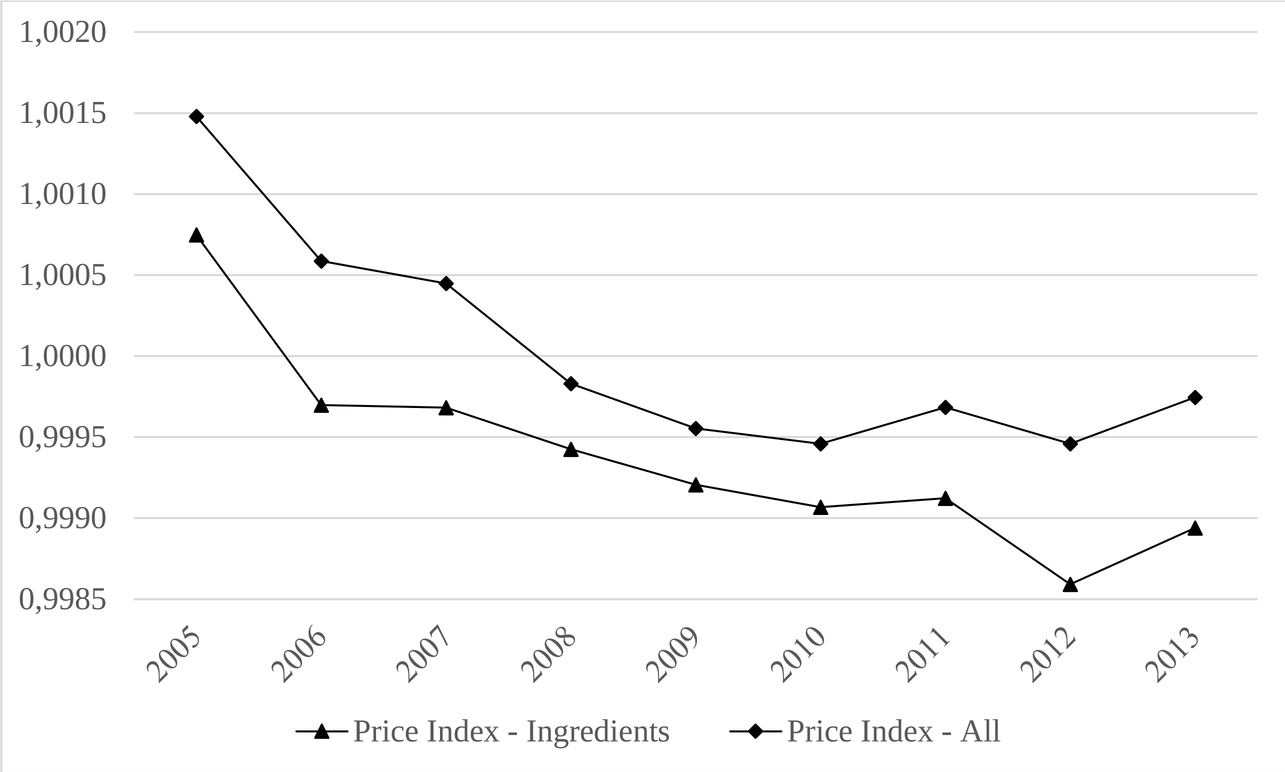

Figure 3. Prices for ingredient foods and for all foods (including ingredient foods) through years

Notes: The plotted prices are the annual average indices.

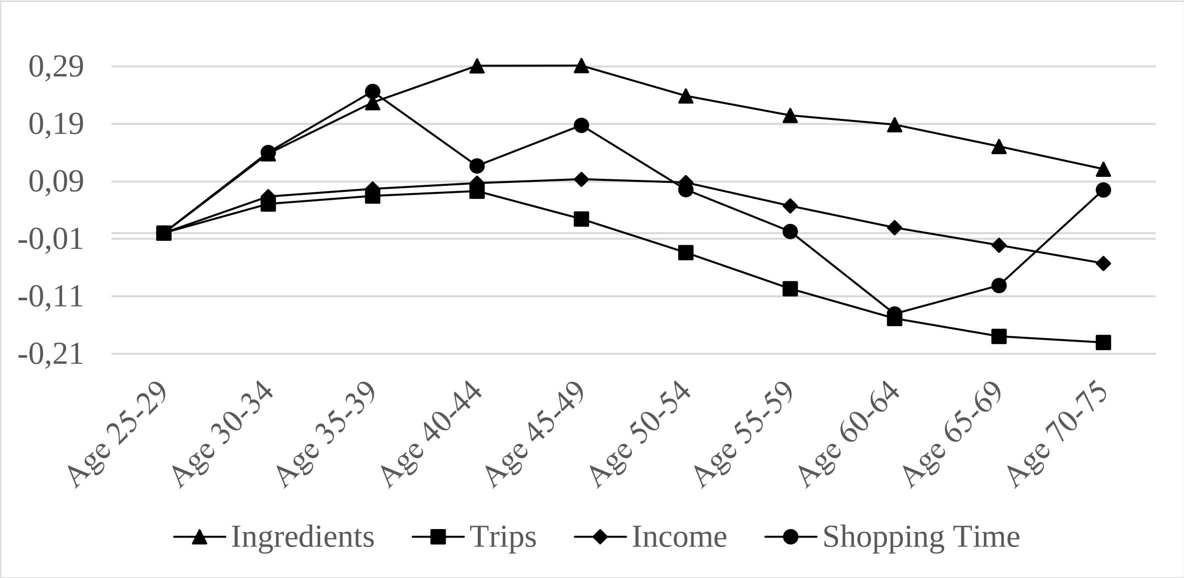

Figure 4. The opportunity cost of time over life-cycle: Log deviation from 25-29-year olds

Notes: The data for this figure are the coefficients from regressions of the opportunity cost of time in (15) and the natural logarithm of household income on age, time and cohort dummies. The income is a categorical variable reported in Kantar. To make it continuous, we replace the category indicator with the midpoint of the category. All the dependent variables are in natural logarithmic transformation. The reference group is the 25-29 year olds.

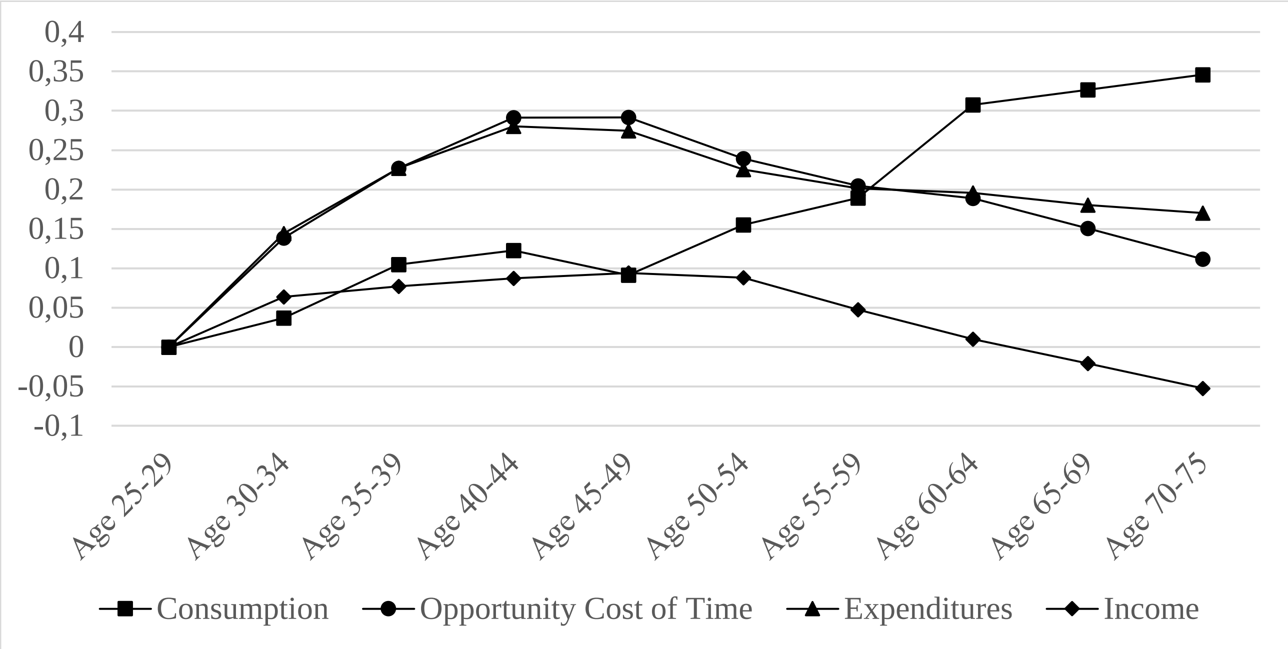

Figure 5. Estimated consumption, opportunity cost of time, food expenditures and income over life-cycle: Log deviation from 25-29-year olds

Notes: The data for this figure are the coefficients from regressions of the consumption (16), opportunity cost of time in (15), income and food expenditures on age, time, area and cohort dummies. The income is a categorical variable reported in Kantar. To make it continuous, we replace the category indicator with the midpoint of the category. All the dependent variables are in natural logarithmic transformation. The reference group is the 25-29 year olds.